A PLACEBO CONTROLLED TRIAL TO DETERMINE THE EFFICACY OF CHIROPRACTIC MANIPULATION IN THE TREATMENT OF WHIPLASH INJURY

By

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I, Brian Kruger, do hereby declare that this dissertation represents my own work in both conception and execution.

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DEDICATION

I would like to dedicate this work to my best friend and loving wife, Loren, and thank her for all her support, not only during this research project, but also throughout my course and life in general.

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ABSTRACT

The purpose of this study was to investigate the efficacy of manipulation of the cervical spine in the treatment of subacute and chronic whiplash injury utilizing a placebo treatment as a means of comparison. Treatment of whiplash injury still requires research in order to establish the effectiveness of manipulation as an adjunct in the management of this type of injury (Spitzer et al. 1995, Foreman and Croft 1995:468). Manipulation and mobilization have demonstrated some degree of effectiveness in the treatment of whiplash injury in past studies (Woodward et al. 1996, McKinney 1989).

Forty patients were used in this study, 20 per group. After an extensive history and examination the patients were diagnosed as suffering from whiplash injury, either of a subacute or chronic nature. The treatment group was assessed in terms of motion palpation findings and received spinal manipulative therapy according to these findings for six visits over a period of 4 weeks. The placebo group received five minutes of detuned ultrasound over the posterior cervical musculature for the same treatment period.

On the first, third and six visits data was collected. All data was collected before the first treatment and after the third and sixth treatments, in order to assess the effectiveness of these treatments. The objective data consisted of cervical range of motion using the CROM goniometer and pain threshold levels using an algometer over the most tender area on the articular pillar of the posterior cervical spine. Subjective data consisted of CMCC Neck Disability Index, the Numerical Pain Rating Scale 101 and the short-form McGill questionnaires.

This data was then analyzed at a 95% confidence interval ($\alpha = 0.05$). Intra-group analysis was performed using the Wilcoxin Signed Rank test in which the data collected at visits one and three, three and six and one and six were compared. Within the treatment group statistically significant changes ($p \leq \alpha / 2$) for all ranges of motion were seen, except flexion and right rotation. A significant difference ($p \leq \alpha / 2$) was seen between visits one and three for right lateral flexion in the placebo group. Substantial improvements were also seen in the treatment group in terms of algometer readings, with the placebo group improving between visits one and six on the left ($p \leq \alpha / 2$). Subjectively both groups improved ($p \leq \alpha / 2$) to a similar degree on intra-group testing.

Inter-group analysis was performed using the Mann-Whitney U-Test. Comparisons were made between the data collected at visits one, three and six. Statistically significant differences ($p \leq \alpha / 2$) were seen for all ranges of motion, except flexion. No statistically significant differences ($p \leq \alpha / 2$) were seen for the algometer readings. Subjectively no statistical differences ($p \leq \alpha / 2$) were seen between the groups for any of the questionnaires presented.

It is apparent from this study that patients suffering from whiplash injury may have an increased range of motion following a series of manipulative therapy. No conclusions can be drawn in terms of pain, discomfort or disability as no significant differences were seen here, although intra-group testing revealed improvements within each group.

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FLEX = flexion reading at the relevant consultation

EXT = extension reading at the relevant consultation

RLF = right lateral flexion reading at the relevant consultation

LLF = left lateral flexion reading at the relevant consultation

RR = right rotation reading at the relevant consultation

LR = left rotation reading at the relevant consultation

ALG = algometer reading at the relevant consultation

NRS = Numerical Pain Rating Scale – 101

MG = McGill Short-Form Pain Questionnaire

(S) = statistically significant value

DEFINITION OF TERMS

Adhesion

A fibrous band or structure by which parts adhere abnormally (Gatterman 1990:405).

Cervical spine

For the purposes of this study this term refers to the vertebrae making up the bony skeleton of the neck including all discs, joints and surrounding soft tissues.

Chiropractic Manipulation

A method of manipulation utilizing specific short levers to which a high-velocity thrust of controlled amplitude is directed, with the aim of restoring mobility to individual articulations (Gatterman 1990:49).

Coupling

A phenomenon of consistent association of one motion (translation or rotation) about an axis with another motion about a second axis (White and Panjabi 1990:646).

Fixation

The state whereby articulation has become temporarily immobilized in a position that it may normally occupy during any phase of physiological movement (Haldemann 1992:623).

Goniometer

An instrument for measuring angles (Gatterman 1990: 408); in this study referring to a device specifically designed for measuring the angles of motion of the cervical spine.

CHAPTER ONE

INTRODUCTION

1.1 The Problem and its Setting

It is speculated that more than 10% of the adult population in the United States suffer from the acute or chronic effects of whiplash injury (Foreman and Croft 1995:353). This percentage is possibly higher in South Africa due to the high incidence of motor vehicle accidents in South Africa (Burger 1996:478). This type of injury appears to lack any form of definitive and effective treatment. It is noted by certain authors that the current available treatment for whiplash injury has limited benefit for the patient and may possibly prolong the suffering of the patients in certain instances (Mealy et al.1986, Borchgrevink et al. 1998 and Spitzer et al. 1995). Disagreement on the appropriate treatment of whiplash injury may be due to the lack of consensus on the appropriate manner in which to measure pain and function (Mooney 1997).

Manipulation has demonstrated some degree of effectiveness in the treatment of whiplash injury (Woodward 1996, McKinney 1989) however further research is necessary (Spitzer et al. 1995, Foreman and Croft 1995:468).

1.2 Statement of The Problem

The purpose of this study is to investigate the efficacy of manipulation of the cervical spine in comparison to detuned ultrasound in terms of subjective and objective clinical findings in the treatment of subacute and chronic whiplash injury.

1.2.1 The First Subproblem

The first objective is to determine the efficacy of manipulation and placebo ultrasound in terms of objective clinical findings.

1.2.2 The Second Subproblem

The second objective is to determine the efficacy of manipulation and placebo ultrasound in terms of subjective clinical findings.

1.3 Need for a Solution to the Problem

Earlier studies indicate some level of effectiveness of manipulation in the treatment of whiplash injury but this effectiveness needs to be confirmed in order to increase the confidence in the use of manipulation in the treatment of whiplash injury (Woodward 1996, McKinney 1989). According to Foreman and Croft (1995:468), many forms of manipulation utilized today are effective in the treatment of whiplash injury, however there is a lack of controlled trials relating to the subject. The Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders (Spitzer et al. 1995) found that although manipulation was used regularly, scientific research backing the use of such treatment was scarce.

1.4 Benefits of the Study

This research project aims to shed some light on the effectiveness of the chiropractic manipulation, in a controlled manner, in the treatment of subacute and chronic whiplash injury. This should enhance the knowledge of the treating clinicians and increase the overall understanding of the condition. This research, being a placebo controlled trial will also provide the basis for further research studies to further increase the amount of knowledge relating to the use of manipulation of the spine in the treatment of whiplash injury.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Whiplash injury appears to present an enigma for many clinicians dealing with the condition due to the lack of adequate defining parameters and a limited response to a myriad of otherwise sound treatment protocols.

It is reported by the Quebec Task Force on Whiplash - Associated Disorders that very little treatment currently available for the treatment of whiplash injury is significantly effective. It goes on to express that, although mobilisation and manipulation help for acute pain, very little, if anything, appears to help for chronic pain. The Task Force states that due to the common use of manipulation in the treatment of whiplash injury, its value needs to be established by means of randomised controlled trials (Spitzer et al. 1995). Tollison and Satterthwaite (1992:311) consider cervical manipulation to be the most controversial form of treatment for patients suffering from whiplash injury.

The Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders reviewed more than 10000 publications related to whiplash for their scientific value and to detect any gaps in the literature. They found only 346 articles of value and a significant lack of treatment that was of clinical benefit in whiplash injury (Spitzer et al . 1995).

The following review outlines various aspects related to whiplash injury, in terms of the biomechanics and basic anatomical aspects involved and possible treatment protocols.

2.2 Defining Whiplash

2.2.1 The Term Whiplash

Whiplash injury was initially known as "Railway spine" as it occurred in people who were involved in train accidents (Tollison and Satterthwaite 1992:292). This mechanism of injury (sudden hyperflexion - hyperextension) is known by a wide range of terms: Whiplash injury, Cervical acceleration/deceleration (CAD) injury and Whiplash-associated disorder (WAD), (Spitzer et al. 1995), amongst others.

Various authors have debated the use of the term "whiplash" and suggest that it be replaced by a more descriptive term (Foreman and Croft 1995:2). However, White and Panjabi (1990:229-230) are of the opinion that the term is ingrained in our language and it is also descriptive of the condition. It is for this reason that this term will be utilised, although more 'technically' correct terms are available. Foreman and Croft (1995:3) use the term "cervical acceleration/deceleration syndrome" (C.A.D). The difficulty in defining the condition arises from the complexity of the various aspects, which comprise this syndrome (White and Panjabi 1990:230). Most terms used describe the mechanism of injury and say little about the clinical entities encountered in association with this type of injury (Spitzer et al. 1995). There are very few classifications which actually provide a quantitative means of defining the syndrome in terms of orthopaedic and other clinical tests as whiplash injury does not involve a clearly defined parameter of injuries or associated conditions (Foreman and Croft 1995:2-3).

In 1995 The Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders developed the following definition: "Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck. It may result from rear-end or side-impact motor vehicle collisions but can also occur during diving or other mishaps. The impact may result in bony or soft-tissue injuries (whiplash injury), which in turn may lead to a variety of clinical manifestations" (Spitzer et al. 1995). The Task Force also developed the following proposal for a grading system from the extensive overview of the literature reviewed by them in an attempt to aid in the definition and identification of the syndrome (Spitzer et al. 1995).

The classification is divided into a clinical-anatomic axis and a time axis. The first level on the clinical-anatomic axis is "grade 0" which consists of no complaints or physical signs involving the neck. "Grade I" consists of neck complaints by the patient including pain, stiffness or tenderness with no associated physical signs. "Grade II" consists of a neck complaint, as seen in grade I, however it also includes signs of musculoskeletal disorder. These musculoskeletal signs are defined by The Task Force as a decrease in range of motion and point tenderness. The presence of neurological signs differentiates "grade III" from "grade II" and these are defined as "decreased or absent tendon reflexes," weakness and sensory deficits. Grade IV is defined by the presence of a fracture or dislocation.

The time axis is defined as the number of days from the date of the motor vehicle accident. The first being 4-21 days, the next 22 – 45 days, the following 46-180 days and those greater than six months. However little was stated about the relevance of these time divisions except that if

the complaints exceeded 45 days, vigorous clinical intervention was necessary (Spitzer et al. 1995).

2.2.2 Signs and Symptoms

The variability of complaints of whiplash injury patients is very broad ranging from minor complaints to severe incapacitation (Yochum and Rowe 1996:681). Gay and Abbott (1953) found that in a "simple neck sprain" that the presenting features were: limitation of neck movement, pain in the lower cervical spine and spasm and tenderness of the cervical spine musculature. The most common presenting feature of whiplash patients according to Norris and Watt (1983) is neck pain (88 – 100%) and headaches (54 -66%) being the second most common feature occurring in these cases.

The symptoms experienced by whiplash patients are many and varied and may also include low back pain, vertigo and tinnitus. Other symptoms such as cognitive impairment, deafness, autonomic dysfunction (Barré - Liéou syndrome), buzzing in ears, insomnia, depression and anxiety have also been reported (Lenhart 1988, Borchgrevink et al. 1998).

A feature complicating the whiplash injury symptom picture is that the patients often experience a delayed onset of symptoms of between 24 – 48 hours, although the patient can present with immediate symptoms. In such a case the doctor's suspicion of osseous damage must be raised (Foreman and Croft 1992:96). White and Panjabi (1990:233) state that some patients may take several days before experiencing any symptoms.

Borchgrevink et al. (1998) consider a condition to be a whiplash injury when no objective radiographic or clinical signs of damage are detected (i.e. fractures or signs of nerve root entrapment.)

2.3 Incidence and Occurrence

The availability of general cervical spine injury and neck pain statistics lag significantly behind those of low back pain, possibly due to the lower effect of cervical spine injury on the ability of the patient to continue their work (Porterfield and DeRosa 1995:1).

Whiplash injury is more common in women than in men and it is possible that this is due to the fact that for the same head size, females have less neck musculature thus making them more prone to whiplash injury (Spitzer et al. 1995).

Whiplash injury is reported in 20 - 60% of all motor vehicle accidents in western countries and the annual cost to health care in 1987 approximated $3 million in Western Australia alone (Taylor and Twomey 1993). Foreman and Croft (1995:353) estimate that the cost of whiplash injury in the United States may exceed $2 billion per annum, particularly in terms of days of work lost. They speculate that more than 10% of the adult population of the United States suffer from the acute or chronic effects of whiplash injury. The incidence of whiplash injury is increasing, possibly due to the use of seat belts (Lenhart 1988), although it is stressed that the morbidity and mortality prevented by the wearing of a seatbelt outweighs the minor benefit gained by not wearing a seatbelt (Spitzer et al. 1995).

In Quebec, whiplash injury accounts for 20% of traffic injury insurance claims (Spitzer et al. 1995). No data specific for South Africa was found although it can be assumed that proportionately, South Africa may have a higher incidence of whiplash injury due to the proportionately higher number of motor vehicle accidents on South African roads (Burger 1996:478).

2.4 Basic overview of Relevant Clinical Anatomy

It is necessary to mention that the neck, containing the cervical spine, is an extremely complex structure. When considering the neck there is a tendency to focus only on the neurological or musculoskeletal structures of the neck however many other important structures are contained in the neck. Besides the more obvious musculoskeletal structures the thyroid and parathyroid glands, vagus nerve, oesophagus and trachea are among the more obvious structures (Moore 1992:783).

The cervical spine has sacrificed stability and strength for increased mobility in order to position vital sensory organs such as eyes and ears by a series of complex movements (Porterfield and De Rosa 1995:83).

This dissertation will cover the musculoskeletal aspects of the neck.

2.4.1 Osseous Structures

Seven vertebrae make up the cervical spine, with the third to sixth being considered typical and the first, second and seventh being considered atypical (Gatterman 1990:205). The common feature of all cervical vertebrae is that they transmit the vertebral artery through the foramen of

the transverse process (Moore 1992:331). Anteriorly the vertebrae consist essentially of the vertebral body, which is made of cancellous bone surrounded by a thin cortical shell. Posteriorly, there is a neural arch consisting of two pedicles and two laminae from which the transverse and spinous processes arise (White and Panjabi 1990:28).

The width of a typical vertebra is 50% greater than the antero-posterior diameter (Porterfield and DeRosa 1995:85). Intervertebral discs separate the bodies of the typical vertebrae. The facets of the superior vertebra are oval and project backward and upward and those of the inferior facets project forward and downward (Gatterman 1990:206). Each zygapophyseal joint is innervated by the medial branches of the cervical dorsal rami (Bogduk 1982) and are therefore capable of producing pain. These joints are most commonly the source of chronic neck pain in whiplash patients (Lord et al. 1996).

Another notable feature in the typical vertebrae are the uncinate processes, which are laterally raised on the superior aspect of the vertebral bodies. These articulate with the inferior lateral facets of the vertebral body above forming the joints of Luschka (Porterfield and De Rosa 1995:86). These processes begin to develop at the age of 6 – 9 years and are fully developed by the age of 18 years. It is thought that these processes act as a guiding mechanism for flexion and extension and limit lateral flexion (White and Panjabi 1990:102). According to Bland (1994) these joints serve to prevent posterolateral herniation of the cervical discs. These joints are true synovial joints (Foreman and Croft 1988:29) and are thus susceptible to degenerative changes (Gatterman 1990:206).

The atlas, axis and vertebra prominens, C1, C2 and C7 respectively, comprise the atypical vertebrae. The skull is supported on the atlas which lacks a vertebral body or true transverse processes. It has an articulation on the anterior internal aspect of the vertebral body for the odontoid peg (dens) of the axis which is held in position by the transverse ligament, dividing the atlas. Each lateral mass has a superior facet that articulates with the condyles of the occiput above and inferior facets which articulate with the superior facets of the axis below. Inferior to the atlas is the axis which provides a pivot point for the atlas via the odontoid peg, hence its name. On the anterior aspect of the odontoid peg is an articular facet. This facet articulates with the facet previously mentioned on the atlas. Laterally the odontoid peg is connected to the alar ligaments (Gatterman 1990:206). The significance of these ligaments and particularly the transverse ligament is that they hold the dens from shifting posteriorly into the spinal cord (Tollison and Satterthwaite 1992:57).

Vertebra prominens (C7) has, as its name suggests, a prominent spinous process although the spinous process of T1 can be as, or more, prominent. The reason for this prominence is due to the attachment of numerous ligaments and muscles to this spinous process. The vertebral artery does not normally pass through the transverse foramen of C7 (Gattermann 1990:207).

2.4.2 Muscles and Ligaments

2.4.2.1 Ligaments of the cervical spine

Ligaments are designed to restrain tensile forces in the direction in which they are orientated. The spinal ligaments help with the maintenance of spinal posture without excessive muscle energy expenditure. Spinal cord motions are restricted within closely defined limits by the

tensile forces of the ligaments. Most importantly there is protection of the spinal cord during traumatic situations in that large amounts of energy are absorbed during a very short time period (White and Panjabi 1990:19), which is clinically significant, particularly for the clinician working with patients suffering from whiplash injury.

There are four ligaments of major significance in a whiplash injury in the cervical spine, these being the anterior and posterior longitudinal ligaments, the ligamentum nuchae and the ligamentum flavum. The ligamentum nuchae is the only ligament that is not continuous with the ligaments found in the thoracic and lumbar spine. This ligament forms a septum between the left and right posterior muscle groups of the cervical spine as it unites one spinous process with the next. It is thought that this ligament contains proprioceptive receptors, which help in positioning of the head, and this explain the proprioceptive anomalies found in whiplash patients (White and Panjabi 1990:287-291). The anterior and posterior longitudinal ligaments attach to the anterior and posterior aspects of the vertebral bodies respectively (White and Panjabi 1990:21). The anterior longitudinal ligament narrows at the levels of the intervertebral discs and the posterior longitudinal ligament is wider at each disc segment.

Ligamentum flava extends from the antero-inferior border of the laminae above to the postero-superior aspect of the laminae below. It starts at the laminae of C2 and ends at the first sacral segment. The ligamenta flava contains large amounts of elastic fibres and according to White and Panjabi (1990:20) is the most elastic structure in the human body. In a whiplash injury this factor is clinically significant, because during the rapid flexion and

extension of the cervical spine this ligament does not suddenly buckle, as it becomes shortened, and impinge on the spinal cord (White and Panjabi 1990:23).

The capsular ligaments of the zygapophyseal joints provide stability during flexion in the cervical spine and prevent horizontal translation of the involved segments (White et al. 1975). These ligaments attach to the rim of the articular facets and are orientated at right angles to the plane of the facet (White and Panjabi 1990:23). This is due to the fact that ligaments restrain forces in the direction which they run.

In the upper cervical spine the ligaments are made up of the anterior longitudinal ligament, the anterior atlanto-dental ligament, the odontoid ligaments, the cruciate ligament, the tectorial membrane, the posterior atlanto-occipital membrane, atlanto-axial membrane and the nuchal ligament. Extending along the anterior aspect of the vertebral column and attaching to the anterior body of C2 and to the ring of C1 is the anterior longitudinal ligament. On the anterior aspect of the dens and to the posterior aspect of the anterior ring of C1 attaches the anterior atlanto-dental ligament. The anterior atlanto-occipital membrane appears to be a continuation of the anterior longitudinal ligament and with the anterior atlanto-dental ligament appears to prevent anterior slippage of the atlas and axis to some degree. The odontoid ligaments consist of the alar ligaments and the apical ligament. The alar ligaments attach to the lateral aspects of the dens and run obliquely to the medial aspects of the occipital condyles. Individually these ligaments restrict rotation of C1. The apical ligament attaches to the apex of the dens and to the anterior edge of the foramen magnum and is thought to contribute to C0 – C1 stability. Translation of C1 on C2 is strongly inhibited by the cruciate ligament. This ligament attaches to the condyles of the atlas. It is divided into an ascending and descending band, which attach

to the anterior edge of the foramen magnum and to the body of C2 respectively. The tectorial membrane is a continuation of the posterior longitudinal ligament and attaches to the anterior aspect of the foramen magnum.

Attached to the posterior edge of the atlas and the posterior edge of the foramen magnum is the posterior atlanto-occipital membrane. The posterior atlanto-axial membranes attach to the posterior aspect of C1 and C2.

Funicular and triangular parts constitute the two portions of the nuchal ligament. The funicular portion runs from the posterior aspect of the occiput to the spine of C7 and the triangular portion divides the posterior aspect of the cervical spine into right and left halves. Damage to these ligaments may be an important factor in certain whiplash injuries however, the biomechanical the role of these ligaments is still unclear. (White and Panjabi 1990:287-291).

2.4.2.2 Muscles of the cervical spine

Providing stability, protection in certain postures and the production of various movements are the major functions of the muscles of the cervical spine (White and Panjabi 1990:58). This muscular system is complex and beyond the scope of this dissertation and will thus only be discussed in general terms. The complex nature of spinal musculature is due to embryonic origins and the majority of muscles have multiple origins and insertions. In general the muscles tend to fan out and blend with the origins of muscles at lower segments (Tollison and Satterthwaite 1992:5).

Biomechanically, muscle is unique in that it has different properties depending whether it is in a contractile or relaxation phase (Foreman and Croft 1995:15). The relaxed muscle provides some resistance against external forces (aided by isometric contractions) and active muscle produces a force (White and Panjabi 1990:63). Due to the speed at which a whiplash injury takes place the neuromuscular system has insufficient time to react thus most soft tissue damage occurs before the protective reflexes can occur (Tollison and Satterthwaite 1992:293).

2.5 Basic Biomechanics of the Cervical Spine

Due to its anatomical arrangement the cervical spine is very vulnerable to traumatic forces, as the cervical spine holds 10% of the body's weight (the head) on the end of a long lever and is thus an open kinematic chain. Primarily the muscles, ligaments and joint capsules are damaged; as these are the main structures protecting the cervical spine (Gatterman 1990:205). Buonocore et al. (1966) found that in 39 of 57 whiplash injury cases (68 %) which they examined biomechanically with cineradiography were abnormal and that 50% of these cases were diagnosed on plain film radiography to be normal. This indicates a careful analysis of the biomechanics of the cervical spine in a whiplash injury is necessary.

The cervical spine with the head resting above is a first class lever. The base of the skull is the fulcrum point and the muscles anteriorly or posteriorly, act as the force and reaction. The cervical spine complex uses a balancing mechanism in order to conserve energy (Gatterman 1990:30) and this plays a significant role in the mechanism of a hyperflexion – hyperextension injury which will be discussed later.

The dramatic difference between the upper two cervical vertebrae and the rest of the cervical vertebrae necessitates the two areas to be discussed separately.

2.5.1 Biomechanics of the atlas, axis and occiput

Rotation is the main function of this region, although as in all segments of the spine all movements do occur to some extent at most levels (Panjabi et al. 1988).

According to White and Panajabi (1990:92), this is the most complex region of the axial skeleton due to the fact that this is the region at which the skull must articulate with the axial skeleton. Two opposing tasks must be accomplished in this region. One requires a high level of mobility in order to place the eyes and ears in the best position to detect sensory information, whilst the other requires stability in order to protect the delicate, yet highly important, vertebral arteries and spinal cord. Placing the instantaneous axis of rotation as close as possible to the spinal cord in order to achieve maximum rotation and movement with minimal bony impingement of the spinal cord allows this to occur (Gatterman 1990:215). Although controversy surrounds the participation of C1 and C2 in saggital plane flexion and extension (White and Panjabi 1990:92), these joints will have a significant role to play in the mechanism of injury in whiplash injury.

The majority of axial rotation occurs at C1-C2 (Panjabi et al. 1988). The significance of this movement in a pure hyperflexion – hyperextension injury, is however questionable. Translation in this region is minimal (White and Panjabi 1990:94) however, even a very small amount of translation occurring between C1 and C2 is significant due to the position of the odontoid process and the close proximity of the spinal cord posteriorly. Some coupling does occur at

the C1 - C2 joint during rotation, in that y-axis rotation is accompanied by some y-Axis distraction (White and Panjabi 1990:94).

2.5.2 Biomechanics of the lower Cervical Spine (C2 – C7)

Movement in the lower cervical spine segments is generally similar and these segments do not make true independent movements of one another (Fielding 1964). The position and shape of the uncovertebral and zygapophyseal joints control these movements (Gatterman 1990:218).

Flexion takes place largely in the middle segments, particularly at the C5 – C6 segments (White and Panjabi 1990:97). Coupling in this region is distinct, clear and of clinical significance. Flexion and extension in this region is a combination of rotation about the x-axis and translation along the z-plane in which the upper segment moves anteriorly on the segment below. The more significant coupling combination in the cervical spine is one of lateral flexion combined with rotation in which the spinous processes rotate towards the outside or convexity of the curve created by lateral bending , thus pure lateral flexion is not possible. These coupling characteristics are as a result of the oblique shape of zygapophyseal joints. (White and Panjabi 1990:99).

2.5.3 Biomechanics of Whiplash

Whiplash injury produces biomechanics that are complex and dependent on many variables; such as: the angle of impact, the speed of impact and the position of the patient.

The biomechanics of a whiplash injury are unique and the cervical spine would never have been exposed to such forces if it were not due to the speed and power of modern motor vehicles (Mooney 1997).

Biomechanically the effect of a whiplash injury is as a result of the head being unrestrained resulting in magnification of the forces and accelerations involved from the vehicle to the head. (White and Panjabi 1990:231). The major patho-mechanical component of whiplash injury occurs when there is excessive negative rotation about the x-axis as the head remains stationary due to inertia and the trunk is accelerated forward. Positive rotation around the x-axis can also occur if there is sudden deceleration of the body (White and Panjabi 1990:230). The anterior longitudinal ligament, superior articular process of the underlying vertebra and the impact of the posterior arches, limit negative rotation. The posterior longitudinal ligament, ligamenta flava and nuchae and the posterior cervical ligaments (Lenhart 1998) limit positive rotation.

Foreman and Croft (1995:66-71) utilise a four-phase system in describing the biomechanics of a typical rear-end collision.

Phase I:

This is a non-elastic collision in which the torso is forced into the seat-back and upward causing compression of the cervical spine. The head and neck begin to extend at the end of this phase resulting in high tensile forces on the cervical spine.

Phase II:

During this phase the torso is forced anteriorly by the elastic recoil of the seat-back and the head and neck are forced upward and into hyperextension. At this stage the foot is drawn away from the brake resulting in further acceleration of the vehicle.

Phase III:

This is the phase in which deceleration of the vehicle begins and the head begins to move into flexion. The brake may be re-applied at this stage resulting in further deceleration.

Phase IV:

The head and torso are now in full deceleration and the restraint caused by the seatbelt will now amplify the flexion of the cervical spine and at the cervico-thoracic junction.

2.6 Current Available Treatment for Whiplash Injury

According to Mooney (1997) no specific form of treatment has emerged as a significant method to ensure a definite positive outcome in the treatment of whiplash injury patients. Current treatment of whiplash typically involves soft collars in conjunction with prescribed rest and analgesics (Ward et al.,1998, Mealy et al. 1986); antidepressants, antihistamines and muscle relaxants are also occasionally used (Borchgrevink et al. 1998).

It was found by the by the Quebec Task Force on Whiplash-Associated Disorders (Spitzer et al. 1995) that analgesics and anti-inflammatory drugs combined with other forms of treatment only provide short-term relief in grade I and II whiplash. They found no acceptable studies regarding the use of muscle relaxants for the treatment of whiplash injury. Analgesic medication is useful during the initial acute stages of the injury, however long term use of analgesics must be avoided due to the risk of dependence developing. The analgesic rather

than the anti-inflammatory properties are thought to be responsible for the relief experienced by patients utilising anti-inflammatory medication for the treatment of whiplash injury. The use of low doses of antidepressant medications such as amitriptyline just prior to sleeping may be useful especially if the condition is affecting the patient's ability to sleep. Antidepressants block the re-uptake of serotonin and enhance the endogenous pain control pathways and in this manner provide the patient with relief. It is important not to induce artificial sleep with the use of benzodiazepines as patients with a whiplash injury generally lack restorative sleep and this will merely compound the problem. (Tollison and Satterthwaite 1992:313.)

Anterior spinal fusion may be indicated, according to certain authors, if there is a persistence of pain for more than three months, provided there are other indications for anterior spinal fusion (White and Panjabi 1990:235). According to Tollison and Satterthwaite (1992:313), surgical intervention is of little or no use in most whiplash injury patients, as they feel that cervical disc herniation is an unlikely source of pain.

In a study by Borchgrevink et al. (1998), in which 201 patients who were involved in Motor Vehicle Accidents (M.V.A) were treated for acute whiplash injury current forms of treatment were examined. One group was instructed to perform their normal daily pre-injury activities whilst the other group was given time off work and immobilised in a soft cervical collar for 14 days. The outcome of the study concluded that it is significantly better for the patients not to be immobilised and to rather perform their usual daily activities ($P < 0.001$). The Quebec Task Force on Whiplash-Associated Disorders (Spitzer et al. 1995) felt that a soft collar used beyond 72 hours probably prolonged the disability in whiplash injury. Mealy et al. (1986) also

found that initial immobility, created by the collar and rest following the whiplash injury, actually gives rise to prolonged symptoms and goes on to recommend that early active treatment could achieve a more rapid improvement. Mooney (1997) also states that there is no scientific evidence to support the use of soft collars even though these are widely utilised in the treatment of whiplash injury.

2.7 Chiropractic Treatment and Proposed Effects on Whiplash Injury

Traditionally chiropractic therapy operated under the hypothesis that neurological deficit and aberrations were the major factor in causing disease (Gatterman 1990:37). Spinal manipulation and its effect on biomechanical mechanisms are poorly understood (Haldeman 1992:437). Various hypothesis have been generated as to the cause of the fixation including muscle spasm, arthrokinetic reflexes, intra-articular jamming, articular adhesions, ligamentous shortening and multiple causative factors, amongst others (Gatterman 1990: 43-47). Bergmann (1990:150) states that the chiropractic fixation may be as a result of adhesions in the joint capsule and the capsular ligaments of the zygapophyseal joint caused by traumatic injury to these ligaments. The chiropractic manipulation seeks to reduce this fixation during manipulation by breaking these adhesions and restoring normal function without causing inflammation. Certain authors have however noted, that if this had to occur it may be too painful a procedure. (Gatterman 1990:45). Bergmann (1990:150) notes that these periarticular adhesions and fibrosis may be caused by acute or repetitive trauma as a result of the healing process and that these can be effectively treated by manipulation. These factors alone may explain the poor results achieved by the prolonged use of cervical collars and

immobilisation of the cervical spine following a whiplash injury (Mealy et al.1986, Borchgrevink et al. 1998) as these may cause increased scar and adhesion formation.

Involvement of the zygapophseal joints of the cervical spine in whiplash injury is widely accepted by many authors (Yochum and Rowe 1996:681). In the dissection of post-mortem spines involved in Motor Vehicle Accidents (M.V.A) it was discovered that of the 16 spines dissected, all had soft tissue injury around the zygapophseal joints and one specimen demonstrated haemarthrosis (Taylor and Twomey 1993).

The incidence of pain in chronic whiplash patients produced by the zygapophyseal joints was investigated by administering a block to the various zygapophyseal joints of the cervical spine in order to determine if they were the source of pain in whiplash injury patients. It was discovered that the zygapophseal joints were the source of pain in 60% (95% confidence interval, P value not stated) of the patients (Lord et al. 1997). They reported that zygapophyseal joint pain following whiplash injury is common however, the treatment of zygapophyseal joint pain is "still in it's infancy."

Studies by Woodward et al. (1996) and McKinney (1989) have indicated that there is significant improvement in whiplash patients following chiropractic manipulation or mobilisation and these warrant further investigation.

Woodward et al. (1996) states that 43% of whiplash patients will suffer ongoing symptoms for which there is no effective conventional treatment. They found, in a non-controlled

retrospective study, that 96% of patients improved following chiropractic treatment and recommended a prospective randomised controlled trial comparing conventional treatment with chiropractic care in chronic whiplash injury.

In a study performed by McKinney (1989) where patients received home self-mobilisation instruction or a physiotherapy program which included active mobilisation, it was found that persistent symptoms at two years were reduced from 45% to 23% by early mobilisation.

Nansel et al. (1990) reported that in unpublished pilot studies it was found that adjustment of the lower cervical spine in patients who had previous neck trauma (1-8 years previously) tended to regain their original symmetry of cervical spine movements 24 – 48 hours following treatment. In their study they found that there was a reduction in asymmetry of movement of the cervical spine following a single adjustment, however the effect was transient.

2.8 Radiological considerations in whiplash injury

Traumatic injuries, including whiplash, present a new set of complications for the clinician utilising manipulation as a form of treatment. The most obvious of these would be fractures of the vertebra and its related elements. Yochum and Rowe (1996: 681) state that all cases of whiplash injury require radiographic examination, not only to rule out contraindications to manipulation, but also as part of a cursory examination of any patient involved in a whiplash injury. Radiographic examination will provide the clinician with information regarding two significant contraindications to manipulation, namely fractures and dislocations and if stress

views are performed, segmental instability. According to Yochum and Rowe (1996: 682), a Davis series should be performed on all whiplash injury patients in order to rule out the above mentioned complications. This series includes an AP open mouth, lateral and AP cervical spine followed by obliques and flexion and extension stress views once major complications have been ruled out on the first set of films. Three areas need to be closely examined when the clinician reviews the radiographs, i.e. abnormal soft tissues, abnormal vertebral alignment and abnormal joints (Yochum and Rowe 1996:682-6).

Typically very little is noted on radiographic examination except for the loss of the normal cervical lordosis. Norris and Watt (1983) found that at least 50% or less of patients had normal cervical spine radiographs and that 46% had a loss of the normal cervical lordosis. Thirty-one percent of the patients had degenerative changes in the cervical spine.

Clinically one must take cognisance of the fact that severe injury, particularly when there is trauma involved, can produce only minor symptoms (Gatterman 1990:237).

2.9 Contra-indications and Possible Complications to Chiropractic Manipulation

Certain complications and contraindications to manipulation do exist, which need to be detected and evaluated by the clinician. The most common complication to manipulation of the cervical spine is vertigo (Haldeman 1992:552). The most well known complication related to cervical manipulation appears to be vascular complications. This includes vertebral artery syndrome, cerebrovascular accidents and aneurysms.

Various authors are of the opinion that the incidence of such complications is so low that the benefits of the treatment outweigh the possible complications (Haldeman 1992:580, Jaskoviak 1980). Adequate screening can further reduce these risks.

Other variable contra-indications include bone infections, such as osteomyelitis and Tuberculosis and the sero-negative arthritides (Gatterman 1990:55-62). The transverse ligament, which stabilises the odontoid peg, can become lax under certain conditions, for example in Down's syndrome and in patients suffering from sero-negative spondyloarthropathies and therefore contraindicating cervical manipulation, particularly at the upper levels of the cervical spine.

Manipulation in such a situation may force the now mobile odontoid peg into the spinal cord (Bergmann et al., 1993:133). Fractures, dislocations and instability are also significant contraindications to manipulation (Gatterman 1990:60), but were dealt with more extensively in section 2.7.

TABLE 2 .1 Contraindications to Cervical Manipulation

OSSEUOUS	VASCULAR
Recent Cervical fracture	Vertebrobasilar insufficiency
Dislocation	Aneurysm
Bone tumours/metastatic disease	Atherosclerosis
Bone Infections (Tuberculosis)	Anticoagulant Therapy
Advanced Osteoarthritis	Clotting disorders
Inflammatory arthritis	NEUROLOGICAL
Joint instability, hypermobility	Disc prolapse with neurologic deficit
Severe sprains and strains	Space-occupying lesion
Osteomyelitis	OTHER
Osteoporosis (moderate to severe)	Vertigo
Metabolic bone disease	Severe pain
	Malingering
	Lack of formal training in spinal manipulation

Adapted from Bergmann et al. (1993:133), Foreman and Croft (1995:469),Gatterman (1990:67).

2.10 Prognosis and Outcome of whiplash injuries

According to Dandy (1995:154) the prognosis of a whiplash injury is "notoriously unpredictable". In a study performed by Norris and Watt (1983) they divided the patients into three groups according to the severity of the complaints. They found that symptoms (including: neck pain, headache and paraesthesiae) in all three groups had subsided to varying degrees within six months following the motor vehicle accident, with the exception of visual symptoms. Patients with objective neurological signs had a poorer prognosis. Radiographically they found that pre-existing degenerative change in the cervical spine and abnormal cervical spine curves

also affected prognosis adversely. According to Spitzer et al. (1995) a pre-trauma headache and neck pain were associated with a delayed recovery. Taylor and Twomey (1993) state that a significant proportion of whiplash patients remain symptomatic in the absence of any organic findings. In a 2-year follow-up study by Hildingsson and Toolanen (1990) they found that 42% of the subjects had fully recovered, 14% had mild discomfort and 44% still had major complaints. Suisse et al. (1995) found that 22% of the patients had no symptoms until 12 hours following the accident. More than one fifth of the patients had recovered within one week, 53% took more than 4 weeks to recover and after one year, 3 % were not performing their usual work and related activities. It was also found that female gender, older age, married status and a higher number of dependants were associated with a longer period of absence. This highlights two other factors involved in prognosis namely litigation and psychological effects associated with whiplash injury which will unavoidably affect the outcome of any study related to whiplash.

Hohl (1974) found on retrospective analysis of 146 patients that the following factors correlated significantly with poor treatment results:

- Numbness or pain or both in an upper limb.
- A sharp reversal of the cervical lordosis.
- Restricted motion at a single segment on stress views.
- Need for a cervical collar for longer than 3 months.
- The need to resume physiotherapy more than once due to the recurrence of symptoms.

According to Grieve (1988:375) the clinician can play a significantly negative role in the outcome of the patients' condition if over enthusiastic treatment is administered during what he terms the "brittle stage." He states that during this stage, which can last between a week and three months, over zealous treatment or any sudden jolt or movement can exacerbate the condition and create severe symptoms in the patient. He does not, however indicate how the clinician can judge whether a patient is in this stage. Therefore one must assume that the clinician has to use his or her clinical judgement in determining these factors.

Foreman and Croft (1995: 442 – 444) utilise a classification system in order to provide doctors, attorneys and patients with a more objective method of prognosis. This system is divided into major injury categories (MIC) one, two and three. This in relation to clinical and subjective findings.

Radnov et al. (1991) notes that psychosocial factors and neuroticism play a limited role in the outcome of whiplash injury.

2.11 Summary

Therefore it appears that the current forms of treatment for whiplash injury are seriously lacking both in their scientific validity and effectiveness. Manipulation, mobilisation and a general increase rather than decrease in motion of the cervical spine at certain stages of a treatment programme appear to be more beneficial than the current protocol of prolonged immobilisation. It is possible that chiropractic manipulation of the cervical spine may improve the outcome of patients suffering from whiplash injury.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter outlines the methods and general procedure utilized in carrying out the research and the gathering of data. The questionnaires used in collecting the subjective data are discussed, along with their respective validity. The treatment of the data and statistical analysis used is also discussed.

3.2 Subject Inclusion and Exclusion Criteria

Patients were recruited by means of advertisements placed on various applicable notice boards, in local newspapers and by referrals from colleagues.

Only patients between the ages of 18 and 50 years of age (inclusive) were considered for this study in order to produce a relatively uniform sample group in terms of age. The patients in the study were informed as to the nature and reasons for the study after which they completed and signed an informed consent form which explained the terms and conditions of the study (Addendum H).

Injuries of a subacute and chronic nature were considered for this study and fell into grades I through III (inclusive) of the Quebec Classification of Whiplash-Associated Disorders (see section 2.1). For the purposes of this study subacute was defined as two to six weeks after the initial injury, whilst chronic was defined as six weeks and longer after the initial injury.

On the initial visit all patients underwent a consultation consisting of a complete case history (Addendum A) and physical examination (Addendum B) followed by a cervical spine examination (Addendum C).

Patients receiving any other form of treatment for whiplash injury were ruled out of the study. This included the use of cervical collars, analgesics or anti-inflammatory medication. Patients requiring documentation relating the Road Accident Fund, Insurance claims or similar situations were excluded, as the researcher could not authorize this documentation. If any contraindications to manipulation were found on any of the above examinations or on radiological examination the patient was not included in the study. These contraindications are outlined by Bergmann et al. (1993: 132-136) and Gatterman (1990: 55-62)

All patients who had not been x-rayed at any stage following the injury were x-rayed at the Technikon Natal Department of Radiography to rule out fractures and other pathology contraindicated to manipulation. The necessity for x-ray confirmation thus eliminated pregnant females from the study, unless they already had radiographs relating to the injury. Patients who had had radiological examination for the condition were asked to present either a radiologist's report or X-rays confirming the absence of fractures, instability and any other major pathology.

3.3 Outline of the Research Methodology

Forty patients were utilized for the study. Convenience sampling was used and patients were randomly allocated using a fair die. The first patient entering the study was allocated to

either group by the roll of a die (odds and evens). The following patient was allocated to the opposite group and thereafter each patient was allocated to the opposite group as the one before. This allowed all patients an equal chance of falling into either group.

Both groups were motion palpated and manipulation, if used, was performed according to these findings as outlined by Bergmann et al. (1993: 241-292). The control group received a course of treatments utilizing detuned ultrasound.

The patients received a maximum of six treatments over a four week period or until they became asymptomatic.

3.4 Measurement and Observations

3.4.1 The Data

The data contained in this study consisted of both primary and secondary data and all primary data was recorded before the first treatment (baseline) and after the third and sixth treatment sessions.

The Primary Data:

Objective:

The patients' pain threshold over the most tender segment of the articular pillar obtained from pressure readings utilizing a pressure algometer.

The range of motion of the patient's cervical spine measured utilizing a CROM goniometer.

Subjective:

- The patients' perception of their disability in the form of the CMCC Neck Disability Index. (Addendum E)
- The patients' perception of the sensory dimension of their pain in the form of the short-form McGill Pain Questionnaire. (Addendum G)
- The patients' perception of their level of pain in the form of the Numerical Pain Rating Scale – 101. (Addendum F)

The Secondary Data:

This was obtained from journal articles, books and any literature related to whiplash injury and manipulative treatment (both chiropractic and other forms) in order to determine the signs and symptoms related to whiplash injury and in orrder to determine the effects of manipulation.

3.4.2 The Methods of Measurement

Objective Measurements:

Two forms of objective measurement were utilized namely: cervical range of motion (CROM) and pain tolerance of specific areas of the articular pillar (Pressure Algometer). (Addendum D)

1. CROM:

This instrument measures flexion and extension, lateral flexion and rotation in degrees. Youdas et al. (1991) noted that the CROM had a good to high reliability and that it was a

preferable form of measurement of active cervical range of motion as the instrument could be placed consistently, even by different therapists without the need for locating precise anatomical landmarks. Thus the serial measurements taken during this study could be reliably compared with little variation in placement occurring, especially as one researcher always placed the instrument.

2. Pressure Algometer:

This instrument is a force gage which measures force in kilograms per square centimeter. It is applied over the most tender area of the articular pillar on the right and left sides as predetermined at the first consultation by tenderness to palpation. The level is recorded as it was assumed that this is related to underlying joint dysfunction (Bergmann 1993:83) Subsequent measurements are taken at the same level. The higher the reading on the algometer, the less tender the underlying structure and thus the greater tolerance to pain by the patient. The reliability of this method of quantification of local tenderness has been established (Fisher 1986).

Subjective Measurements:

This consisted of the CMCC Neck Disability Index, the Numerical Pain Rating Scale 101 and the McGill Short-Form Pain Questionnaire.

1. CMCC Neck Disability Index:

This questionnaire (Addendum E) indicates the degree to which the patients neck pain affects their everyday life or activities of daily living. The patients has to answer 10

questions which can each score a maximum of 5 points and a minimum of 0 points. The total score is thus out of 50 and calculated as a percentage.

Vernon and Mior (1991) found that the CMCC Neck Disability Index had a high level of reliability and internal consistency. They also found that it was unaffected by gender and it had an acceptable level of validity.

2. The Numerical Pain Rating Scale 101:

This is a questionnaire (Addendum F) which assesses the patient's perception of the pain, they are experiencing. The patient indicates on a line, between 0 and 100 (inclusive) the intensity of their pain when it is at its worst and on a separate line when it is at its least. The average of these two figures indicates the average pain experienced by the patient. Jenson et al. (1986) compared six methods of measuring clinical pain intensity and found that the Numerical Pain Rating Scale 101 was the "superior measure". The advantages were that it was easy to administer and score, it does not appear to be affected by age.

3. McGill Short-Form Pain Questionnaire:

This questionnaire (Addendum G) consists of fifteen descriptors which are rated on an intensity scale: 0 = none, 1 = mild, 2 = moderate and 3 = severe. The total score of 45 is reflected as a percentage. This system of questionnaire has been shown to be sufficiently sensitive to demonstrate differences due to treatment at statistical levels and is the most widely utilized questionnaire of its kind. (Melzack 1987.) According to Melzack and Katz (1992:163), this questionnaire correlates highly with sensory, affective and total indices of

the McGill Long-Form questionnaire and eliminates patient fatigue by reducing the number of forms need to be filled out in the research process.

3.5 Interventions

3.5.1 Control Group

The control group was motion palpated prior to each treatment, and these findings were recorded. They then received a course of detuned ultrasound treatments over the cervical spine and trapezius region for a 5-minute period with approximately half of the time being spent on each side of the spine. The unit was turned on and the timer was engaged; however an intensity of zero was set. The patient was instructed as to the possible effects and benefits of ultrasound therapy.

3.5.2 Experimental Group

The experimental group received standard chiropractic manipulation to the cervical spine based on motion palpation findings as outlined by Bergmann et al. (1993: 241-292). The Diversified manipulative technique was utilized.

Cervical rotary and lateral break techniques were used utilizing index, thumb and hypothenar contacts. The patients were generally seated for the manipulations, unless the patients felt uncomfortable in this position, in which case they were placed in a supine position. A maximum of two fixations were manipulated at each visit and these were determined at the discretion of the researcher.

The techniques used in this study are described by Bergmann et al. (1993:253-292) and the most frequently utilized techniques are briefly outlined below:

I Hypothenar occiput:

This technique is indicated for restricted rotation, lateral flexion or extension of the C0 – C1 complex. The patient lies in a supine position with their head off the end of the table, supported by the doctor's indifferent hand. The head is rotated away from the side of dysfunction and the doctor stands at the head of the table on the side of the manipulative contact. The hypothenar of the hand on the side of the segmental contacts the supramastoid groove and the hand is arched to cup over the patient's ear (index or hypothenar contacts may be utilized). The head is laterally flexed to the side of contact and rotated away. Joint tension is removed and a single, low amplitude thrust is applied in the desired direction.

II Calcaneal Zygomatic:

This manipulation is indicated for lateral flexion restrictions at the C0-C1 level. The patient is supine with the head rotated away from the lesion side and the doctor positions himself behind the patient's rotated head. A contact with the heel of the hand is made with the zygomatic arch, with the fingers pointing to the vertex of the skull and the indifferent hand cups the ear on the opposite side with fingers running down the cervical spine to provide support. The thrust is a "scooping" type motion from lateral to medial.

III Index Atlas:

This manipulation is indicated for a loss of rotation, lateral flexion or extension at C1-C2. The patient lies supine with the doctor at the head of the table at 45 degrees on the side of the manipulative contact. Contact with the vertebral segment is made on the lateral aspect of the transverse process for lateral flexion, on the posterolateral aspect of the transverse process for rotation and on the posterior aspect of the lateral mass in order to induce extension. On the same side the thumb contacts the patient's cheek. Support for the patient's cervical spine and occiput is provided by the doctors indifferent hand on the opposite side. The thrust is either posterior to anterior with a clockwise or anti-clockwise motion to induce rotation, directly posterior to anterior to induce extension on the ipsilateral side and medial to lateral to induce lateral flexion. A low amplitude thrust is then applied along the desired vector.

IV Index pillar – Seated:

This manipulation is indicated for restricted rotation or lateral flexion from C2 to C7. The patient is seated and the doctor stands behind the patient, slightly to the side of the contact hand. The index finger of the contact hand (on the side of the lesion) contacts the articular pillar of the superior vertebra with the palm facing upward and the thumb resting on the patient's cheek. Stabilization is provided by the opposite hand which is placed on the opposite side of the cervical spine and occiput with the fingers pointing down the cervical spine. A lateral to medial thrust is used for rotation (with the patient's head rotated away from the side of the lesion and slightly laterally flexed over the contact hand) or lateral to medial and superior to inferior for lateral flexion (with the patient's head laterally flexed

over the contact hand). At the point of joint tension a thrust is induced in the desired direction.

3.6 Statistical Analysis

3.6.1 Treatment of the Data

Subjective Data:

- All questionnaires were checked in order to ensure that they were correctly completed.
- The amounts from the questionnaires were converted to percentages and recorded separately for each group.
- The data was then analyzed.

Objective Data:

- The cervical ranges of motion were separately recorded for each group.
- The algometer readings were recorded separately for each group.
- The data were then analyzed.

3.6.2 Statistical analysis of the data

Non-parametric tests were used to analyze both categorical and continuous variables as the sample size per group was too small and the assumption of normality is violated. Group 1 (the placebo group) and group 2 (the treatment group) also had 20 patients each. The two groups were independent. The SPSS statistical package was used for data entry and analysis.

Procedure 1: Comparison between 2 related samples within group 1

Wilcoxon's sign ranked test was used to compare results from related samples. In each test, the null hypothesis states that there is no significant improvement between the 2 related samples being compared, at the $\alpha = 0.05$ level of significance. The alternative hypothesis states that there is a significant improvement.

Decision rule:

The null hypothesis is rejected at the α level of significance if $p \leq \alpha / 2$ where p is the observed significance level or P-level. Otherwise, the null hypothesis is accepted at the same level.

Procedure 2: Comparison between related samples within group 2

Procedure 1 is repeated within Group 2 with the same decision rule.

Procedure 3: Comparison between 2 unpaired (independent) samples

The Mann-Whitney unpaired U test was used to compare 2 independent samples with respect to each variable. In each test, the null hypothesis states that there is no significant difference between Groups 1 and 2 with respect to the variable change, at the $\alpha = 0.05$ level of significance. The alternative hypothesis states that there is a significant difference.

Decision Rule:

The null hypothesis is rejected at the α level of significance if $p \leq \alpha / 2$ where p is the observed level of significance or P-value. Otherwise, the null hypothesis is accepted at the same level.

Procedure 4: Comparison using barcharts

Visual summaries of analytical findings were given by the use of barcharts to compare Groups 1 and 2. Average (mean) readings were used to construct barcharts.

CHAPTER 4

THE RESULTS

4.1 Introduction

The statistical findings of this study are presented in this chapter. The subjective and objective findings of both the placebo and experimental groups are discussed. The objective data was obtained from the cervical range of motion and algometer readings whilst the subjective data was obtained from the questionnaires completed on the first, third and sixth visits.

The intra and inter-treatment results were considered for both groups. Demographic data consisting of age and gender of the subjects were also highlighted.

4.2 Solving the Subproblems

The results obtained from the statistical analysis conducted on the collected data were used to solve the two subproblems. The null (Ho) and alternative (Ha) hypothesis for each of the subproblems were as follows:

1. The First Subproblem

The first objective was to determine the efficacy of manipulation and placebo ultrasound in terms of objective clinical findings in the treatment of whiplash injury.

The hypotheses for the experimental and placebo groups were:

Ho: there would be no statistically significant difference in the objective clinical findings on analysis of the data.

Ha : there would be a statistically significant difference in the objective clinical findings on analysis of the data.

2. The Second Subproblem

The second objective was to determine the efficacy of manipulation and placebo ultrasound in terms of subjective clinical findings in the treatment of whiplash injury.

The hypotheses for the experimental and placebo groups were:

Ho: there would be no statistically significant difference in the subjective clinical findings on analysis of the data.

Ha : there would be a statistically significant difference in the subjective clinical findings on analysis of the data.

4.3 The Analyzed Data

During this and subsequent chapters, the experimental group is referred to as group one and the placebo group is referred to as group two. The null hypothesis was rejected at the α level of significance ($\alpha = 0.05$) if $p \leq \alpha / 2$.

NOTE: P values that are statistically significant are denoted with a (S)

4.3.1 Non-parametric paired tests (Wilcoxon Signed Ranks Test)

4.3.1.1 Objective data

TABLE 4.1 One sample analysis of goniometric measurements of the cervical spine for group one and two.

GROUP ONE		GROUP TWO	
VISIT	P VALUE	VISIT	P VALUE
FLEX 1- FLEX 3	0.422	FLEX 1- FLEX 3	0.219
FLEX 3-FLEX 6	0.679	FLEX 3-FLEX 6	0.051
FLEX1-FLEX 6	0.970	FLEX1- FLEX 6	0.247
EXT 1-EXT 3	**0.009 (S)**	EXT 1-EXT 3	0.212
EXT 3-EXT 6	0.098	EXT 3-EXT 6	0.359
EXT 1-EXT 6	**0.001 (S)**	EXT 1-EXT 6	0.444
RLF 1-RLF 3	0.037	RLF 1-RLF 3	**0.023 (S)**
RLF 3-RLF 6	**0.021 (S)**	RLF 3-RLF 6	0.545
RLF 1-RLF 6	**0.001 (S)**	RLF 1-RLF 6	0.186
LLF 1-LLF 3	**0.010 (S)**	LLF 1-LLF 3	0.136
LLF 3-LLF 6	0.206	LLF 3-LLF 6	0.852
LLF 1-LLF 6	**0.003 (S)**	LLF 1-LLF 6	0.477
RR 1-RR 3	0.662	RR 1-RR 3	0.751
RR 3-RR 6	0.044	RR 3-RR 6	0.920
RR 1-RR 6	0.045	RR 1-RR 6	0.695
LR 1-LR 3	0.558	LR 1-LR 3	0.190
LR 3-LR 6	0.058	LR 3-LR 6	0.831
LR 1-LR 6	**0.010 (S)**	LR 1-LR 6	0.211

FLEXION

On intra-group analysis of flexion for both groups the null hypothesis is accepted as no statistically significant difference was noted, indicating that treatment did not improve the flexion range of motion.

EXTENSION

The extension range of motion was statistically significant between visits one and three and between visits one and six for the experimental group and therefore the null hypothesis was rejected for these visits. This indicated that treatment was effective in increasing extension range of motion.

RIGHT LATERAL FLEXION

A statistically significant change was found between visits one and three for the placebo group. In the experimental group the null hypothesis was rejected for the comparisons between visits three and six and visits one and six as statistically significant changes were seen here. This indicates that although the treatment increased right lateral flexion in the experimental group, improvement was also seen in the placebo group.

LEFT LATERAL FLEXION

The alternative hypothesis was accepted for the comparison between visits one and three and between visits one and six for the experimental group, indicating that treatment was effective in improving left lateral flexion.

RIGHT ROTATION

The null hypothesis was accepted for all comparisons here as there were no statistically significant differences seen here for either group.

LEFT ROTATION

The null hypothesis was rejected for left rotation in the experimental group on comparison between visits one and six. Besides indicating the effectiveness of treatment, it also indicates that although there was no statistically significant difference between visits one and three and visits three and six, these visits still contributed to the overall improvement of the six visits.

TABLE 4.2 One sample analysis of algometer measurements for group one and two.

GROUP ONE		GROUP TWO	
VISIT	P VALUE	VISIT	P VALUE
ALG 1- ALG 3 LEFT	0.048	ALG 1- ALG 3 LEFT	0.489
ALG 3-ALG 6 LEFT	**0.009 (S)**	ALG 3-ALG 6 LEFT	0.121
ALG 1- ALG 6 LEFT	**0.001 (S)**	ALG 1- ALG 6 LEFT	**0.014 (S)**
ALG 1- ALG 3 RIGHT	0.190	ALG 1- ALG 3 RIGHT	0.537
ALG 3-ALG 6 RIGHT	**0.020 (S)**	ALG 3-ALG 6 RIGHT	0.313
ALG 1- ALG 6 RIGHT	**0.012 (S)**	ALG 1- ALG 6 RIGHT	0.126

The null hypothesis was rejected for the comparison between visits three and six and one and six on the left hand side for the treatment group, which indicates a reduced tenderness over the selected areas. For the placebo group a statistically significant change was also found between visits one and six indicating a reduction in tenderness over the selected point. On the right hand side a statistically significant change was seen between visits one and three and between visits three and six for the experimental group and therefore the null hypothesis was rejected in both instances.

4.3.1.2 Subjective Data

TABLE 4.3 One sample analysis of Numerical Pain Rating Scale for group one and two

GROUP ONE		GROUP TWO	
VISIT	P VALUE	VISIT	P VALUE
NRS 1-NRS 3	**0.013 (S)**	NRS 1-NRS 3	**0.009 (S)**
NRS 3-NRS 6	**0.001 (S)**	NRS 3-NRS 6	0.053
NRS 1- NRS 6	**0.000 (S)**	NRS 1- NRS 6	**0.004 (S)**

Statistically significant change was seen between all comparisons for both groups, except in the placebo group for the comparison between visit three and six. This indicates that in both groups the patients' perception of the pain intensity was reduced.

TABLE 4.4 One sample analysis of McGill short-form pain questionnaire index for group one and two

GROUP ONE		GROUP TWO	
VISIT	P VALUE	VISIT	P VALUE
MG 1- MG 3	**0.000 (S)**	MG 1- MG 3	**0.005 (S)**
MG 3- MG 6	**0.006 (S)**	MG 3- MG 6	**0.008 (S)**
MG 1-MG 6	**0.000 (S)**	MG 1-MG 6	**0.000 (S)**

Statistical significance was found for all the above comparisons indicating that in both groups the patients' perception of the sensory dimension of their pain was reduced, regardless of whether or not manipulation was received.

TABLE 4.5 One sample analysis of CMCC Neck Disability Index for group one and group two

GROUP ONE		GROUP TWO	
VISIT	P VALUE	VISIT	P VALUE
CMCC 1-CMCC 3	**0.002 (S)**	CMCC 1-CMCC 3	0.072
CMCC 3-CMCC 6	**0.014 (S)**	CMCC 3-CMCC 6	**0.001 (S)**
CMCC 1-CMCC 6	**0.003 (S)**	CMCC 1-CMCC 6	**0.000 (S)**

Between the third and sixth and the first and sixth visits statistically significant differences were found for both groups. For the comparison between the first and third visits a statistically significance difference was noticed for the treatment group. This demonstrates that the patients felt that there was an overall improvement in their daily life with respect to their neck pain, regardless of which group they were in, although it may be indicated that this improvement occurred slightly quicker in the treatment group.

4.3.2 Non-parametric unpaired tests (Mann-Whitney Test)

4.3.2.1 Objective data

TABLE 4.6 Two sample analysis of goniometric measurements of the cervical spine for group one and two

VARIABLE	P VALUE	MEDIAN 1	MEDIAN 2
FLEX 1	0.290	68	61
FLEX 3	0.189	63	58
FLEX 6	0.560	64.5	62
EXT 1	0.935	58.05	58
EXT 3	0.042	66.5	54.5
EXT 6	**0.021 (S)**	69	59
RLF 1	0.903	41	38
RLF 3	0.139	41.5	35
RLF 6	**0.008 (S)**	46.5	38
LLF 1	0.158	39.5	34
LLF 3	0.062	42	39.5
LLF 6	**0.019 (S)**	48	38
RR 1	0.136	65	62
RR 3	0.125	62	59.5
RR 6	**0.013 (S)**	69.5	60
LR 1	**0.019 (S)**	66	60
LR 3	0.030	69	62
LR 6	**0.003 (S)**	70	61

FLEXION

No statistically significant changes were noticed for the inter-group comparison for flexion indicating that treatment did not significantly improve flexion in comparison to placebo treatment.

EXTENSION

The null hypothesis was rejected for extension on the sixth visit as a statistically significant change was seen. However one can also observe, however that although for the third visit comparison no statistical difference was noticed the P value approached α / 2 indicating that the combination of the first and third treatments contributed to the overall significant difference noticed on the sixth visit.

RIGHT LATERAL FLEXION

The null hypothesis was rejected for right lateral flexion at the sixth visit as a statistically significant difference was found between the placebo and treatment groups, indicating that treatment improved right lateral flexion.

LEFT LATERAL FLEXION

The null hypothesis was rejected for left lateral flexion at the sixth visit as a statistically significant difference was found, indicating that treatment improved left lateral flexion

RIGHT ROTATION

The null hypothesis was rejected for the inter-group comparison of right rotation on the sixth visit comparison, indicating that manipulation improved right rotation after six treatments.

LEFT ROTATION

On comparison of left rotation a statistically significant difference was seen before the first visit indicating that a significant difference existed between the groups before treatment. It is for this reason one needs to interpret the subsequent statistically significant difference between the groups with caution. The fact that no significant difference was seen at the third visit comparison may give some strength to the difference that is seen at the sixth visit as the change seen at the first visit did not carry through all the comparisons.

FIGURE 4.1 Comparison of mean range of motion between group one and group two.

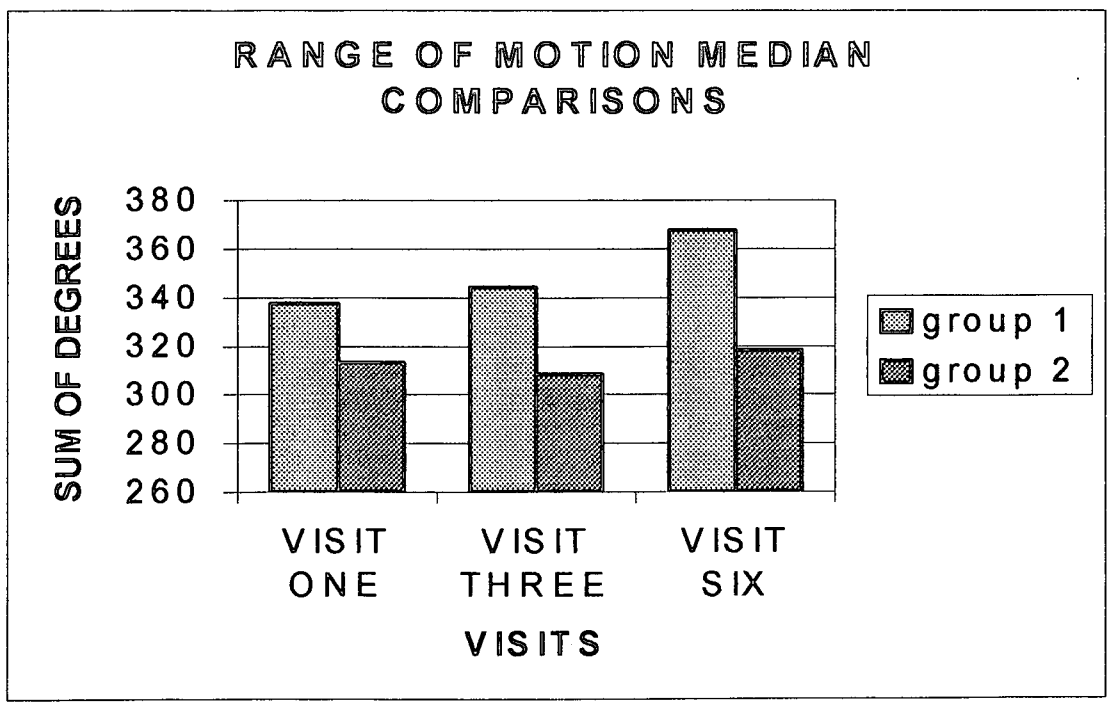


TABLE 4 .7 Two sample analysis of algometer measurements

VARIABLE	P VALUE	MEDIAN 1	MEDIAN 2
ALG 1L	0.171	2.7	2.1
ALG 3L	0.078	3.45	2.6
ALG 6L	0.213	3.75	3
ALG 1R	0.279	3.1	2.35
ALG 3R	0.244	3.1	2.8
ALG 6R	0.126	3.5	2.95

The null hypothesis was accepted for all visits as no statistically significant differences between the groups were found.

4.3.2.2 Subjective data

TABLE 4 .8 Two sample analyses of Numerical Rating Scale measurements

VARIABLE	P VALUE	MEDIAN 1	MEDIAN 2
NRS 1	0.541	35	47.5
NRS 3	0.957	36.25	32.5
NRS 6	0.587	20	22.5

No statistically significant differences were found for the numerical rating scale and thus the null hypothesis was accepted for all visits.

TABLE 4 .9 Two sample analysis of McGill short-form questionnaire index measurements

VARIABLE	P VALUE	MEDIAN 1	MEDIAN 2
MG 1	0.448	12.5	16
MG 3	0.171	5	10
MG 6	0.586	3	3

No statistically significant differences were found for the McGill short-form questionnaire and thus the null hypothesis was accepted for all visits comparisons.

TABLE 4 .10 Two sample analysis of CMCC Neck Disability Index Measurements

VARIABLE	P VALUE	MEDIAN 1	MEDIAN 2
CMCC 1	0.329	11	12.5
CMCC 3	0.090	6.5	9
CMCC 6	0.253	4.5	6

No statistically significant differences were found for the CMCC neck disability index and thus the null hypothesis was accepted for all visits.

TABLE 4 .11 Gender distribution

GENDER	GROUP 1	GROUP 2
MALES	6 (30%)	7 (35%)
FEMALES	14 (70%)	13 (65%)

TABLE 4 .12 Age distribution

	GROUP 1	GROUP 2
AVERAGE	32.9	38
RANGE (MAX)	20	21
RANGE (MIN)	49	49

This closely matches the age restrictions determined by the researcher of 18 to 50 years of age. It can also be seen that the average age for group 2 (placebo group) was approximately five years greater than for group one (experimental group). The average age was 35.5 years of age.

4.4 Conclusion

This chapter provides a summary of the statistical tests performed on the data gathered. On intra-group and inter-group testing various statistically significant tests were seen, however no significant changes were noticed on inter-group testing for the subjective aspect of the data. The significance of the statistical test findings will be discussed in the following chapter.

CHAPTER 5

DISCUSSION

5.1 Introduction

This chapter involves the discussion of the objective and subjective data that was presented in chapter four.

Two remarkable features are noticed from the result of this study. The first being that, on objective range of motion; statistically significant changes were seen. The second is that, subjectively, no statistically significant differences were seen between the groups. The relevance of these observations along with others will be considered in this chapter.

In comparing the various statistically significant differences one must keep in mind that visit comparisons which do not demonstrate statistical significance still contribute to the overall significant changes seen in subsequent visits for the same variable.

5.2 Comparison of Intra-group analysis

5.2.1 The Objective Measurements

5.2.1.1 Cervical Range of Motion

Both the treatment and placebo groups showed no statistically significant differences between the first, third or sixth visits for forward flexion (Table 4.1). The fact that no improvement occurred in flexion for the treatment group is possibly due to the isometric

contraction of the anterior cervical musculature causing compression of the facet joints in the lower cervical spine (Foreman and Croft 1995:101). If these joints are tender it is possible that reflex or conscious inhibition occur in order to avoid pain, and this may restrict flexion.

The treatment group demonstrated statistically significant differences between visits one and three and visits one and six for extension, indicating that a clinically significant improvement occurred in extension. The improvement in extension could be as a result of manipulation resolving the cervical facet syndrome that existed and therefore a subsequent reduction in pain occurred. In future studies it may be advisable to perform joint challenge or other tests following the last treatment to ascertain whether or not the facet joints were still symptomatic with respect to pain. Performing such tests may serve to reduce the above speculation.

The treatment group also demonstrated statistically significant differences in right lateral flexion between visits three and six and visits one and six. This indicates that manipulation improved right lateral flexion.

The placebo group demonstrated a statistically significant difference between visits one and three for right lateral flexion, however no other statistically significant differences were seen for subsequent visits. This improvement can be attributed to the placebo effect. Between visits one and three and visits one and six for the treatment group, a statistically significant difference was seen in left lateral flexion. This indicates a clinically

significant increase in left lateral flexion following manipulation. Therefore there was an improvement in both left and right lateral flexion. These improvements again could be as a result of the resolution of the cervical facet syndrome. The only statistically significant difference demonstrated for rotation was in the treatment group for left rotation between visits one and six.

In summary one can see that most improvements in range of motion occurred in the treatment group (See fig 4.1) except for flexion.

This increase in range of motion following manipulation correlates with other studies involving manipulation. In a study performed by Cassidy et al. (1992) similar findings were noted for mean range of motion increases in a comparison between the use of manipulation and mobilization for unilateral neck pain (see section 5.5).

5.2.1.2 Algometer Readings

Almost all statistically significant differences occurred in the treatment groups as these were seen between visits three and six and one and six bilaterally. Therefore there was a clinically significant reduction in overlying joint tenderness at the selected levels for the treatment group on intra-group testing. A statistically significant difference was seen in the placebo group between visits one and six and again this could be due to the placebo effect. These findings must be compared with those of the inter-group tests (see section 5.3.1.2).

The pain relieving effect produced by the placebo mechanism, may be due to the initiation of pain-suppressing mechanisms by the brain due to external influences such as reassurance from the doctor (Haldeman 1992:124). This explains both the subjective improvement and the improved algometer readings seen in this study, suggesting an increase in pain threshold.

5.2.2 The Subjective Measurements

5.2.2.1 Questionnaires

Statistically significant changes were seen for all intra-group comparisons of the questionnaires, except for the numerical pain rating scale between visits three and six and for the CMCC neck disability index between visits one and three in the placebo group comparisons. Therefore the patients felt that their pain and discomfort was significantly reduced in both groups, regardless of whether or not they received active treatment or not.

This suggests that treatment did not play a more active role than that of the placebo effect in improving the patients perception of their pain and discomfort as both groups improved equally.

5.3 Comparison of Inter-group analysis

5.3.1 The Objective Measurements

5.3.1.1 Cervical Range of Motion

On comparison between the mean values for flexion no statistically significant differences were found between group one and two. On all other ranges of motion statistically significant changes were seen between the sixth visits. Although a statistically significant difference was noted at the first visit for left rotation, if the difference between the initial and final P value is reviewed, it can be seen that a substantial change took place during the treatment period. This indicates that there was clinically an overall improvement in the range of motion in the group which received manipulative treatment for their whiplash injury. Due to the fact that there were no statistically significant changes by the third visit may indicate that a minimum of six (or possibly five) treatments are necessary in order to achieve the desired result in restoring range of motion in whiplash injury.

The reasons for these observations are comparable to those discussed under the intra-group testing (section 5.2.1.1).

5.3.1.2 Algometer Readings

No statistically significant differences were seen between the two groups indicating that clinically there was no difference in improvement between the groups, although significant improvements were seen within the treatment group these were obviously not large enough to produce a statistically significant inter-group difference.

5.3.2 The Subjective Measurements

5.3.2.1 Questionnaires

Subjectively no statistically significant differences were seen between the treatment and placebo groups for the Numerical Pain Rating scale (Table 4.8), the McGill Short Form Questionnaire (Table 4.9) and the CMCC neck disability index (Table 4.10). This indicates that there was no difference between the intra-group improvements as seen above (section 5.2.2.1) and therefore both groups improved equally in terms of subjective measurements. Active treatment therefore does not improve the patient's perceptions of his or her pain or disability any more than placebo treatment.

5.4 Discussion

The only major difference detected statistically between the two groups was that of an increase in overall range of motion (see fig 4.1). Due to the fact that no long-term follow-up was included in the study, it cannot be predicted how long the effect of the increased range of motion would last in the patients suffering from whiplash injury. This may be an area for future improvements. The improvement in overall range of motion may be attributed to a break down of adhesions formed within the joint capsule of the zygapophyseal joints during the trauma exerted on these joints by the motor vehicle accident. This breakdown of adhesions would therefore increase the range of motion of the cervical spine as a biomechanical unit (Bergmann 1990:150).

A difference should have been expected in the algometer readings (Table 4.7), however this did not occur and may be due to the fact that the algometer was recording the tenderness of the overlying posterior muscle spasm as opposed to direct joint tenderness.

Due to the fact that no treatment was provided for the muscle spasm (stretching, massage, cryotherapy etc), may explain the lack of statistical difference between the two group's algometer readings.

Subjectively it would also have been expected (if the treatment were entirely successful) that the treatment group would have improved to a more significant degree than the placebo group, however no statistical significance was noted on inter-group comparison.

As previously mentioned, statistically significant changes were seen on intra-group comparison for most visit comparisons. These changes were seen for all comparisons between visits one and six indicating that over the six treatment period both groups improved. The improvement seen in the placebo group can only be attributed to the placebo effect, indicating that this phenomenon may be used effectively within a treatment protocol. The fact that a medical professional is taking such a high degree of interest in the patients' case may counteract the negative psychological effects attributed to whiplash injury (Radnov et al. 1991). Thirdly the patients may simply have answered the questionnaires in such a way so as to please the researcher, thereby producing a false indication that there was improvement and this could apply to both the treatment and placebo groups.

Gender distribution (Table 4.11) indicated that more females than males were included, by random selection, in the study but it has been noted by Spitzer et al. (1995) that whiplash injury is more common in females.

5.5 Limitations

A major weakness of this study was that the sample sizes were too small (20 per group). This creates a problem in that the sample chosen may not be representative of the population (of people suffering from the effects of subacute or chronic whiplash injury). A small sample size could result in a Type 2 error where the null hypothesis is accepted as true when in fact it is false.

The objective measurements obtained from the CROM goniometer could not have been accurate to the nearest degree as the instrument is marked in increments of two degrees and thus one has to rely on the judgement of the person recording the measurements. Subtle movements of the apparatus and the possibility of the error of paralax occurring may also have limited the accuracy of measurements taken from the goniometer although all precautions were taken to avoid such errors.

As previously mentioned patients may have answered the questionnaires in such a way as either to consciously or unconsciously please the researcher and thus record an improvement above that which was actually felt, hence the significant improvement in both groups.

Another major limitation of this study was that no consideration was given to the nature of previous treatment received by the patients and how long ago or how extensive this treatment was. This may be particularly relevant if the previous treatment involved

rehabilitative exercises or familiarized the patient with the various treatments utilized in the treatment of whiplash injury, particularly manual therapies.

The number of motor vehicle accidents in which the patient was involved was also not considered and the researcher noted a variance of between one and fifteen motor vehicle accidents. The nature and speed of the motor vehicle accidents should also have been taken into account in creating a more uniform sample group.

5.6 Comparison with other research

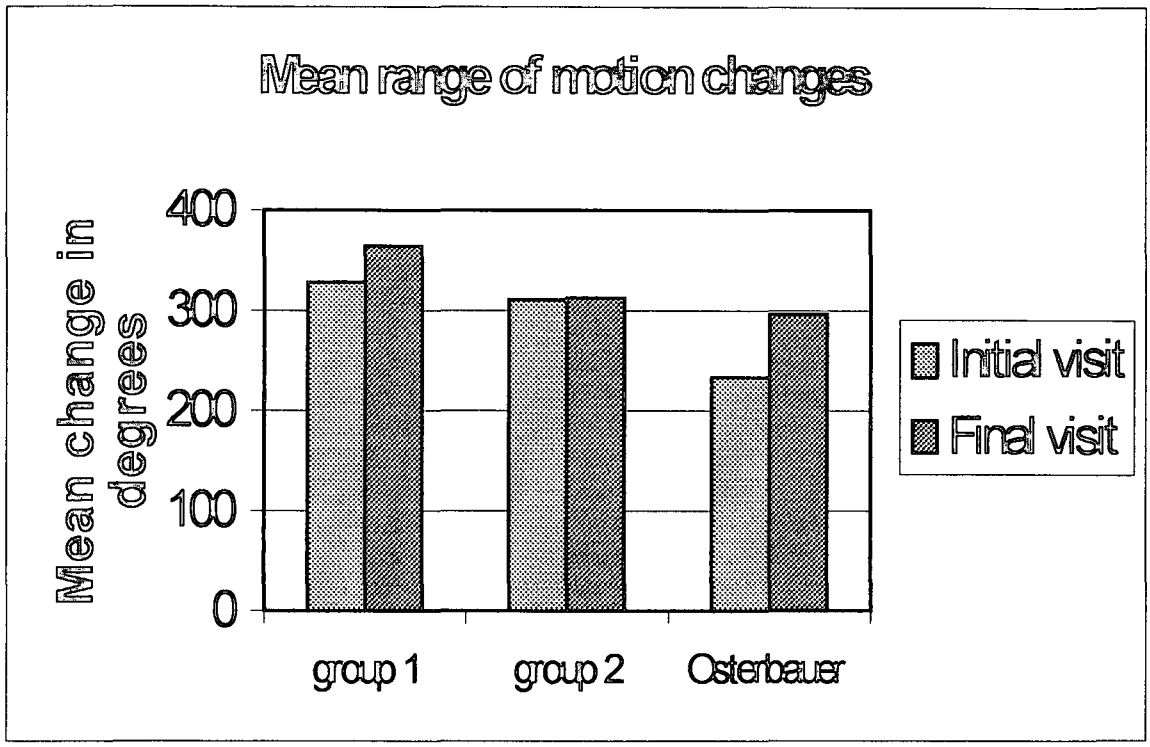
The Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders reviewed more than 10 000 articles relating to whiplash injury and found only 346 of value (Spitzer et al. 1995). This indicates a lack of good quality research related to whiplash injury.

In a retrospective study performed by Woodward et al. (1996) twenty-eight patients were reviewed and their response to chiropractic treatment was classified in terms of their current symptoms. Twenty-six (93%) of the patients showed improvement ($U=34$, $P<0.001$). Due to the fact that these patients received a variety of treatments including manipulation, proprioceptive neuromuscular facilitation and cryotherapy, a close comparison can not be made with this research study.

Osterbauer et al. (1992) performed a pilot study on ten patients who had suffered from acute to chronic whiplash injury. These patients were treated with a six week regimen of

short lever manually assisted adjustments with an Activator Instrument. Mean pain scores (Visual Analogue Scale) and the mean pre and post treatment differences in cervical range of motion were noted, these can be compared with this study. One should note the differences in techniques used during treatment. The range of motion was also assessed using a technique different from this study, which placed more emphasis on three dimensional head kinematics. Mean pain scores decreased from 44.1 to 10.5 ($t = 4.93$; $p<0.0001$) and total range of motion increased from 234 to 297 degrees ($t = 5.68$; $p<0.0001$). This is a mean change of 63 degrees. The total range of motion increase for this study was from 328 to 364 degrees. This is a mean change of 36 degrees. The possible reason for such a vast difference between the two studies may be due to the fact that in the study performed by Osterbauer et al. (1992) patient selection included those who suffered from acute whiplash injury. Therefore these patients presented with a much more restricted range of motion which allowed for a greater magnitude of improvement over the treatment period. The current study only selected patients suffering from subacute and chronic whiplash injury, and it can be assumed that some improvement in range of motion was gained in the time following the motor vehicle accident due to the natural history of the disease. In summary, both studies did not begin with the same baseline measurements.

FIGURE 5.1 Comparison of mean change of overall range of motion with study by Osterbauer et al. (1992)

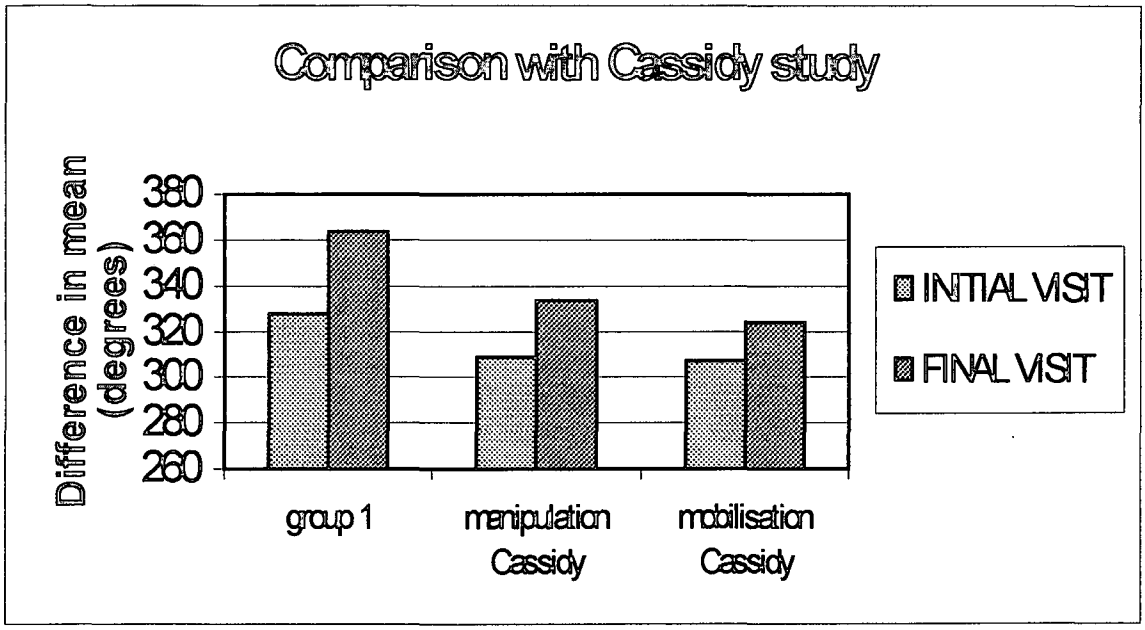


Cassidy et al. (1992) carried out a study in order to compare the effect of manipulation and mobilization on neck pain (NRS –101) and range of motion in patients suffering from unilateral neck pain. One hundred patients were utilized in this study and 31 had a history of cervical spine injury following a motor vehicle accident, 28 patients had other types of neck trauma. Following an examination, the patients were asked to complete an NRS-101 form and their pre-treatment cervical range of motion was measured. The mean overall change in total range of motion for the manipulation group was 24.6 degrees and the mean overall change in total range of motion for the mobilization group

was 16.8 degrees. The mean change in range of motion for this study was 36 degrees. Although the difference between these groups appears substantial it is necessary to note that the current study consisted of six manipulations as opposed to the single manipulation or mobilization performed by Cassidy et al. (1992).

This study was used as it was considered by Spitzer et al. (1995) to be of significant value in their review of over 10 000 articles.

FIGURE 5.2 Comparison of mean change of overall range of motion with study by Cassidy et al. (1992).



Note: In figure 5.2 the initial visit findings of this study were compared to Cassidy's pre-treatment findings and the final visit findings were compared to the post-treatment findings of the Cassidy study.

As previously mentioned, very little research directly relating to the effects of manipulation on whiplash injury exist. This fact makes it difficult to make accurate, direct and meaningful comparisons with other studies as vastly different factors are being compared.

CHAPTER 6

Recommendations and Conclusions

6.1 Conclusions

This study consisted of 40 patients divided randomly and equally into two groups forming the experimental and placebo groups. All patients underwent an extensive medical history, physical and orthopaedic examination from which it was determined whether the patient suffered from whiplash injury and whether it was of a subacute or chronic nature.

Both groups had six visits per patient over a four week period in which the patient either received a placebo treatment consisting of detuned ultrasound to the posterior cervical spine musculature or spinal manipulative therapy to the cervical spine.

The results of this study suggest that the use of manipulation in patients suffering from subacute or chronic whiplash injury can have beneficial effects on improving the range of motion of the cervical spine as significant changes were seen in all ranges of motion except flexion. The patients' perception of their pain, comfort or disability was not significantly different between the two groups, although both improved, very little meaningful information can be derived from this.

The long-term efficacy of manipulative therapy in the treatment of whiplash injury is unfortunately not considered in this study. This may be achieved in future studies by

including a follow-up consultation after a specific and pre-determined time period has elapsed.

In terms of pain intensity, disability and sensory perception of pain of the patients, little can be derived from the results of this study as no statistically significant changes were seen between the experimental and placebo groups with both groups improving to an equal degree.

It is necessary at this point to bear in mind the fact that manipulation is only a single form of treatment that can be utilized as part of a treatment protocol in whiplash injury. Involvement of the cervical spine musculature is another significant area that needs to be taken into consideration during the treatment of whiplash injury due to the nature of the injury and the findings of this study are probably significantly affected by this single factor.

Overall it appears that significant benefit can be derived from the use of manipulative therapy in the treatment of whiplash injury, however many further studies are necessary in order to determine the success of this form of treatment. Furthermore it still needs to be established which manipulative techniques are more suitable, and at which stage in the progression of the injury is manipulation most useful. A study of this nature is however necessary in order to provide a basis for future studies on the effects of manipulation in the treatment of whiplash injury.

6.2 Recommendations

On initial orthopaedic examination of the cervical spine, a large number of the patients had active myofacial trigger points, particularly in the trapezius and posterior cervical muscles. This study only took into account the injury that occurred to the zygapophyseal joints and future studies should definitely include treatment of the associated myofacial syndromes seen in whiplash injury. This may not only improve the overall range of motion of the patients but also reduce the intensity of pain experienced by the patient and provide a more realistic treatment protocol for study.

In terms of treatment, manipulation of the thoracic spine should be included in future studies as it was noted that a large number of patients also suffered from thoracic symptoms, but this area was not treated.

Due to the variable nature of whiplash injury subsequent studies should consider methods of producing a more uniform sample group. This can be achieved by only including patients suffering from a chronic or subacute injury with only one motor vehicle accident and no previous history of significant neck pain. Previous treatment protocols should also be taken into account.

Psychological factors should also be evaluated in future studies as these will most definitely affect the outcome of any treatment protocol. Depression and anxiety are often seen in association with whiplash injury, (Lenhart 1988, Borchgrevink et al. 1998) which

may be due to the traumatic nature of the injury or due to the chronic nature of the injury. A questionnaire recording changes in this area should be included in future studies.

Sample groups with at least thirty per group, preferably more, should be used in future studies of this kind so that paired and unpaired t-tests could be performed. Trends in results would become more apparent and sensitive to subtle data changes.

Manipulators need to devise a method for future studies whereby the operator or person delivering the manipulation can be blinded, so as not to inadvertently influence the outcome of the results. This may possibly be achieved by utilizing manipulators who are completely unaware of the dynamics of the study design and are only given strict instruction on which manipulation is required. The person delivering the detuned ultrasound should also not be aware of the status of the treatment being delivered.

Successful manipulation requires a level of skill and experience. For this reason it would be of benefit in future studies that the operator delivering the manipulation has at least five years clinical experience.

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ADDENDUM A:

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient:_____ Date: _____
file #:_____ X-Ray#:_____
Age:_____ Sex:_____ Occupation:_____
Intern:_____ Signature:_____

FOR CLINICIAN'S USE ONLY
Initial visit clinician:_____Signature:_____

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

Case Status:

PTT: Conditional: Signed Off: Final Sign out:

Recommendations:

Intern's Case History

1. Source of History:

2. Chief Complaint: (patient's own words)

3. Present Illness:

- Location
- Onset
- Duration
- Frequency
- Pain (Character)
- Progression
- Aggravating Factors
- Relieving Factors
- Associated S & S
- Previous Occurrences
- Past Treatment and Outcome

4. Other Complaints:

5. Past Medical History:

- General Health Status
- Childhood Illnesses
- Adult Illnesses
- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

6. Current health status and life-style:

- Allergies
- Immunizations
- Screening Tests
- Environmental Hazards (Home, School, Work)
- Safety Measures (seat belts, condoms)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

ADDENDUM B:

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Patient:_____File#: _____Date:_____
Clinician:_____Signature:_____
Intern:_____Signature:_____

1. VITALS

Pulse rate:
Respiratory rate:
Blood pressure: R L
Temperature:
Height:
Weight:

2. GENERAL EXAMINATION

General Impression:
Skin:
Jaundice:
Pallor:
Clubbing:
Cyanosis (Central/Peripheral):
Oedema:
Lymph nodes - Head and neck:
- Axillary:
- Epitrochlear:
- Inguinal:

Urinalysis:

3. CARDIOVASCULAR EXAMINATION

1) Is this patient in Cardiac Failure ?
2) Does this patient have signs of Infective Endocarditis ?
3) Does this patient have Rheumatic Heart Disease ?

Inspection - Scars
- Chest deformity:
- Precordial bulge:
- Neck -JVP:

Palpation: - Apex Beat (character + location):
- Right or left ventricular heave:
- Epigastric Pulsations:
- Palpable P2:
- Palpable A2:

Pulses:
- General Impression:
- Radio-femoral delay:
- Carotid:
- Radial:
- Dorsalis pedis:
- Posterior tibial:
- Popliteal:
- Femoral:

Percussion:
- borders of heart

Auscultation:
- heart valves (mitral, aortic, tricuspid, pulmonary)
- Murmurs (timing,systolic/diastolic, site, radiation, grade).

4. RESPIRATORY EXAMINATION

1) Is this patient in **Respiratory Distress** ?

Inspection
- Barrel chest:
- Pectus carinatum/cavinatum:
- Left precordial bulge:
- Symmetry of movement:
- Scars:

Palpation
- Tracheal symmetry:
- Tracheal tug:
- Thyroid Gland:
- Symmetry of movement (ant + post)
- Tactile fremitus:

Percussion
- Percussion note:
- Cardiac dullness:
- Liver dullness:

Auscultation
- Normal breath sounds bilat.:
- Adventitious sounds (crackles, wheezes, crepitations)
- Pleural frictional rub:
- Vocal resonance
  - Whispering pectoriloquy:
  - Bronchophony:
  - Egophony:

5. ABDOMINAL EXAMINATION

1) Is this patient in **Liver Failure** ?

Inspection
- Shape:
- Scars:
- Hernias:

Palpation
- Superficial:
- Deep = Organomegally:

- Masses (intra- or extramural)
- Aorta:

Percussion - Rebound tenderness:
- Ascites:
- Masses:

Auscultation - Bowel sounds:
- Arteries (aortic, renal, iliac, femoral, hepatic)

Rectal Examination
- Perianal skin:
- Sphincter tone & S4 Dermatome:
- Obvious masses:
- Prostate:
- Appendix:

6. G.U.T EXAMINATION

External genitalia:
Hernias:
Masses:
Discharges:

7. NEUROLOGICAL EXAMINATION

Gait and Posture
- Abnormalities in gait:
- Walking on heels (L4-L5):
- Walking on toes (S1-S2):
- Rombergs test (Pronator Drift):

Higher Mental Function
- Information and Vocabulary:
- Calculating ability:
- Abstract Thinking:

G.C.S.:
- Eyes:
- Motor:
- Verbal:

Evidence of head trauma:

Evidence of Meningism:
- Neck mobility and Brudzinski's sign:
- Kernigs sign:

Cranial Nerves:

I Any loss of smell/taste:
Nose examination:

II External examination of eye:
- Visual Acuity:
- Visual fields by confrontation:

- Pupillary light reflexes = Direct:
  = Consensual:
- Fundoscopy findings:

III Ocular Muscles:
Eye opening strength:

IV Inferior and Medial movement of eye:

V a. Sensory - Ophthalmic:
- Maxillary:
- Mandibular:

b. Motor - Masseter:
- Jaw lateral movement:

c. Reflexes - Corneal reflex
- Jaw jerk

VI Lateral movement of eyes

VII a. Motor - Raise eyebrows:
- Frown:
- Close eyes against resistance:
- Show teeth:
- Blow out cheeks:

b. Taste - Anterior two-thirds of tongue:

VIII General Hearing:
Rinnes = L: R:
Webers lateralisation:
Vestibular function - Nystagmus:
- Rombergs:
- Wallenbergs:
Otoscope examination:

IX & X Gag reflex:
Uvula deviation:
Speech quality:

XI Shoulder lift:
S.C.M. strength:

XII Inspection of tongue (deviation):

Motor System:

a. Power
- Shoulder = Abduction & Adduction:
  = Flexion & Extension:
- Elbow = Flexion & Extension:
- Wrist = Flexion & Extension:

- Forearm = Supination & Pronation:
- Fingers = Extension (Interphalangeals & M.C.P's):
- Thumb = Opposition:
- Hip = Flexion & Extension:
  = Adduction & Abduction:
- Knee = Flexion & Extension:
- Foot = Dorsiflexion & Plantar flexion:
  = Inversion & Eversion:
  = Toe (Plantarflexion & Dorsiflexion):

b. Tone
- Shoulder:
- Elbow:
- Wrist:
- Lower limb - Int. & Ext. rotation:
- Knee clonus:
- ankle clonus:

c. Reflexes
- Biceps:
- Triceps:
- Supinator:
- Knee:
- Ankle:
- Abdominal:
- Plantar:

Sensory System:

a. Dermatomes
- Light touch:
- Crude touch:
- Pain:
- Temperature:
- Two point discrimination:

b. Joint position sense
- Finger:
- Toe:

c. Vibration:
- Big toe:
- Tibial tuberosity:
- ASIS:
- Interphalangeal Joint:
- Sternum:

Cerebellar function:

Obvious signs of cerebellar dysfunction:
= Intention Tremor:
= Nystagmus:
= Truncal Ataxia:

Finger-nose test (Dysmetria):
Rapid alternating movements (Dysdiadochokinesia):
Heel-shin test:
Heel-toe gait:
Reflexes:
Signs of Parkinsons:

8. SPINAL EXAMINATION:(See Regional examination)

Obvious Abnormalities:
Spinous Percussion:
R.O.M:
Other:

9. BREAST EXAMINATION:

Summon female chaperon.

Inspection
- Hands rested in lap:
- Hands pressed on hips:
- Arms above head:
- Leaning forward:

Palpation
- masses:
- tenderness:
- axillary tail:
- nipple:
- regional lymph nodes:

ADDENDUM C:

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC
REGIONAL EXAMINATION - *CERVICAL SPINE*

Patient: _____ File: _____

Date: _____ Intern/Resident: _____

Clinician: _____ Sign: _____

OBSERVATION:

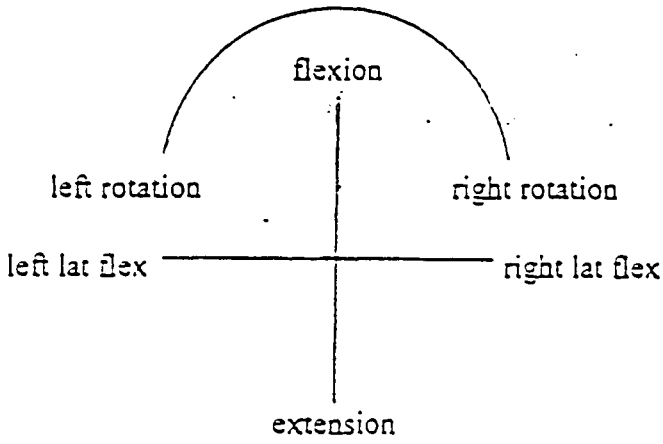
Posture
Swellings
Scars
Discolouration
Hair Line
Bony & Soft Tissue Contours

Shoulder position:
Left:
Right:
Muscle spasm
Facial expression

RANGE OF MOTION:

Flexion (45'):
L/R Rotation (70'):

Extension (70'):
L/R Lat Flex (45'):



PALPATION:

Lymph Nodes
Thyroid Gland

Trachea

ORTHOPAEDIC EXAMINATION:

Tenderness
Trigger Points: SCM, Scalenii, Post Cervicals, Trapezius, Lev Scap

Doorbell sign
Kemp's test
Cervical distraction
Halstead's test
Hyperabduction test
Shoulder abduction test

Cervical compression
Lateral compression
Adson's test
Costoclavicular test
Eden's test
Shoulder depression test

Dizziness rotation test Lhermitte's sign
Brachial plexus tension

NEUROLOGICAL EXAMINATION:

Dermatomes	Left	Right	Myotomes	Left	Right	Reflexes	Left	Right
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					

VASCULAR:

	Left	Right
Blood Pressure		
Carotid arts.		
Subclavian arts.		
Wallenberg's test		

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:

Right: Motion palpation:
Joint Play:

Basic Exam: Shoulder:
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

Upper T horacics:
Motion Palpation:
Joint Play:

Basic Exam: Thoracic Spine:
Case History:

ROM: Motion Palp:
Active:
Passive:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

ADDENDUM D:

Name:_____ File No._____ Group:_____

ALGOMETER READINGS

Treatment	One	Three	Six
Left			
Right			

GONIOMETER READINGS

Treatment	One	Three	Six
Flexion			
Extension			
Right Lateral Flexion			
Left Lateral Flexion			
Right Rotation			
Left Rotation			

ADDENDUM E:
CMCC NECK DISABILITY INDEX

Patient Name: _____ File no.: _____ Date: _____

This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only ONE box as it applies to you. We realize you may consider that two of the statements in any one s could relate to you, but please just mark the box which most closely describes your problem.

Section 1 - Pain Intensity

- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

Section 2 - Personal Care (Washing, Dressing ...)

- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain..
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of self care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

Section 3 - Lifting

- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights but it gives extra pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned .
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

Section 4 - Reading

- ☐ I can read as much as I want to without pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I cannot read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

Section 5 - Headaches

- ☐ I have no headaches at all.
- ☐ I have slight headaches which come infrequently.
- ☐ I have moderate headaches which come infrequently.
- ☐ I have moderate headaches which come frequently.
- ☐ I have severe headaches which come frequently.
- ☐ I have headaches almost all the time.

Section 6 - Concentration

- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have fair degree of difficulty in concentrating when I want to.
- ☐ I have a lot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

Section 7 - Work

- ☐ I can do as much work as I want to .
- ☐ I can do only my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I cannot do any work at all.

Section 8 - Driving

- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I like with moderate pain in my neck.
- ☐ I cannot drive my car as long as I want because of moderate pain i my neck.
- ☐ I can hardly drive at all because of severe pain in my neck..
- ☐ I cannot drive at all.

Section 9 - Sleeping

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (<1 hour sleep loss).
- ☐ My sleep is mildly disturbed (1-2 hours sleep loss).
- ☐ My sleep is moderately disturbed (2-3 hours sleep loss).
- ☐ My sleep is greatly disturbed (3-5 hours sleep loss).
- ☐ My sleep is completely disturbed (5-7 hours sleep loss).

Section 10 - Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities. with some pain in my neck.
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck.
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I cannot do any recreation activities at all.

Vernon/Hagino, modified from Foubister et al..Physiotherapy, 1980

ADDENDUM F:

Numerical Rating Scale

Patients name_____

Please indicate on the line below the number between 0 and 100 that best describes the pain of your major problem at this point, *when it is at its worst*. A zero (0) would mean "no pain at all" and one hundred (100) would mean "pain as bad as it could be." Please write only one number.

0_____100

Please indicate on the line below, the number between 0 and 100 that best descrbes the pain of your major problem at this point, *when it is at its least.* A zero (0) would mean "no pain at all" and one hundred (100) would mean "pain as bad as it could be." Please write only one number.

0_____100

ADDENDUM G:

SHORT-FORM McGILL PAIN QUESTIONNAIRE (SF-MPQ)

Ronald Melzack

Patients Name:_____ File #: _____ Date: _____

	NONE	MILD	MODERATE	SEVERE
THROBBING	0)_____	1) _____	2) _____	3) _____
SHOOTING	0)_____	1) _____	2) _____	3) _____
STABBING	0)_____	1) _____	2) _____	3) _____
SHARP	0)_____	1) _____	2) _____	3) _____
CRAMPING	0)_____	1) _____	2) _____	3) _____
GNAWING	0)_____	1) _____	2) _____	3) _____
HOT-BURNING	0)_____	1) _____	2) _____	3) _____
ACHING	0)_____	1) _____	2) _____	3) _____
HEAVY	0)_____	1) _____	2) _____	3) _____
TENDER	0)_____	1) _____	2) _____	3) _____
SPLITTING	0)_____	1) _____	2) _____	3) _____
TIRING-EXHAUSTING	0)_____	1) _____	2) _____	3) _____
SICKENING	0)_____	1) _____	2) _____	3) _____
FEARFUL	0)_____	1) _____	2) _____	3) _____
PUNISHING-CRUEL	0)_____	1) _____	2) _____	3) _____

ADDENDUM H:

Dear patient

Thank you for participating in this research project, your contribution will benefit both the doctors and future patients.

This project is attempting to ascertain the effectiveness of chiropractic treatment in whiplash injury. You will be randomly allocated into one of two treatment groups.

You have been selected as you meet the specific criteria of the research and have shown no obvious contra-indications to the treatment. All treatment will be free of charge for the duration of the research. You will be required to attend a maximum of six treatments over a one month period and all treatments will be supervised by a qualified Doctor of Chiropractic.

While you are part of this research project you may not receive any other form of treatment for your injury as this will exclude you from the research. If you re-injure yourself during the treatment period please inform the researcher.

If you have any further questions do not hesitate to ask me. Your co-operation is greatly appreciated.

Yours sincerely

Brian Kruger (Sixth year intern)