Chiropractors' inter- and intra-examiner reliability of cervical spine radiographic analysis and its impact on clinical management

By

Carla Marais

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I, Carla Marais, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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Carla Marais Date

Approved for Final Submission

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Dr C. Korporaal Date

M.Tech:Chiropractic, CCFC, CCSP, ICSSD

DEDICATION

I dedicate this dissertation to my parents, Rodney and Elizabeth Marais.

You more than just my parents, you are the greatest role models a child could wish for. I love and respect you with all that I am. Your unfailing love, support and belief in me is the reason I am here today. Thank you.

I can do all things through Christ who strengthens me.

Philippians 4:13

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ABSTRACT

BACKGROUND:

Plain film radiography is the most common imaging technique requested by chiropractors to assist in the management of patients with musculoskeletal complaints. There is a paucity literature indicating that chiropractors' interpretive radiographic skills are consistently able to achieve the same outcome given a particular set of radiographs. An important indication for the use of radiography in chiropractic is to exclude any possible contraindications to spinal manipulative therapy (SMT) that could cause serious injury to a patient if it is left unmodified or excluded as a treatment option.

OBJECTIVES:

The study aimed to investigate the inter- and intra-examiner reliability of chiropractor's diagnosis on cervical spine radiographs. Additionally, the effect of clinical history added to the radiographs was assessed.

METHODS:

Inter- and intra-examiner evaluations occurred on two consecutive readings of 30 radiographs by six qualified chiropractors. No clinical history was given during Round One, but was available during Round Two.

RESULTS:

The inter-observer agreement for categorisation and management went from "poor agreement" in Round One (K=0.1962 and K=0.1996 respectively) to "fair agreement" (K= 0.2041 and K=0.2036 respectively) beyond that expected by chance in Round Two. Identification remained "fair agreement" beyond that expected by chance over both rounds (K=0.3113 and K=0.2159). Sensitivity at Round One was 94.4% and the specificity was 61.1%. At Round Two the sensitivity had decreased to 93.8% and the specificity had decreased to 50%. There was no significant difference between the accuracy of the Round One and Round Two results for categorisation (p=0.243) and management (p=0.220), but there was a clinical difference for identification (p=0.014).

CONCLUSION:

Differences in the result were small indicating clinical relevance with regards to inter-examiner reliability was fair in most instances. Although clinical history did not influence categorisation or management, it did improve accuracy of identification of pathology. Chiropractors successfully identified between 93.8% and 94.4% of abnormal radiographic findings demonstrating that chiropractors use of radiographs as a diagnostic tool when looking for contraindications to spinal manipulative therapy was sensitive. This demonstrates that its use as a diagnostic tool for contraindications to spinal manipulative therapy (SMT) is sensitive.

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LIST OF ABBREVIATIONS

ADI	Atlanto-odontoid interspace
AHPCSA	Allied Health Profession Council of South Africa
AP	Antero-posterior
C1	First cervical vertebra
C2	Second cervical vertebra
C3	Third cervical vertebra
C4	Fourth cervical vertebra
C5	Fifth cervical vertebra
C6	Sixth cervical vertebra
C7	Seventh cervical vertebra
CASA	Chiropractic Association of South Africa
CT	Computed Tomography
DC	Doctor of Chiropractic
DUT	Durban University of Technology
ed.	Edition or editors
FIFA	Federation International Football Association
IVD	Intervertebral disc
IVDs	Intervertebral discs
M.Tech	Masters of Technology
MRI	Magnetic Resonance Imaging
N/A	Not applicable
NAD	No anomaly detected

ROM	Range of motion
SD	Standard deviation
SE	Standard error
SMT	Spinal Manipulative Therapy
SPSS	Statistical Package for the Social Sciences
T1	First thoracic vertebra

LIST OF DEFINITIONS

Absolute contraindication: Set of circumstances where a particular treatment or intervention is always inappropriate (because it places the patient at undue risk) (Redwood and Cleveland III, 2003).

Adjustment: The chiropractic adjustment is a specific form of direct articular manipulation, using either long- or short-leverage techniques with specific contacts, characterised by a dynamic thrust of controlled velocity, amplitude and direction (Peterson and Bergmann, 2002).

Anterolisthesis: Anterior translation of the vertebral body (Peterson and Bergmann, 2002).

Cohen's kappa (K): A measure of agreement between two sets of categorical measurements on the same individuals. If K = 1, then there is perfect agreement; if K = 0, then there is no better than chance agreement (Petrie and Sabin, 2009).

Complication: A problem that occurs after the application of a procedure (Peterson and Bergmann, 2002).

Concordance: This indicates the agreement between measurements that are produced by different instruments. Commonly, concordance is expressed as a number between 0 and 1, where 0 represents no agreement at all, and 1 represent complete duplication. In some concordance measurements a negative value may be produced, which signifies opposite results (Fleiss, Levin and Cho Paik, 2003).

Contraindication: A problem identified before a procedure in applied that would make the application of the treatment inadvisable because of its potential to cause harm or delay appropriate treatment (Peterson and Bergmann, 2002).

Confidence Interval (CI) for a parameter: The range of values within which statisticians are 95% confident that the results can be generalised to the population (Petrie and Sabin, 2009).

Manipulation: Passive manoeuvre in which specifically directed manual forces are applied to vertebral and extravertebral articulations of the body, with the object of restoring mobility to restricted areas (Gatterman, 2003).

1. Long-lever manipulation – High velocity force exerted on a point of the body some distance from the area where it is expected to have its beneficial effect.

2. Short lever manipulation – High velocity thrust directed specifically at an isolated joint

Spinal Manual therapy: Spinal manipulative therapy broadly defined includes all procedures in which the hands are used to mobilise, adjust, manipulate, apply traction, massage, stimulate or otherwise influence the spine and paraspinal tissues with the aim of influencing the patient's health (Gatterman, 2003).

Null Hypothesis (H_0): The statement that assumes no effect in the population (Petrie and Sabin, 2009).

Relative contraindication: Set of circumstances where a particular treatment or intervention may be appropriate, only if it is modified or applied in an unusual manner (Redwood and Cleveland III, 2003)

Reliability: A general term which encompasses repeatability, reproducibility and agreement (Petrie and Sabin, 2009).

Repeatability: The extent to which repeated measurements by the same observer in identical conditions agree (Petrie and Sabin, 2009).

Reproducibility: The extent by which two results can be obtained in different circumstances, e.g. by two methods of measurement, or by two observers (Petrie and Sabin, 2009).

Sensitivity: The proportion of individuals with the disease who are correctly identified by the observers (Petrie and Sabin, 2009).

Specificity: The proportion of individuals without the disease who are correctly identified by the observers (Petrie and Sabin, 2009).

Validity: Validity implies that the measurement measures what it intends to measure. A measurement is valid if it is appropriate for the question being addressed and is accurate, precise and complete (Petrie and Sabin, 2009).

CHAPTER ONE

1.1 INTRODUCTION

Radiography and radiology have always been an integral part of the chiropractic curriculum and practice. It assists in both diagnosis and management of patients with musculoskeletal complaints (Marchiori, Adams and Henderson, 1999 (Part One); Yochum and Rowe, 2005). In this context, an important part of plain film radiographic imaging (radiographs) is the accurate interpretation of the results. This is particularly important as radiologist reports often do not accompany the radiographs (Smith, Araya-Guerra, Bublitz, Parnes, Dickinson, Van Vorst, Westfall, and Pace, 2005), which leaves the interpretation up to the chiropractor. An important indication for the use of radiography in chiropractic is to exclude any possible contraindications to spinal manipulative therapy (SMT) that could potentially cause serious injury to a patient if left unmodified or excluded as a treatment option (Gatterman, 2003; Beck, Holt, For and Hurtgen-Grace, 2004; Gatterman 2005; Haldeman, 2005). There is a paucity of literature indicating that chiropractors are consistently able to interpret cervical spine radiographic imaging. This chapter sets to outline the importance, aims, objectives and necessity of this particular study.

1.2 BACKGROUND

The low cost and easy availability of obtaining radiographs make plain film radiography the most common spinal imaging technique used by chiropractors worldwide to assist in the diagnosis and management of musculoskeletal complaints. (Yochum and Rowe, 2005; Airaksinen, Brox, Cedeaschi, Hildebrandt, Klaber-Moffett, Kovacs, Mannion, Reis, Staal, Ursin and Zanoli, 2006). In addition, chiropractors in many countries are legally permitted to own their own radiographic equipment (Jackson, 2001; Wilson, 2003) although the trend is shifting more towards chiropractors choosing instead to refer patients to imaging centres (Haldeman, 2005).

In the South African context, when a chiropractor radiographs a patient in his or her own private practice, it is legally required that he or she also then interpret the radiograph (Allied Health Professions Act 63 of 1982 (as amended)). If a patient is referred to a medical imaging centre, most have radiologists on staff providing a report, although this is not always the case. However, misunderstandings between the radiologist's report and the referring practitioner may occur (Berlin, 2000). In addition observer variation or error in image interpretation are also recognised (Tudor, Finlay and Taub, 1997) as confounders of image interpretation and common causes include limitations of technique, misleading or

incomplete clinical data, unavailability of previous studies or reports, false positive errors, incomplete scanning, misinterpretation of perceived findings, lack of knowledge and errors in judgement (Robinson, 1997). To complicate the clinical scenario even further, radiographic reports may also be missing (Smith *et al.,* 2005) and therefore a chiropractor cannot rely solely on the presence of and / or consistency of present imaging reports in the management of patients.

As a result, this affects the management of patients as certain absolute and relative contraindications to spinal manipulative therapy (SMT) exist, and therefore require identification in order that the patient is appropriately managed (Gatterman, 2003; Haldeman, 2005). These contraindications are often best seen on plain film radiographs. In this context, Peterson and Bergmann (2002) state that, “manual therapy is contraindicated when the procedure may result in an injury, worsen an associated disorder or delay appropriate curative or life-saving treatment.” Based on this, conditions that contraindicate or require modification to SMT include but may not be limited to: malignancy, infection, fractures, inflammatory spondylitis, spondylolysis with / without listhesis and ligamentous instability (Peterson and Bergmann, 2002; Gatterman, 2003; Haldeman, 2005). Many of these are visible at some point in their pathogenesis on plain film radiographic imaging, but missed contraindications can lead to further patient injury, worsening of the disorder or delay necessary treatment. Therefore radiographs are particularly important in the confirmation of diagnosis and the chiropractic management of patients (Marchiori, 1999; Yochum and Rowe, 2005). Philips (1992) mentions the following reasons for chiropractor’s clinical use of radiographs:

1. To rule out pathology,
2. To make biomechanical evaluations,
3. For medico legal protection,
4. Financial gain, and/or
5. Routinely as part of clinical assessment.

In this context, Robinson, (1997) identified three categories into which observer variation studies in radiology fall: measurement (e.g. Cobb angle analysis), scoring or grading (e.g. classifying fractures or grading the severity of a condition or disease) and / or diagnoses related studies. Several studies falling into the “scoring or grading” category have looked at reliability of interpretation of lumbar spine radiographs in benign mechanical low-back pain focusing on different medical fields namely: rheumatologists (Coste, Paolaggi and Spira, 1990), radiologists (Espeland, Korsbrekke, Albrektsen and Larsen, 1998) and chiropractors and radiologists (Philips, Frymoyer, Mac Pherson and Newburg, 1986 and

Assendelft, Bouter, Knipschild and Wilmink, 1997). Conclusions from such studies vary and demonstrate that observer variation is much greater with some image features (e.g. facet arthrosis) than with others (e.g. spondylolisthesis). Observers tend to agree more often in “easy” patient presentations (viz. advanced disease or gross classifications), rather than in “difficult” patient presentation (viz. more subtle radiographic presentation of cases) (Robinson, 1997; Tudor, Finlay and Taub, 1997).

In a study by de Zoete, Assendelft, Algra, Oberman, Vanderscheuren and Bezemer (2002), they looked at both reliability and validity of contraindications to chiropractic treatment detected by chiropractors, chiropractic radiologists and medical radiologists on plain lumbosacral spine radiographs. The study showed that chiropractors were the least consistent of the three groups; however the unit of analysis was still classified as fair to good for identification of contraindications to SMT.

Additionally previous studies have looked at reliability and / or validity of radiograph reading (usually the lumbosacral region) by chiropractors, often compared to other medical professionals (Philips *et al*., 1986; Coste *et al*., 1990; Taylor, Clopton, Bosch, Miller and Marcelis, 1995; Assendelft *et al*., 1997; Espeland *et al*., 1998 and de Zoete *et al*., 2002); but there has been no research that has looked at the cervical spine and subsequent patient management which is an essential part of any medical profession (Marchiori, Adams and Henderson, 1999 (Part One)).

Therefore with the paucity of literature indicating that chiropractors are consistently able to interpret the same radiographic outcome given a particular set of cervical spine radiographs, this study aimed to investigate the inter- and intra-examiner reliability of chiropractor’s cervical spine diagnoses.

1.3 AIMS AND OBJECTIVES

The aim of this study was to determine chiropractors' inter- and intra-examiner reliability of cervical spine radiographic analysis and its impact on clinical management.

OBJECTIVE ONE

To determine the inter- and intra-examiner reliability of cervical spine radiographic diagnosis.

NULL HYPOTHESIS ONE

Correlation of the inter- and intra-examiner reliability of cervical spine radiographic diagnosis would be low.

OBJECTIVE TWO

To determine the influence of clinical history on cervical spine radiographic diagnosis and patient management.

NULL HYPOTHESIS TWO

Clinical history would not significantly alter cervical spine radiographic diagnosis and patient management.

OBJECTIVE THREE

To assess the influence of identifying cervical spine radiographic contraindications on patient management.

NULL HYPOTHESIS THREE

Cervical spine radiographic contraindications to chiropractic management would not significantly influence patient management.

1.4 SCOPE OF THE STUDY

Six qualified chiropractors with ten years or more experience, practising in the Durban area participated in this study in which the inter- and intra-examiner reliability of radiographic diagnosis of cervical spine radiographs was assessed. The same set of radiographs were observed over two rounds. Round One excluded patient information, whereas Round Two included a brief patient clinical history.

1.5 BENEFITS

Intra- and inter-examiner variability is recognised in radiograph interpretation (Tudor, Finlay and Taub, 1997) and should be kept to a minimum in clinical practice. This study intended to highlight differences or similarities in radiographic interpretation by chiropractors and thus bring about educated changes in radiograph interpretation if errors or variations were found to be significant.

1.6 DELIMITATIONS

1. This study relied on participants being open and honest when completing data sheet.
2. For logistical reasons, only chiropractors in the Durban area were included in the study.
3. Due to limited ability in obtaining radiographs with patient consent, only 30 radiographs were viewed during each session.

1.7 CONCLUSION

From the above, it can be seen that plain film radiography is a common imaging technique used to assist in the diagnosis and management of patients with musculoskeletal complaints (Marchiori, Adams and Henderson, 1999 (Part One); Yochum and Rowe, 2005). Further it has been noted that inter-observer variation in image interpretation is recognised, but should be kept to a minimum (Tudor, Finlay and Taub, 1997). This is of particular relevance when considering Gatterman (2005) and Peterson and Bergmann (2002), stated that manual therapy is contraindicated when the procedure negatively impacts on the patient's health. However, the literature that is available focused specifically on chiropractors' inter- and intra-examiner reliability of cervical radiographic diagnosis. So, this study aimed to investigate this inter- and intra-examiner reliability and the related patient management protocols. In addition, the influence of clinical history on these radiographic diagnoses was determined.

Therefore, Chapter Two includes a detailed look at the literature surrounding this topic with Chapter Three highlighting the materials and methods used in obtaining data for this study. Chapter Four presents the results and discusses the results with Chapter Five presenting the conclusions and recommendations.

CHAPTER TWO

2.1 INTRODUCTION

This chapter focuses on the literature surrounding and influencing the ideas behind this dissertation. The history of radiography and its use by practitioners worldwide is discussed as well as its importance as a diagnostic imaging tool which is specifically used by chiropractors. Part of this chapter also critically examines previous inter- and intra-reliability studies and the importance of the continuance of such studies.

2.2 THE HISTORY BEHIND RADIOGRAPHS AND ITS USES

In 1895 Wilhelm Conrad Roentgen accidentally discovered radiographs while conducting experiments in his laboratory (Redwood and Cleveland, 2003; Yochum and Rowe, 2005). That same year D.D Palmer developed his initial theories on chiropractic and in 1910, the Palmer School of Chiropractic in Davenport, Iowa purchased the first radiographic unit in the chiropractic profession. Since then, radiography and radiology have been integral parts of the chiropractic curriculum and practice (Gatterman, 2003; Redwood and Cleveland, 2003).

Radiographs are more colloquially known as “x-rays”. The “x” in x-rays represented the unknown quantity as Roentgen did not know what to name the invisible rays he had discovered (Yochum and Rowe, 2005). The most significant aspect of this discovery was the development of the clinical radiograph which allowed individuals to “see” internal structures of the body, especially the bony tissue (Gatterman, 2003) permitting a degree of specificity in neuromuscular diagnosis that would otherwise be impossible (Redwood and Cleveland, 2003). Although radiographs were considered an excellent diagnostic imaging tool, the harmful aspect of radiation cannot be ignored (Redwood and Cleveland, 2003; Yochum and Rowe, 2005). However, since its discovery, there have been several advancements in technology, but plain film radiography is still the most common skeletal imaging technique used / requested by chiropractors (Peterson and Bergmann, 2002; Gatterman, 2003).

When requesting cervical spine radiographic examinations, several basic views should be requested by the chiropractor: anteroposterior (AP) lower cervical spine, AP open mouth, left and right lateral and left and right oblique cervical spine views (Marchiori, 1999; Taylor

and Resnick, 2000; Yochum and Rowe, 2005). Each view offers a different view of relevant structures and can be used for different diagnostic evaluations (Table 2.1). Further optional cervical radiographic studies also exist and include flexion and extension (collectively referred to as stress views) and pillar views (Table 2.2) (Marchiori, 1999; Taylor and Resnick, 2000).

TABLE 2.1 Basic cervical spine projections (adapted from Yochum and Rowe, 2005)

BASIC VIEW	DEMONSTRATES	CLINICORADIOLOGIC CORRELATIONS
AP Lower Cervical	Lower five cervical vertebrae-vertebral bodies, vertebral endplates, von Luschka's joints and spinous processes-upper two or three thoracic vertebrae and ribs; medial border of the clavicles; lung apices; trachea and neck muscles	Many conditions including: Traumatic Arthritic Neoplastic and Congenital Anomalies
AP Open Mouth	Atlas, dens, axis and occipital condyles	
Cervical Lateral	Cervical Spine, soft tissues of the neck and the base of the skull	*Important for showing*: Fractures Dislocations Anomalies Disc Space Integrity
Cervical Obliques	Intervertebral foramina, von Luschka joints, apophyseal joints and pedicles	Posterior obliques demonstrate the contralateral foramina (e.g. Right Posterior Oblique - left foramina) and anterior obliques demonstrate the ipsilateral structures (e.g. Right Anterior Oblique – right foramina)

TABLE 2.2 Optional cervical spine projections (Yochum and Rowe, 2005)

OPTIONAL VIEW	DEMONSTRATES	CLINICORADIOLOGIC CORRELATIONS
Flexion-Extension	As per neutral lateral (Cervical Spine, soft tissues of the neck and the base of the skull) but also evaluates: Global and intersegmental motion and ligamentous instability	Used in cases of trauma, congenital anomalies and inflammatory arthropathy to assess for ligamentous stability
Pillars	Articular pillars, apophyseal joints, laminae and spinous processes. Both sides must be done for comparison.	The most common site for fracture in the cervical spine is the neural arch, of which the articular pillar is the most vulnerable to fracture.

There is much debate surrounding chiropractors and their use of radiography and the value or benefit of taking radiographs to evaluate many clinical situations presented by patients (Brown, 2001; Beck, Holt, Fox and Hurtgen-Grace, 2004). Ernst (1998), Ernst (2008) and Ammendolia, Taylor, Pennick, Cotè, Hogg-Johnson and Bombardier (2008) suggest that radiography is overused by chiropractors for non specific back pain, and that

2.3 THE IMPORTANCE OF RADIOGRAPHS IN CHIROPRACTIC AND CONTRAINDICATIONS TO SPINAL MANIPULATIVE THERAPY (SMT)

According to Haldeman, (2005), SMT is practiced by other professionals (e.g. osteopaths, physiotherapists and doctors) but up to 90% of all spinal manipulations are carried out by chiropractors. Manipulation in the chiropractic context is defined as a "passive manoeuvre in which specifically directed manual forces are applied to vertebral and extra vertebral articulations of the body, with the object of restoring mobility to restricted articulations" (Gatterman, 2003). Usually, this is characterised as a short lever high-velocity, low amplitude thrust directed specifically at an isolated joint (Peterson and Bergmann, 2002; Gatterman, 2003; Haldeman, 2005).

As a result of this therapeutic intervention and the nature of chiropractic treatment, there is a potential risk of serious injury to a patient if important clinical "red flags" are missed (Brown, 2001; Beck *et al.,* 2004). These "red flags" signal potential underlying patho-physiological processes which may contraindicate SMT and may require either further investigation or referral by the chiropractor to another more appropriate practitioner. These "red flags" include, but are not limited to: infection, neoplasm, fracture, neurological compromise and age (Brown, 2001; Penney, 2009). According to, Airaksinen *et al.,* (2006), with particular emphasis on the spine, it is noted that most spinal conditions are benign and self limiting. However, the challenge for the clinician is to distinguish serious spinal (orthopaedic or neurological) pathology from non-specific neck or back pain (Rubinstein and van Tulder, 2008). Even with diagnostic tools such as history taking, physical examination, orthopaedic and neurological testing, red flags can still be missed and it is sometimes the co-incidental finding on a radiograph that enables the practitioner to make the diagnosis and manage the patient appropriately (Resnick and Taylor, 2000).

Therefore, if a chiropractor sends for radiographs, it is understood that chiropractic therapy cannot be based solely on radiographic findings and must be placed in the proper clinical perspective. In this context, chiropractors have been noted to utilise radiographs for varying reasons with the most notable being to locate the presence or absence of pathology and to analyse structure, posture, diseases and biomechanics of the spinal column (Peterson and Bergmann, 2002; Gatterman, 2003). However, Philips (1992) states that radiographs for medico legal protection, financial gain and / or as a routine part of clinical evaluation also need to be considered as possible reasons. In contrast, Deyo, Diehl, Wyatt and Schultz (as cited by Gatterman, 2005:117) argue that radiography should never be used as a general / routine screening procedure without specific clinical indication. This is in support of Brodin (as cited by Ernst, 1998) who reported that unsuspected pathological findings seen on routine lumbar radiographs are as frequent as 1:2500 making coincidental findings relatively rare (Resnick and Taylor, 2000; Ammendolia *et al.,* 2008; Ammendolia, Cotè, Hogg-Johnson and Bombardier, 2009).

Irrespective of the reason for the use of radiographs expressed by the chiropractor as part of the clinical encounter and in this maze of clinical uncertainty, certain absolute and relative contraindications to SMT still remain a reality (Gatterman, 2003; Haldeman, 2005) (Table 2.3). In this regard a contraindication is a problem identified before a procedure is applied that would make the application of the treatment inadvisable (Dorland's Pocket Medical Dictionary, 2010). Thus, according to Peterson and Bergmann (2002), "manual therapy is contraindicated when the procedure may result in an injury, worsen an associated disorder or delay appropriate curative or life-saving treatment." Conditions that contraindicate or require modification to SMT include but may not be limited to: malignancy, infection, fractures, inflammatory spondylitis, spondylolysis with / without listhesis and ligamentous instability (Peterson and Bergmann, 2002; Gatterman, 2003; Haldeman, 2005).

TABLE 2.3 Conditions that Contraindicate or Require Modification to Spinal Manipulative Therapy (Peterson and Bergmann, 2002:107)			
CONDITION	**POTENTIAL COMPLICATION FROM MANIPULATION**	**METHOD OF DETECTION**	**MANAGEMENT MODIFICATIONS**
Atherosclerosis of major blood vessels	Blood vessel rupture (haemorrhage) Dislodged thrombi	Palpation Auscultation Radiographic examination Visualisation Doppler Ultrasound	Soft tissue and mobilizing techniques with light or distractive adjustments Referral to vascular surgeon
Vertebrobasilar insufficiency	Wallenburg's syndrome Brain stem stroke	History Positional tests Doppler ultrasound Angiography MRA[1]	No cervical thrusting techniques Referral for anticoagulant therapy
Aneurysm	Rupture Haemorrhage	Irregular pulse Abdominal palpation Auscultation Radiographic examination	Referral*
Tumours	Disease progression Pathologic fracture	Palpation Radiographic examination Laboratory findings MRI[2] CT[3]	Referral*
Fractures	Increased instability Delayed healing	Radiograph CT	If severe, referral* If not, manipulation of areas of fixation
Severe Sprains	Increased instability	Stress radiographic examination Motion palpation	Mobilization Gentle manipulation
Osteoarthritis (late stage)	Neurologic compromise Increased pain	Radiograph CT	Mobilisation Gentle manipulation
Uncoarthritis	Vertebral artery compromise or dissection	Radiograph	Distractive adjustments Gentle traction Mobilising and soft tissue techniques
Clotting disorders	Spinal hematoma	History of anticoagulant therapy Pulse Bruises	Forceful manipulation contraindicated
Osteopenia	Pathologic fracture	History of long-standing steroid therapy Postmenopausal females Anticonvulsive medication Malabsorption syndrome Nutritional deficiencies Radiographic examination	Forceful manipulation contraindicated Mobilisation technique with light distractive adjustments
Space-Occupying lesions	Permanent neurologic deficits	MRI CT (myelography)	Referral*
Diabetes (neuropathy)	Joint injury resulting from unresponsiveness to pain	Laboratory findings Examination of lower extremities Skin (trophic changes) Diminished pulse	Referral*
Malingering Hysteria Hypochondriasis	Prolonged treatment Treatment dependency	Symptom amplification Waddell scale Libman's test	Referral* for psychological evaluation Active care
Alzheimer's	Inappropriate response or unresponsiveness to pain or treatment	Mental status evaluation	Gentle manipulation Mobilising and soft tissue techniques

1 MRA: Magnetic Resonance Angiography; 2 *MRI:* Magnetic Resonance Imaging; 3 *CT:* Computed tomography

*NOTE: Although referral for medical treatment of the specific pathologic process is deemed appropriate and necessary, it does not preclude the patient from receiving manipulative therapy to unaffected areas or, in some cases, to the areas of pathology for symptomatic relief or quality-of-life enhancement.

All disorders listed as potential contraindications to manipulative therapy are not necessarily all absolute contraindications to manipulation. These are known as “relative contraindications” which implies that caution should be used in applying the manipulative therapy and consideration given for possible altered treatment methods (Peterson and Bergmann, 2002; Gatterman, 2003).

Further compounding factors to the clinical interaction between the patient and the chiropractor, is the fact that even if potential contraindications are seen on the radiograph, there is not always agreement on what the contraindication is and to what extent it can be viewed as a contraindication (Taylor and Resnick, 2000). This mismatch is principally as a result of radiograph misinterpretation or misunderstandings between those reporting and those receiving reports and accepting them as read (Robinson, 1997; Berlin, 2000).

2.4 MISINTERPRETATION AND ERRORS IN REPORTING

Due to the low cost and availability of plain film radiographic examinations, they are the most common spinal imaging technique requested by chiropractors to assist in the diagnosis and management of patients with musculoskeletal complaints (Yochum and Rowe, 2005; Airaksinen *et al.,* 2006). Chiropractors in many countries are legally allowed to own their own radiography equipment (Jackson, 2001; Wilson, 2003) or refer patients for these examinations. The use of radiography for back pain ranges from (as cited by Ammendolia *et al.,* 2009) 54% to 92% in the United States, 35% to 113% in Canada and 72% (ranging from 25% in Sweden to 93% in Italy) in Europe. In some jurisdictions, Beck *et al.,* (2004) reported that 84% of new patients receive full spine radiography regardless of complaint.

In the South African context, when a chiropractor radiographs a patient in his or her own private practice, it is legally required that he or she would also then interpret the radiograph (Allied Health Professions Act 63 of 1982 (as amended)). If a chiropractor refers a patient to a medical imaging centre, radiologists should provide a report, but this is not always the case as has been reported on an international level by Smith *et al.,* (2005). Similarily, there are instances in South Africa, where reports may or may not accompany the radiographic examination.

Interpreting the radiograph correctly places a great deal of responsibility on the practitioner, who in essence has no method of confirming his / her radiographic diagnosis.

Even if the patient has been referred and a radiologist's report is present, misunderstandings between the interpretation of the report and the referring practitioner may still occur (Berlin, 2000; Brealey, King, Hahn, Crowe, Williams, Rutter and Crane, 2005).

In addition to observer variation, error in image interpretation is also recognised (Tudor, Finlay and Taub, 1997; Espeland, Korsbrekke, Albrektsen and Larsen, 1998; Taylor and Resnick, 2000; Bono, Schonenfeld, Anderson, Harrop, France, Vaccaro, Dvorak and Fehlings, 2010) as a confounding element in reaching congruence between the radiologist and the chiropractor. Common reasons for observer variation include limitations of technique, misleading or incomplete clinical data, unavailability of previous studies or reports, false positive errors, incomplete scanning of the radiograph, misinterpretation of perceived findings, lack of knowledge and errors in judgement (Robinson, 1997; Fitzgerald, 2001; Tins and Cassar-Pullicino, 2004) as well as variations in anatomical structure (Resnick and Taylor, 2000; Yochum and Rowe, 2005; Bono *et al.,* 2010).

As a result of this incongruence, several research studies have tried to establish what the factors are that influence this incongruence, and have suggested methods by which these enabling or detracting factors can be re-inforced or removed respectively. According to Sup Song, Hiang Song, Park, Jin Ahn, Yang, Byun, Su Jeon, Young Kim Soo Kim, Lim, Joo Kim, Sun Kim, Yul Kim, and Whee Bahk (1992); Aideyan, Berbaum and Smith (1995); Tudor, Finlay and Taub (1997); Leslie, Jones and Goddard (2000) and Loy and Irwig (2004) the intervention of clinical history in image interpretation studies does improve diagnostic accuracy.

2.5 PLAIN FILM READING PERFORMANCE STUDY DESIGNS AND POSSIBLE VARIATION OR BIAS

Brealey, Scally and Thomas, (2002) have identified three different plain film study designs, which measure respectively:

- diagnostic accuracy,
- diagnostic performance and
- diagnostic outcome.

Table 2.4 describes each of these designs.

TABLE 2.4 Plain Film Reading Performance Study Designs (Brealey, Scally and Thomas, 2002)

DESIGN	DESCRIPTION	EXAMPLE
Diagnostic Accuracy	To assess the film reading performance of one (or more) group of observers in controlled (ideal) conditions.	Radiographers reporting on a validated bank of films as part of a postgraduate course.
Diagnostic Performance	To assess the film reading performance of one group of observers during clinical practice.	An audit of radiographers' film reading performance
Diagnostic Outcome	To assess the film reading performance of two (or more) groups of observers during clinical practice.	A comparison of radiographers and casualty officers film reading performance.

In terms of the incongruence between the radiologist and the chiropractor, as discussed in the previous section (Section 2.4), this would fall into the category of "diagnostic accuracy", which Robinson (1997) has further subdivided into three sub-categories, including:

- measurement accuracy (e.g. Cobb angle analysis),
- scoring or grading accuracy (e.g. classifying fractures or grading the severity of a condition or disease) and / or
- diagnostic accuracy (accuracy at achieving the correct diagnosis based on the evidence provided in the radiograph).

As the above categories are all important, when considering the radiographic assessment of a patient and the consequent impact on patient management; several studies falling into the "measurement accuracy" (Ganasram, 2006; Pillay, 2007; Naidoo, 2008; Bono *et al.,* 2010; Gajeerajee, 2010; Hubbard, Vowles and Forest, 2010) have been completed. Each of these studies has indicated that there are variations in the presentation of

radiographic images based particularly on population variances (Naidoo, 2008; Gajeerajee, 2010), resulting in varied measures of angles, shapes and sizes of bony architecture of various anatomical sections of the spine. Therefore it has been noted that these measures do impact on the manner in which normal and abnormal findings are noted and reported on in radiographic reports (Resnick and Taylor, 2000; Yochum and Rowe, 2005; Sunder, 2006; Gajeerajee, 2010). This highlights how these variations impact directly on the agreement between radiographic evaluators and hence the reliability of consistent readings / reports (Yochum and Rowe, 2005). As a result of these reports, it stands to reason that there will be a direct impact on the manner in which practitioners are able to utilise the information contained therein and that it impacts on the manner in which the clinical management of the patient is constructed.

Similarly, the research in the "scoring or grading accuracy" category has looked at reliability[1] of interpretation of lumbar spine radiographs in benign mechanical low-back pain focusing on comparing members of different medical fields (either internally or between professions) namely: rheumatologists (Coste, Paolaggi and Spira, 1991), radiologists (Espeland *et al.,*1998) and chiropractors and radiologists (Philips, Frymoyer, Mac Pherson and Newburg, 1986 and Assendelft et al., 1997).

Conclusions from such reliability studies demonstrate that observer variation is much greater with some image features (e.g. vertebral fractures) than with others (e.g. narrow central spinal canal) (Espeland *et al.,* 1998); where observers tend to agree more often in "easy" patient presentations (viz. advanced disease or gross classifications), than in "difficult" patient presentation (viz. more subtle radiographic presentation of cases) (Robinson, 1997; Tudor*,* Finlay and Taub*,* 1997; Espeland, *et al*., 1998).

Findings from studies of "measurement accuracy" and "scoring and grading accuracy" highlight possible variations in examiner interpretation. One must however also consider the possibility of design methodology or reporting bias when reading results from such studies as highlighted by the Standards for Reporting of Diagnostic Accuracy (STARD) committee (Bossuyt, Reitsma, Bruns, Gatsonis, Glasziou, Irwig, Lijmer, Moher, Rennie and de Vet, 2003).

Bias in diagnostic accuracy studies can occur early in the study design: during patient or film selection, observer selection or bias associated with the application of a reference

[1] Reliability is a general term which encompasses repeatability, reproducibility and agreement (Petrie and Sabin, 2009). Reliability should demonstrate internal consistency. This means that when the same group of individuals are measured at a later stage, the results should be similar (Scott and Mazhindu, 2005). Measurements are likely to vary between individuals (inter-individual variation) as well as within the same individual (intra-individual variation) if the measurement of that individual is repeated, either immediately or some time later (Petrie and Sabin, 2009).

standard, or due to independence of interpretation bias (Brealy, Scally and Thomas, 2002; Bossuyt, Reitsma, Bruns, Gatsonis, Irwig, Moher, Rennie, de Vet and Lijmer, 2003). Table 2.5 highlights these biases and what is usually addressed in order to avoid these biases.

TABLE 2.5 Questions Asked When Assessing Presence of Bias (Brealey, Scally and Thomas, 2002)

Film selection

1. Was an attempt made to include a case mix based on criteria like prevalence of disease, severity and range of disease type, pertinent body areas (*spectrum bias*)?
2. Were criteria stated for those films eligible for inclusion in the study? (*film-filtering bias*?)
3. Is the establishment(s) where the study was undertaken stated (*centripetal bias*)?
4. Is the establishment from where the patients were referred stated (*popularity bias*)?
5. Was a series of films over a suitable time period included; or a valid random sample of films selected (*population bias*)?
6. Were criteria stated for those films eligible for inclusion in the study? (*film-filtering bias*?)
7. Were all eligible films interpreted (*film-selection bias*)?

Observer selection

1. Was an appropriate group of observers selected (*observer-cohort bias*)?
2. Were groups of observers matched according to relevant characteristics e.g. number of years experience in the profession/relevant speciality (*observer-cohort-comparator bias*)?

Application of the reference standard

1. Were all the films interpreted by the observers also interpreted by the reference standard (*verification bias*)?
2. Was the observers' report used to decide whether the reference standard is applied (*work-up bias*)?
3. Was the observers' report used to generate the reference standard (*incorporation bias*)?

Measurement of results

1. Was appropriate radiological review used (*disease-progression bias*)?
2. Are equivocal reports included (*indeterminate results*)?
3. Are all films and clinical details available for verification (*loss to follow-up bias*)?
4. Was a subsample of the same films interpreted by different observers (*inter-observer variability*)?
5. Was a subsample of the films re-interpreted by the observers at a later date (*intra-observer variability*)?
6. Was a subsample of the reports compared by independent ararbiratorsbiters (*inter-arbiter variability*)?
7. Was a subsample of reports compared by the same arbiter at a later date (*intra-arbiter variability*)?

Independence of interpretations

1. Were the observers' blind to the reference standard report (*observer-review bias*)?
2. Was the reference standard blind to the observers reports (*reference-standard-review bias*)?
3. Did all observers interpret the films independently (*observer bias*)?
4. Did all observers interpret the same or a similar set of films (*observer-comparator bias*)?
5. Did all observers only have access to plain films (*co-image bias*)?
6. Was the arbiter one of the observers or the reference standard (*arbiter-review bias*)?
7. Was the arbiter blind to whether the report was made by an observer or the reference standard (*arbiter bias*)?
8. Did the arbiter judge whether reports agreed without access to the films (*film-access bias*)?
9. Did both cohorts interpret the same films independently (*cohort-comparator bias*)?
10. Did both cohorts have similar access to other films (*co-image-comparator bias*)?
11. Was the arbiter blind to which observers were responsible for the different reports (*arbiter-comparator bias*)?

Therefore, given the variances reported in the literature with regard to measurement accuracy, scoring or grading accuracy and diagnostic accuracy and the importance in the clinical context, several studies have investigated their clinical impact.

2.6 PREVIOUS STUDIES ON PLAIN FILM INTERPRETATION AND DIAGNOSIS

A study by de Zoete *et al.,* (2002), looked at both reliability and validity of contraindications to chiropractic treatment detected by chiropractors, chiropractic radiologists and medical radiologists on plain lumbosacral spine radiographs. This study used 300 AP and lateral radiographs that included all lumbar vertebrae and more than half of the sacrum. The radiographs were selected using a computerised database from a general hospital and only included if abnormalities were described in the initial radiologic report. These results were confirmed using other tests (e.g. laboratory, CT or MRI) and then confirmed by a chiropractor and medical expert. The selection of radiographs aimed at over-representation of contraindications to chiropractic treatment, but also included "normal" radiographs. The study showed that chiropractors were the least consistent of the three groups; however the unit of analysis (kappa) was still classified as fair to good (K=0.58) for identification of contraindications to SMT. This study did not look at possible implications on patient management.

Additionally, previous studies have looked at reliability and / or validity of radiograph readings (usually the lumbosacral region) by chiropractors which have often been compared to other medical professionals' readings (Philips *et al.*, 1986; Coste *et al*., 1991; Taylor *et al*., 1995; Assendelft *et al*., 1997; Espeland *et al*., 1998 and de Zoete *et al*., 2002).

However, because of the limited number of studies and their focus on the lumbosacral spine and because of the limited interpretation of the results which may have impinged on the clinical management of patients (Marchiori, Adams and Henderson, 1999 (Part Two)), this study focussed on cervical spine radiographic diagnosis and evaluating the impact of radiographic interpretation on clinical patient management.

2.7 CONCLUSION

From the above, it can be seen that plain film radiography is a common imaging technique used to assist in the diagnosis and management of patients with musculoskeletal complaints (Marchiori, Adams and Henderson, 1999 (Part One and Two); Yochum and Rowe, 2005). Further, it has been noted that inter-observer variation in image interpretation is recognised, but should be kept to a minimum (Tudor, Finlay and Taub, 1997). This is of particular relevance when considering Gatterman (2003) and Peterson and Bergmann (2002), stated that manual therapy is contraindicated when the procedure negatively impacts on the patients' health. However there is a paucity of literature focused specifically on chiropractors' inter- and intra-examiner reliability of cervical radiographic diagnosis. Therefore this study aimed to investigate inter- and intra-examiner reliability of chiropractors identifying radiographic diagnoses and the related patient management protocols. In addition, the influence of clinical history on these radiographic diagnoses was determined.

CHAPTER THREE

3.1 INTRODUCTION

This chapter looks at the process by which the researcher gathered all the information needed to conduct the research for this dissertation. It examines the study design and outlines the step by step processes the researcher took to ensure accuracy and reliability of results.

3.2 ABBREVIATIONS FOR THIS CHAPTER

AHPCSA	:	Allied Health Professions Council of South Africa
CASA	:	Chiropractic Association of South Africa
CI	:	Confidence Interval
C0	:	Atlas of the Cervical Spine
DC	:	Doctor of Chiropractic
FIFA	:	Fédération Internationale de Football Association (FIFA)
K	:	Kappa
M.Tech	:	Masters of Technology
Nfg	:	Number of Focus Group Members
NP	:	Number of Participants
NR	:	Number of Radiographs
SE	:	Standard Error
SMT	:	Spinal Manipulative Therapy
T1	:	First Thoracic Spine Vertebrae

3.3 STUDY DESIGN

This study was designed as an inter- and intra-examiner, test re-test reliability study of chiropractors identifying cervical spine radiographic diagnoses and its impact on clinical management.

The study consisted of two phases:

3.3.1. Phase One

Phase one included the identification by the researcher of possible radiographs for use in the study. The radiographs selected represented a wide selection of diseases and were randomly selected therefore eliminating potential *spectrum or population bias* as noted by Brealey and Scally, (2001). In addition, to have consistency in identifying diagnoses from the radiographs, the researcher developed a template study reference standard (Appendix 4), which was then submitted to a focus group. This focus group assisted in identifying important components required for a diagnosis, as well as compiling the final reference standard[1] for thirty radiographs for use in this study. To trial run the research procedure, a pilot study was then completed.

3.3.2. Phase Two

Phase two included the process whereby participants were requested to report on the same set of radiographs over two separate rounds. The first reporting round occurred blind with the participant having access to only the radiographs in order to make a radiographic diagnosis / diagnoses. The second reporting round took place two weeks later, with the participants having access to both the patient clinical history and radiographs. Participants were unaware that they were viewing the same radiographs in both rounds.

Based on the above design, this study was approved by the Faculty of Health Sciences Research and Ethics Committee, indicating that this research fulfilled the requirements of the Declaration of Helsinki (1975) as noted by (Johnson, 2005).

[1] According to the Standards for Reporting of Diagnostic Accuracy (STARD) steering committee, a reference standard is considered to be the best available method for establishing the presence or absence of a condition / diagnosis (Bossuyt *et al.,* 2003).

3.4 ADVERTISING

No advertising was required as the participants were contacted directly by the researcher, in line with the inclusion and exclusion criteria of the study.

3.5 SAMPLING METHOD

3.5.1 PHASE ONE

3.5.1.1 Radiographs

Plain film radiographs were collected from the following sources (NR_1=40) namely:

1. Durban University of Technology – Department of Radiography archives, with permission from Head of Radiography Department (Appendix 1.1 and 1.2).
2. A Private Chiropractor in East London (Appendix 2 – Permission granted by patients).
3. Downloaded from the Internet (Appendix 3).[2]

Inclusion Criteria for submission to focus group:

- Full (C0 to T1 visible) cervical spine plain film radiograph of sufficient diagnostic quality[3].

The inclusion criteria for all radiographs eliminated potential *film selection bias* as noted by Brealy and Scally, (2001).

Inclusion Criteria for submission to pilot study:

- An unanimously agreed diagnosis by the focus group members.

[2] Radiographs obtained from the internet fell within the required rules and regulations as outlined by the Copyright Office and are all referenced in Appendix 3.
[3] Including all skeletal structures forming part of the cervical spine and having appropriate kV and mas values (allowing for improved clarity of the radiograph).

3.5.1.2 Focus Group Sampling

a. Population size of the Focus Group

According to the Chiropractic Association of South Africa's (CASA) handbook (2009:25-28) and the Allied Health Professions Council of South Africa (AHPCSA) register and based on the inclusion / exclusion criteria 31 chiropractors (Nfg_1=31) met the criteria for participation in the focus group.

b. Allocation of the Focus Group

No group allocation was required.

c. Sampling Method for the Focus Group

Systematic sampling was utilised (Fink, 2009), with every fifth chiropractor in the chiropractic handbook that met the inclusion criteria having been phoned and asked to participate in the focus group. The process continued until three chiropractors (nfg_2=3) agreed to take part in the focus group, along with a radiologist[4] who confirmed the focus group findings at a different date. All 31 chiropractors from the generated list were phoned but only three chiropractors were able to participate in the focus group. The focus group was conducted during the vacation period that coincided with the Fédération Internationale de Football Association (FIFA) World Cup and as a result, many were unable to participate due to work and / or family commitments or they were on vacation at the time.

d. Sample Characteristics of the Focus Group

In order to take part in the study, participants needed to meet the following criteria:

[4] The radiologist was required to meet the same criteria as the chiropractic focus group participants with the exception that he would need to have the appropriate qualification as required by the HPC, which regulates the registration of radiologists.

Inclusion Criteria for Focus Group:

1. The focus group members were required to be qualified chiropractors with either a Masters in Technology of Chiropractic (M.Tech: Chiropractic) or Doctor of Chiropractic (DC) degree and be registered with the AHPCSA at the time of the study.
2. All focus group members were required to have had a minimum of ten years clinical experience.
3. All focus group members were required not to have had any further formal training in radiology or other imaging techniques.

This specific inclusion criteria helped to eliminate *observer cohort and comparator bias* as highlighted by Brealey and Scally (2001).

Exclusion Criteria for Focus Group:

1. Chiropractors not willing or unable to participate in the focus group.

3.5.2. Phase Two

3.5.2.1 Participant Sampling

a. Population size of research sample (NP_1=28)

According to the CASA handbook (2009:25-28) and the AHPCSA register and based on the inclusion / exclusion criteria 28 chiropractors fell into the research sample. This was as a result of 3 chiropractors being removed from the sample population due to their participation in the focus group (see Section 3.5.2.2c).

b. Allocation of research sample

No group allocation was required.

c. Sampling Method for research sample (np_2=6)

Systematic sampling was again employed (Fink, 2009) such that every fifth chiropractor from the CASA handbook (2009; 25-28) and the AHPCSA register (Mullinder, personal communication 15 May 2010) generated list, who met the criteria were phoned and asked to participate in the study. If they did not wish to participate or did not meet the inclusion criteria, they were excluded and the process was repeated until six participants agreed to participate in the study.

d. Sample Characteristics of research sample

In order to take part in the study, participants needed to meet the following criteria:

Inclusion Criteria for the Participants

1. Participants were required to be a qualified chiropractor with either an M.Tech: Chiropractic or DC degree and had to be registered with the AHPCSA at the time of the study.
2. All participants were required to have had a minimum of ten years clinical experience.
3. All participants were required not to have had any further formal training in radiology or other imaging techniques.

Exclusion Criteria for the Participants

1. Participants not willing or unable to participate in the study.
2. Those who participated in the focus group – three members – in order to negate the possibility of bias in terms of prior understanding of the research aims and objectives as well as their previous exposure to and discussion of the radiographic diagnoses in the focus group procedure.

3.24 RESARCH PROCEDURE FOR DEVELOPMENT OF THE RESEARCH TOOL:

3.24.1 PHASE ONE

3.6.1.1 Focus Group Procedure

Focus groups are indispensable for gathering early impressions about possible research (Berg and Latin, 2004) thus a focus group is usually conducted for several reasons and in the context of this research, these reasons included:

1. Discussion about radiographs in order to agree on the diagnoses for all radiographs shown to the focus group and thus provide a reference standard to which participants were later compared.
2. Discussion about the reporting format / answer sheets (Appendix 4) to develop ideas about the format within the particular context of this study so to achieve outcomes that would complement the objectives of this study.

The focus group consisted of three chiropractors selected on the same criteria noted in Section 3.5.1.2d. All members of the chiropractic profession residing in the greater Durban area, who met the inclusion criteria (N=31) were telephonically contacted to participate in the focus group. Of these 31 practitioners 3 members were able to attend the focus group and gave valued input into the development of the research tools.

On arrival at the focus group venue, all group members were given a Letter of Information and Informed Consent (Appendix 5) as well as a Code of Conduct Agreement (Appendix 6) to sign. For reference purposes, the focus group meeting was filmed but no personal information or details of group members shall be published in this dissertation (Appendix 12[5]).

[5] This appendix is only available for purposes of examination and will be removed from the final dissertation in order to maintain the anonymity of the focus group participants and to maintain the confidentiality clause signed at the focus group.

Focus group's role in identifying the radiographs (NR_2=34)

The researcher placed 40 individual sets of radiographs on the viewing boxes and six images were projected from a laptop via a data projector onto a projection screen. There were six viewing boxes available and the members walked around the room discussing each radiographic case individually. When viewing the final six radiographs that were projected onto the projection screen, members sat at individual desks and were able to get up and view the images directly from the laptop for clarity (as was required).

Clinical histories were available to the focus group members to ensure accurate diagnoses were obtained for all the selected radiographs. Focus group member's comments were noted by the researcher and a group discussion followed. Radiographs were excluded based on the previously mentioned inclusion and exclusion criteria. The process continued until 34 radiographs were selected by unanimous agreement of the focus group members.

A radiologist was then consulted and reviewed all of the chosen radiographs and confirmed the previous diagnoses. If chiropractors and radiologist were not in an unanimous agreement on a diagnosis, the radiographs were excluded.

The process resulted in the selection of 30 radiographs being taken into this study for purposes of testing the hypothesis (NR_3=30) (Appendix 7).

Focus group's role in developing the answer sheet (Appendix 4) for reporting

Marchiori, Adams and Henderson (1999) (Part One) successfully developed a test structure that provided information on the observer's ability to localise, categorise, manage and identify pathologic conditions on imaging studies. This measure of clinical competency in radiography formed the basis of the measurement tool that was subjected to the focus group.

As this current study focused specifically on the cervical spine, the observer's ability to localise the area of severity has been excluded as per unanimous recommendation of the focus group. Therefore, the final answer sheet consisted of three questions in total (Appendix 4):

- The first question was a multiple choice question which asked the participants to categorise the pathology seen on the radiograph by circling one appropriate choice A to J.
- The second question dealt with patient management and gave the participant four options from which to choose.
- The final question required a simple specific diagnosis from the participant of the pathology seen on the radiograph.

The focus group members were then asked to review the answer sheet to assess whether it was adequate for the objectives of the current study. Suggestions and comments from all members were taken into account and the necessary alterations made.

Changes recommended in addition to the removal of the "localisation of the area of severity" included the following:

- Question one option a) initially read: no abnormal finding, which the focus group recommended it be changed to: no abnormal/pathological finding
- The focus group also recommended that option B) other be changed instead to degenerative changes.
- Amendments to question two included "high force spinal adjustment" read instead spinal manipulative therapy (SMT) and
- Option two included the word precautionary before SMT.
- No changes were made to question three.

3.6.1.2 Pilot Study Procedure

After the completion of the focus group session and consolidation of their recommendations to Appendix 4, a pilot study was conducted to assess reliability, user friendliness and layout of the research documents (Fink and Kosecoff, 1985). The pilot study was also used to gauge approximately how long it would take to view the radiographs, complete the form and then repeat the process.

In order to complete this pilot, four clinicians at the Durban University of Technology and two qualified chiropractors practising in East London, were asked to observe 5 radiographs (as a representative sample) and to complete answer sheets and make any

recommendations. Each pilot study member took between 60 to 90 seconds to view the radiographs and fill out the answer sheets provided. This time allocation was consistent with the study conducted by Marchiori, Adams and Henderson, 1999 (Part Two).

A few recommendations to the answer sheet were made, which included:

- It was suggested for question one that option c) *arthritis* be more specific and so was differentiated from degenerative changes (which includes osteoarthritis) by changing it to *inflammatory arthritis*.
- The pilot study participants found question two very verbose and recommended that it be re-worded or made easier to read.
- Alterations to the management options were also made. Although a chiropractor may not adjust at the level of pathology, they may adjust a patient above or below this area. This recommendation was taken into consideration and the necessary changes made.
- No changes were made to question three, however it was suggested that a space be allocated for any comments by participants in the study.

3.6.2. PHASE TWO

3.6.2.1 Research Procedure:

3.6.2.1.1 Day One

A date and time were set up with each participant as to when they could accommodate the research process and have sufficient time to interpret the radiographs. In order to avoid inter-examiner (inter-participant) discussion of the radiographs, the researcher visited each participant individually at his or her private practice, the participants were blinded to others and all participants were given a Letter of Information and Informed Consent (Appendix 9) to sign, which requested that they did not communicate with colleagues regarding the study.

Each participant was given a maximum of 90 minutes to interpret all of the radiographs and fill in the answer sheets provided. Extra time was given to allow for changing of radiographs. Participants were allowed to review the radiographs and their answers during their 90 minute slot, but not allowed to look up any information or refer to any

documentation that may have aided in their diagnoses. Once they had completed the task, all answer sheets were placed into an envelope and sealed.

Throughout the duration of the above procedure, the researcher left the room in which the practitioner was completing the assigned task in order not to communicate or in any manner influence their clinical decision making process. Furthermore, to avoid *arbiter bias* (Brealey and Scally, 2001) and maintain participant anonymity, each participant selected a number from one to six from a box to which the researcher was blinded. This number was then written on their answer sheets and placed into the sealed envelope. The participant was asked to remember their number, one to six, to ensure that Round Two data was accurately matched to the correct participant data in Round One.

Only once all six participants had completed the first round the envelopes were opened and the data analysed for Round One data collection for Round Two then commenced.

3.6.2.1.2 Day Two (two weeks later):

Round Two followed the same procedure as Round One, with the inclusion of a basic patient clinical history (Appendix 8), based on availability of information (relating to the radiographs). The clinical history was printed on corresponding answer sheets and included:

- Gender,
- Age,
- Main complaint and
- Mechanism of injury (where applicable).

To reduce participant *recall bias* (Brealey and Scally, 2001), Round Two was conducted two weeks after Round One and, as suggested by Hubbard, Vowles and Forest (2010), all radiographs were re-numbered and show to all participants in a different order from Round One.

Only once all six participants had completed the second round, was the data analysis done.

3.7 MEASUREMENT FREQUENCY

One answer sheet per participant and per radiograph was used in each of the two rounds with the rounds having had a two week break between them.

3.8 STATISTICAL ANALYSIS (Appendix 10)

Responses were classified as accurate or not based on direct comparison with the reference standard. The accuracy of response was used to assess inter-rater reliability of each question at each round using Fleiss kappa. Fleiss Kappa statistics, standard errors of the estimates, 95% confidence intervals were calculated in Round One and Round Two separately by comparing the ratings between all 6 examiners using Stat Tools freeware (http://amchang.net/StatTools/CohenKappa_Pgm.php Fleiss's Kappa from rating scores).

The interpretation of the kappa statistic given on this website is: “The Kappa is a measurement of agreement. In Cohen's Kappa, it measures agreements between two raters. In Fleiss's Kappa, it measures the overall agreements between all the raters. Conventionally, a Kappa of <0.2 is considered poor agreement, 0.21-0.4 fair, 0.41-0.6 moderate, 0.61-0.8 strong, and more than 0.8 near complete agreement. Given that Kappa is an estimate from a sample, the Standard Error (SE) provides an estimate of error. The 95% confidence interval (CI) is Kappa ± 1.96 SE. Although concordance is usually used as a scalar measurement of agreement, a 95% confidence interval of Kappa that does not cross the zero value does allow a conclusion that signifies concordance exists.”

The comparison between the ratings of the same assessor in Rounds One and Two provided the intra-observer agreement. Comparing the ratings of all assessors in each round to each other (e.g. Participant one with participant two, participant one with participant three, participant one with participant four, participant one with participant five, participant one with participant six etc) provided inter-examiner agreement.

SPSS version 15.0 was used to analyse the data for validity. Frequency of accurate responses were tabulated at each round, and compared between rounds using McNemar’s chi square test for paired proportions. A p value <0.05 was considered statistically significant.

CHAPTER FOUR

4.1 INTRODUCTION

This chapter presents and discusses the results found in this study. The results are divided into three different categories based on the answer sheet used as the data collection tool (Appendix 4). These are: categorisation of radiographic findings, patient management and identification of any disease. Both inter- and intra-examiner results are discussed for both rounds and for each question.

Unlike the usual presentation of a separate chapter for results and discussion, this research will present both in this chapter for ease of reference to the reader and for increased ability for the reader to reference appropriate tables and figures.

4.2 DATA

Data sources utilized to compile this chapter were from both primary and secondary sources of information.

4.2.1 Primary Data

Primary sources included information collected from the respondents of the study in the form of completed answer sheets (Appendix 4).

4.2.2 Secondary Data

Secondary data sources included various books on statistical analysis (Scott and Mazhindu, 2005; Petrie and Sabin, 2009), personal communications with the statistician (Esterhuizen, 2010) and the supervisor of the research project (Korporaal, 2010). It must be noted that the discussion of this chapter also required the use of the literature outlined in chapter two, which was obtained from books, journal articles and other appropriate sources.

4.3 ABBREVIATIONS FOR THIS CHAPTER

CI : Confidence Interval

K : Kappa

NAD : No Anomaly Detected

p : McNemar's Coefficient

SE : Standard Error

SMT : Spinal Manipulative Therapy

4.4 RESULTS

4.4.1 INTER-EXAMINER RELIABILITY

Six participants evaluated the same 30 radiographs on two occasions (180 responses at each Round). To measure agreement between examiners, Cohen's Kappa was used. According to Petrie and Sabin (2009) K = 1 implies perfect agreement and K = 0 suggests that agreement is no better than that which would be obtained by chance. However, kappa is often judged as providing agreement which is:

- Poor if K <0.2
- Fair if 0.21≤ K≤ 0.4
- Moderate if 0.41≤ K ≤ 0.6
- Strong if 0.61≤ K ≤0.8
- Almost perfect if K ≥ 0.81

4.4.1.1 Categorisation Round One

Overall Kappa = 0.1962

SE = 0.0471

95% CI = 0.1038 to 0.2886

Therefore there was poor agreement between the raters but since the 95% confidence interval did not overlap with zero, the agreement was better than expected by chance.

4.4.1.2 Categorisation Round Two

Overall Kappa = 0.2041

SE = 0.0471

95% CI = 0.1117 to 0.2965

There was fair agreement which was better than chance, and the 95% CI overlapped with those of the first round, therefore, the improvement was not statistically significant.

4.4.1.3 Management Round One

Overall Kappa = 0.1996

SE = 0.0471

95% CI = 0.1072 to 0.2920

There was poor agreement which was better than chance.

4.4.1.4 Management Round Two

Overall Kappa = 0.2036

SE = 0.0471

95% CI = 0.1112 to 0.2960

There was fair agreement which was better than chance, and the 95% CI overlapped with those of the first round, therefore, the improvement was not statistically significant.

4.4.1.5 Identification Round One

Overall Kappa = 0.3113

SE = 0.0471

95% CI = 0.2189 to 0.4037

There was fair agreement which was better than chance.

4.4.1.6 Identification Round Two

Overall Kappa = 0.2159

SE = 0.0471

95% CI = 0.1235 to 0.3083

There was fair agreement which was better than chance. No improvement was seen.

Table 4.1 Kappa for Inter-Observer Reliability

	OVERALL KAPPA		Standard Error 0.0471 95% Confidence Interval (CI)	
	Round One	Round Two	Round One	Round Two
Question One: Categorisation	0.1962	0.2041	0.1038 to 0.2886	0.1117 to 0.2965
Question Two: Management	0.1996	0.2036	0.1072 to 0.2920	0.1112 to 0.2960
Question Three: Identification	0.3113	0.2159	0.2189 to 0.4037	0.1235 to 0.3083

4.4.1.7 Discussion of inter- and intra-examiner reliability

Categorisation and Management for Rounds One and Two improved from poor inter-examiner agreement to fair agreement beyond that expected by chance, although it was noted that the improvement was not statistically significant. These findings are consistent with Marchiori, Adams and Henderson, 1999 (Part Two) where students demonstrated similar aptitudes for categorising and managing pathologic conditions. No other studies were found to look specifically at categorisation and management and therefore no comparisons with the literature could be made.

Kappa for identification of pathology was fair in both Rounds One and Two, but it did decrease slightly, although it was noted that this decrease was not statistically significant.

Based on these results, it cannot be assumed that clinical history impacted the results between Round One and Round Two. Further, these results seem to suggest that there are different factors which influence the categorisation, management and identification of pathology. These may be related to the effect of the patient interaction, the history, the physical examination and / or the availability of any special investigations that the practitioner may have with him / her at the time of the consultation. As a result, this research was developed to assess the effect of the history on the categorisation, management and identification of pathology and this will further be discussed in section 4.4.2.

Additionally, it is difficult to compare kappa statistics for similar reliability studies as kappa can be influenced by several factors, for example the number of radiographs observed. A larger number of radiographs decrease the standard error measurement as well as the confidence interval making it easier to detect any significant changes. In this context, de Zoete *et al.,* (2002) used 300 radiographs and obtained a mean kappa of K=0.58 which represents a moderate agreement between observers. de Zoete *et al.,* (2002), however,

did not use any intervention between rounds (e.g. addition of clinical history) thus the results, although comparable superficially, are influenced by different input data. Tudor *et al.,* (1997) used 50 plain radiographs of all spinal regions and extremities and produced results of K=0.31 (fair agreement) in Round One without clinical history and K=0.58 (moderate agreement) in Round Two with clinical history. Similar to Tudor *et al.,* (1997) findings, this study used only 30 radiographs producing fair agreement between observers in both rounds. Taylor *et al.,* (1995) used 21 radiographs all of which showed varying degrees of pathologies. No “normal” radiographs were used and no kappa statistics were generated therefore no comparison could be made between this study, the Tudor *et al*., (1997) study and Taylor *et al.,* (1995) research.

Therefore, the results of this study need to be interpreted with caution, in that the effects of the numbers of radiographs may have had an effect on the sensitivity and specificity of the results to arrive at a kappa with a small standard deviation. Thus, it is recommended that future studies look specifically at the effects of radiograph numbers and its effect on kappa as well as looking at the comparability of the studies that have been done previously (e.g. a meta- analysis or systemic review).

4.4.2 SENSITIVITY AND SPECIFICITY

There were six (20%) normal radiographs in this study and 24 radiographs that had abnormal radiographic findings. In the first round, participants were able to correctly identify 61.1% (22/36) normal radiographs and 94.4% (136/144) of the abnormal radiographs. Therefore the sensitivity at Round One was 94.4% and the specificity was 61.1%. At Round Two the sensitivity had decreased to 93.8% and the specificity had decreased to 50%.

TABLE 4.2 Sensitivity and Specificity of Identifying Abnormal Radiographs at Round One

			Normal Reference Standard		Total
Radiographs			Abnormal	Normal	
Normal Round 1	Abnormal	Count	136	14	150
		% within Normal Reference standard	94.4%	38.9%	83.3%
	Normal	Count	8	22	30
		% within Normal Reference standard	5.6%	61.1%	16.7%
Total		Count	144	36	180
		% within Normal Reference standard	100.0%	100.0%	100.0%

TABLE 4.3 Sensitivity and Specificity of Identifying Abnormal Radiographs at Round Two

			Normal Reference Standard		Total
Radiographs			Abnormal	Normal	
Normal Round 2	Abnormal	Count	135	18	153
		% within Normal Reference standard	93.8%	50.0%	85.0%
	Normal	Count	9	18	27
		% within Normal Reference standard	6.3%	50.0%	15.0%
Total		Count	144	36	180
		% within Normal Reference standard	100.0%	100.0%	100.0%

4.4.2.1 Discussion of Sensitivity and Specificity

It has been noted by Esterhuizen (2010 personal communication 23 November) that sensitivity is the proportion of individuals (in this instance radiographs) with the disease / pathology that are correctly identified by the test (in this instance, the participants); whereas specificity is the proportion of radiographs without pathology that are correctly identified by the chiropractors. Whether aiming for a high sensitivity or high specificity depends on the condition that is being detected, along with the implications for the patient of either a false negative or false positive result (Scott and Mazhindu, 2005; Petrie and Sabin, 2009).

For this study, Esterhuizen (2010 pers. comm. 23 November) suggested that a higher sensitivity was more desirable as opposed to a high specificity. This means that it was more preferable for this test to correctly identify individuals with pathology in order to avoid patients being managed incorrectly. In this regard, the statistical analysis showed high sensitivity for both Round One (94.4%) and Two (93.8%). In contrast, specificity was low for both rounds showing a significant drop from Round One (61.1%) to Round Two (50%) which means that in Round Two, fewer radiographs without pathology ("normal" radiographs) were correctly identified increasing false positives (i.e. the participants found that there was evidence of radiographic pathologies on radiographs that were in essence normal or normal variations of cervical spine skeletal structure).

Although in this study, sensitivity was more desirable, the decrease in specificity raised new concerns with regards to patient management. From this significant drop in specificity between rounds (11.1%), it could be deduced that the intervention that occurred between the rounds (addition of clinical history) increased false positive results; showing that with clinical history, participants tended to be over cautious and tended to report pathology where no pathology was actually present. This reporting impacts on patient management (Marchiori, Adams and Henderson, 1999 (Part Two); Taylor and Resnick, 2000) as practitioners have an increased likelihood of developing incorrect differential diagnoses, which impacts on the appropriate selection of special investigations perceived to be required by the practitioner. These investigations are therefore either then inappropriate and do not give the required information to allow for appropriate care or they require unnecessary medical / time expenditure. This may also delay the appropriate intervention(s) for the condition with which the patient presents.

This 10% drop in specificity therefore highlights an area of less clear distinction of pathology, a "*grey zone"* in which appropriate management of patients could become increasingly problematic. Therefore, this study recommends that further studies be done

to investigate and confirm if management of patients changes between successive rounds or radiographic reporting. In addition, these studies should include a report by the participants on further special investigations that they would require the patient to undergo in order to confirm or refute suspected pathologies seen on radiographs. This is particularly important in testing the assertion that inappropriate care can stem from inaccurate reading and reporting on radiographs (Marchiori, 1999; Taylor and Resnick, 2000; Naidoo, 2008; Gajeerajee, 2010).

4.4.3 CATEGORISATION

At Round One the overall percentage of correct categorisation was 63.3% with some radiographs having as low as 0% correct (radiograph 8) and some as high as 100% correct (radiograph 12) (Table 4.4). Overall, at Round Two the percentage of correct categorisation had increased slightly to 68.3% (Table 4.5).

TABLE 4.4 Categorisation: Round One

		Accuracy Question One Round One			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	1	16.7%	5	83.3%
	2	3	50.0%	3	50.0%
	3	4	66.7%	2	33.3%
	4	3	50.0%	3	50.0%
	5	2	33.3%	4	66.7%
	6	1	16.7%	5	83.3%
	7	1	16.7%	5	83.3%
	8	6	100.0%	0	.0%
	9	3	50.0%	3	50.0%
	10	2	33.3%	4	66.7%
	11	4	66.7%	2	33.3%
	12	0	.0%	6	100.0%
	13	1	16.7%	5	83.3%
	14	4	66.7%	2	33.3%
	15	3	50.0%	3	50.0%
	16	0	.0%	6	100.0%
	17	1	16.7%	5	83.3%
	18	0	.0%	6	100.0%
	19	4	66.7%	2	33.3%
	20	0	.0%	6	100.0%
	21	5	83.3%	1	16.7%
	22	0	.0%	6	100.0%
	23	1	16.7%	5	83.3%
	24	2	33.3%	4	66.7%
	25	5	83.3%	1	16.7%
	26	3	50.0%	3	50.0%
	27	2	33.3%	4	66.7%
	28	1	16.7%	5	83.3%
	29	3	50.0%	3	50.0%
	30	1	16.7%	5	83.3%
	Total	66	36.7%	114	63.3%

TABLE 4.5 Categorisation: Round Two

		Accuracy Question One Round Two			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	0	.0%	6	100.0%
	2	5	83.3%	1	16.7%
	3	2	33.3%	4	66.7%
	4	0	.0%	6	100.0%
	5	4	66.7%	2	33.3%
	6	2	33.3%	4	66.7%
	7	0	.0%	6	100.0%
	8	4	66.7%	2	33.3%
	9	0	.0%	6	100.0%
	10	2	33.3%	4	66.7%
	11	2	33.3%	4	66.7%
	12	1	16.7%	5	83.3%
	13	0	.0%	6	100.0%
	14	5	83.3%	1	16.7%
	15	1	16.7%	5	83.3%
	16	1	16.7%	5	83.3%
	17	2	33.3%	4	66.7%
	18	0	.0%	6	100.0%
	19	3	50.0%	3	50.0%
	20	1	16.7%	5	83.3%
	21	4	66.7%	2	33.3%
	22	1	16.7%	5	83.3%
	23	2	33.3%	4	66.7%
	24	1	16.7%	5	83.3%
	25	4	66.7%	2	33.3%
	26	5	83.3%	1	16.7%
	27	1	16.7%	5	83.3%
	28	2	33.3%	4	66.7%
	29	2	33.3%	4	66.7%
	30	0	.0%	6	100.0%
	Total	57	31.7%	123	68.3%

There was no significant difference between the accuracy of Round One and Round Two results. (p=0.243). Therefore, the intervention of clinical history did not affect the accuracy for categorisation, although there was a tendency for the categorisation to improve with the clinical history.

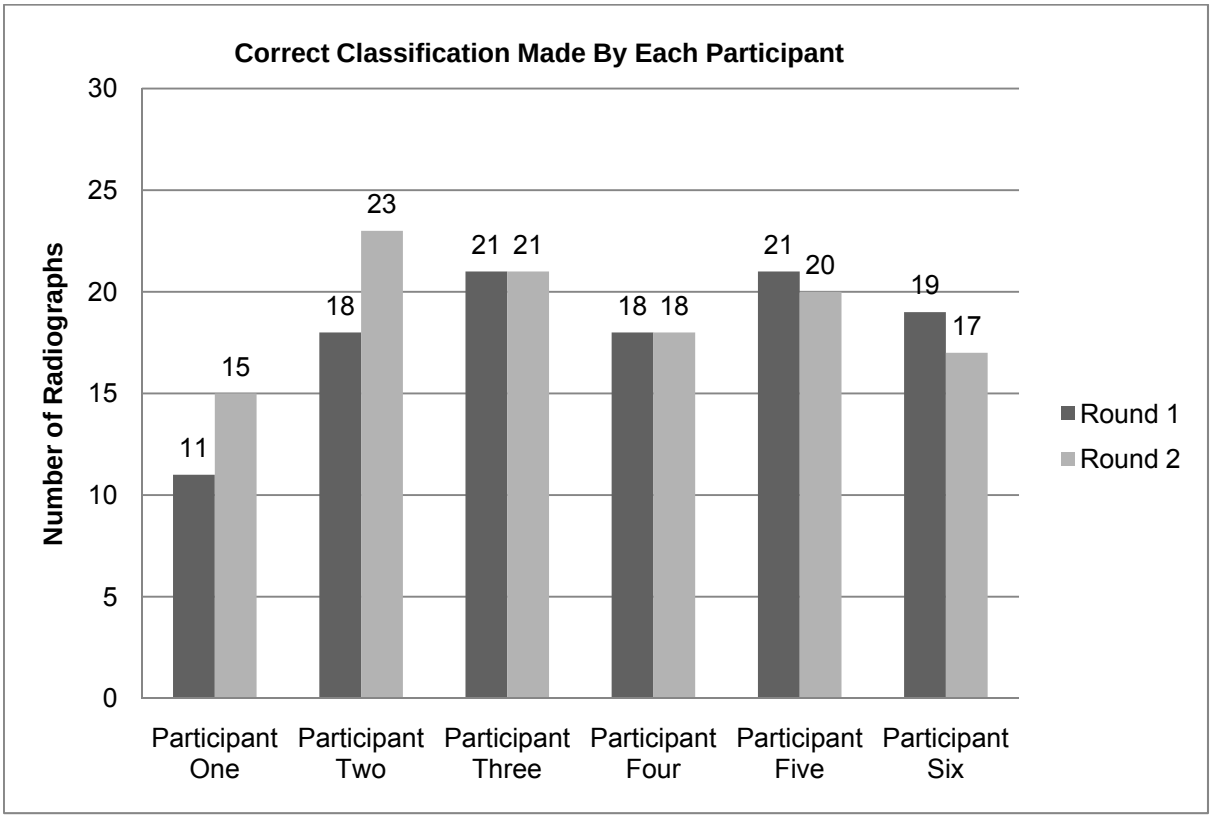
TABLE 4.6 Comparison of Accuracy of Categorisation at Round One and Two

		Accuracy Question One Round Two		Total
		Incorrect	Correct	
Accuracy Question One Round One	Incorrect	38	28	66
	Correct	19	95	114
	Total	57	123	180

McNemar's p =0.243

4.4.3.1 Discussion of Categorisation

Although clinical history did not affect the overall accuracy for categorisation, it did influence certain examiners to change initially correct answers to incorrect answers (e.g. radiograph 12) and incorrect answers to correct answers (e.g. radiograph 30). In this regard, there appeared to be a trend where in less common diagnoses (e.g. radiograph eight: multiple myeloma) the case history allowed for more accurate classifications, where in "normal" cases, the case history influenced participants negatively causing them to change their answers (e.g. radiograph five: NAD).



GRAPH 4.1 Correct Classification Made By Each Participant

This "phenomenon" is supported by Robinson (1997) who when reporting on several studies drew two broad conclusions. Firstly, variation between observers is always greater than the variation within a single individual's performance; and secondly the frequency of errors and the magnitude of observer variation both increase in proportion to the "difficulty" of the task. He further defined that "easy" cases may be defined as those cases with advanced disease or gross classifications (i.e. later in the pathogenesis of the condition) and "difficult" cases are those with less obvious signs (i.e. early in the pathogenesis of the condition) and those in which expert opinion is divided.

These findings concur with the outcomes in this study on sensitivity and specificity, where it was previously noted that there was an increase in the number of false positive reports on radiographs where there was no pathology.

Thus, when considering the outcomes achieved in this research with regard to the changes in classification of pathology and looking at this in the context of the *"grey zone"* discussed earlier; it can be seen that this would further compound patient management negatively. An example would be a classification change from infection to tumour. This would mean that the special investigations sought by the practitioner would change according to the required pathology. Therefore, if the practitioner identified a bony pathology on a normal radiograph and sent the patient for special investigations, the patient would not receive the appropriate care until after the results of the special investigations were known.

Thus, the impact of changing the classification of the pathology in the context of the history as well as a decrease in the specificity of the radiograph readings seems to increase the *"grey zone"*, which is a zone that should be minimised in order to optimise early, appropriate and effective care for patients.

4.4.4 MANAGEMENT

At Round One the correct management was identified in 53.9% of radiographs (Table 4.7), but by Round Two, the result had dropped to 48.3% (Table 4.8) overall accuracy.

TABLE 4.7 Management: Round One

		Accuracy Question Two Round One			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	1	16.7%	5	83.3%
	2	4	66.7%	2	33.3%
	3	4	66.7%	2	33.3%
	4	6	100.0%	0	.0%
	5	4	66.7%	2	33.3%
	6	1	16.7%	5	83.3%
	7	5	83.3%	1	16.7%
	8	2	33.3%	4	66.7%
	9	2	33.3%	4	66.7%
	10	3	50.0%	3	50.0%
	11	5	83.3%	1	16.7%
	12	4	66.7%	2	33.3%
	13	1	16.7%	5	83.3%
	14	3	50.0%	3	50.0%
	15	4	66.7%	2	33.3%
	16	0	.0%	6	100.0%
	17	2	33.3%	4	66.7%
	18	1	16.7%	5	83.3%
	19	5	83.3%	1	16.7%
	20	3	50.0%	3	50.0%
	21	6	100.0%	0	.0%
	22	3	50.0%	3	50.0%
	23	1	16.7%	5	83.3%
	24	0	.0%	6	100.0%
	25	3	50.0%	3	50.0%
	26	1	16.7%	5	83.3%
	27	2	33.3%	4	66.7%
	28	4	66.7%	2	33.3%
	29	3	50.0%	3	50.0%
	30	0	.0%	6	100.0%
	Total	83	46.1%	97	53.9%

TABLE 4.8 Management: Round Two

		Accuracy Question Two Round Two			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	0	.0%	6	100.0%
	2	5	83.3%	1	16.7%
	3	3	50.0%	3	50.0%
	4	6	100.0%	0	.0%
	5	2	33.3%	4	66.7%
	6	2	33.3%	4	66.7%
	7	6	100.0%	0	.0%
	8	1	16.7%	5	83.3%
	9	4	66.7%	2	33.3%
	10	5	83.3%	1	16.7%
	11	5	83.3%	1	16.7%
	12	4	66.7%	2	33.3%
	13	1	16.7%	5	83.3%
	14	4	66.7%	2	33.3%
	15	3	50.0%	3	50.0%
	16	2	33.3%	4	66.7%
	17	3	50.0%	3	50.0%
	18	1	16.7%	5	83.3%
	19	3	50.0%	3	50.0%
	20	1	16.7%	5	83.3%
	21	6	100.0%	0	.0%
	22	3	50.0%	3	50.0%
	23	3	50.0%	3	50.0%
	24	4	66.7%	2	33.3%
	25	5	83.3%	1	16.7%
	26	4	66.7%	2	33.3%
	27	1	16.7%	5	83.3%
	28	2	33.3%	4	66.7%
	29	4	66.7%	2	33.3%
	30	0	.0%	6	100.0%
	Total	93	51.7%	87	48.3%

There was no significant difference between the accuracy of Round One and Round Two (p=0.220). Therefore, the intervention of clinical history did not affect the accuracy for management. It is, however, noted that the accuracy of clinical management recorded decreased from Round One to Round Two.

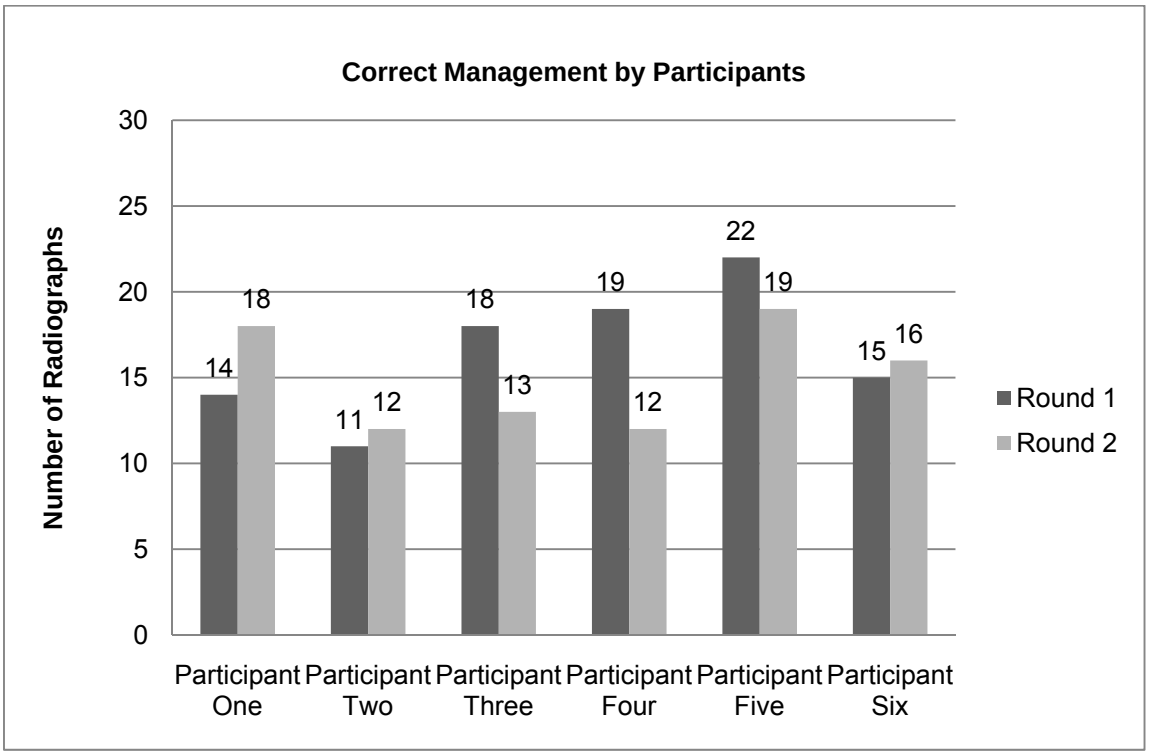
TABLE 4.9 Comparison of Accuracy of Management at Round One and Two

		Accuracy Question 2 Round 2		Total
		Incorrect	Correct	
Accuracy Question 2 Round 1	Incorrect	61	22	83
	Correct	32	65	97
	Total	93	87	180

McNemar's chi square p=0.220

4.4.4.1 Discussion of Management

Management of patients will vary, as shown in Graph 4.2, from practitioner to practitioner and patient to patient. This concurred with the outcomes of this study, where the highest agreement with the reference standard was 22/30 by participant five and the lowest being 11/30 by participant two in Round One. Participants One, Two and Six increased agreement from Round One to Round Two, while participants Three, Four and Five decreased their agreement with the reference standard from Round One to Round Two.



GRAPH 4.2 Correct Management Made by Participants

As the principle objective of this study was with regards to management and particularly to identify whether participants would apply SMT to the cervical spine where an absolute or relative contraindication to SMT was present on the radiograph; it should be noted that there were 13/30 radiographs (Table 4.10) that the reference standard considered to be absolute contraindications to SMT.

In this context, agreement with the reference standard decreased from 70.5% for Round One to 65.40% for Round Two, meaning that participants would proceed with SMT, despite the presence of at least one contraindication to manipulation.

When looking closely at the possible reasons for this decrease, it was noted that the most disagreement to manipulation was in respect of agenesis of the posterior arch of the atlas which can cause instability in some patients. Highest agreement for contraindication to

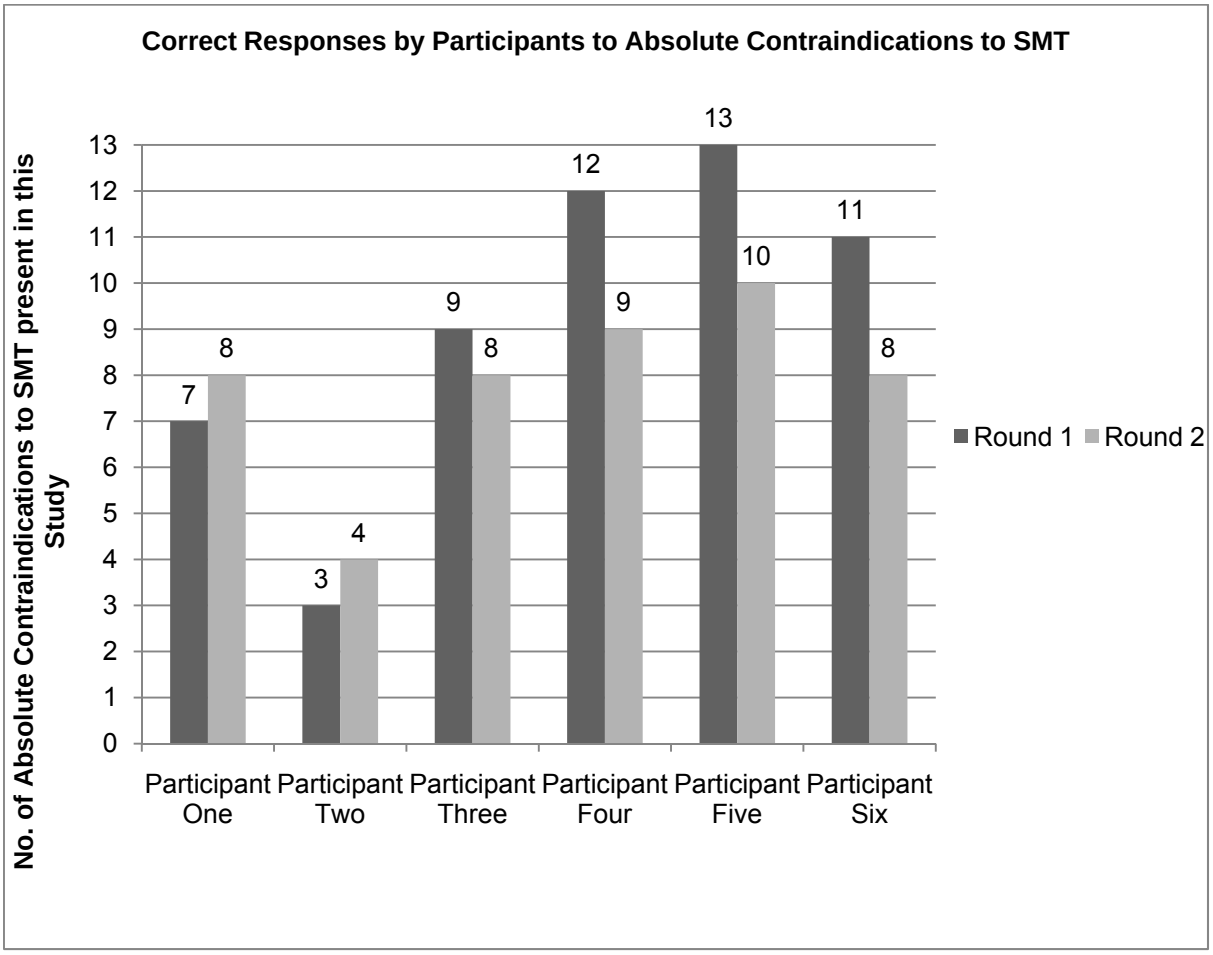
SMT was a pathologic fracture of C4 vertebral body secondary to metastatic disease. As agenesis of the posterior arch of the atlas is an uncommon condition whereas pathologic fracture secondary to metastatic disease is fairly common; it explains the results found and again highlights Robinson's (1997) conclusion that frequency of errors and the magnitude of observer variation both increase in proportion to the "difficulty" of the task (Robinson, 1997).

Additionally, it can also be seen that as specificity decreases, categorisation decreases and patient management becomes less congruent with the reference standard, indicating that there seems to be a relationship between the "*grey zone"* increasing and the patient management becoming more haphazard.

Table 4.10 List of Pathologies Contraindicated to SMT and Participant Responses

List of Pathologies Considered Contraindication to SMT	Round One Correct Responses (Max 6)	Round Two Correct Responses (Max 6)	TOTAL (Max 12)
Flexion "Teardrop" fracture of C5 with anterior dislocation of C6	5	6	11
Prevertebral mass at C1 – Post mortem report = Multiple Myeloma	4	5	9
Agenesis of the Atlas Posterior Arch	3	1	4
Fracture of lamina of C6 and Fractured spinous process of C7	5	5	10
Fracture of lamina and spinous process of C2	4	3	7
Fracture of C2 lamina; Posterior ponticle; fusion of posterior arch	5	5	10
Ankylosing Spondylitis	6	2	8
Atlantoaxial Instability caused by Rheumatoid arthritis	3	1	4
Diffuse Idiopathic Skeletal Hyperostosis	5	2	7
Type II Odontoid Fracture	4	5	9
Ossification of the Posterior Ligament	2	4	6
Extension Teardrop Fracture of C2	3	2	5
Pathologic fracture of C4 vertebral body as a complication of Metastatic Disease	6	6	12
TOTAL	55	47	102
PERCENTAGES	70.50%	60.30%	65.40%

In congruence with the above, participants three, four, five and six all agreed less with the reference standard from Round One to Round Two, but their results were still consistently higher than participants one and two whose agreement increased from Round One to Round Two, but whose accuracy was lower than the other participants (Graph 4.3).



GRAPH 4.3 Correct Responses by Participants to Absolute Contraindications to SMT

Therefore, the result of this study demonstrates the variation in patient management between chiropractors and again highlights the possible impact of the *"grey zone"* and its effect on patient management. This needs to be examined more closely, as the study seems to suggest that the application of a patient history with a radiographic special investigation, decreases specificity and also changes the systems classification of the possible differential diagnoses that the practitioners considered. Both of these factors occurred simultaneously with a decreased agreement in terms of the management of the patient (with regards to the reference standard).

This has certain implications which include but may not be limited to:

- The use of the radiographs in practice, where they are not being used to determine a diagnosis by exclusion, but rather as an additional test (e.g. an additional orthopaedic test), which may or may not add information to the pool required to determine a differential and definitive diagnosis. Additionally the combination of the two procedures seems to support the development of a "*grey zone*", which impacts negatively on patient management.
- Practitioners may recommend unwarranted special investigations i.e. in those instances where pathology was seen in normal radiographs.
- It suggests that while practitioners may be fairly good at reading radiographs in a context without the clinical history, their confidence and ability seems to falter in the context of the clinical history (even despite the fact that all practitioners in this study had more than 10 years of clinical experience).
- Participants were more willing to treat patients using SMT after the intervention of clinical history, irrespective of the fact that the reported pathologies increased. This has obvious negative implications for the impact that the intervention may present to the patient, especially when SMT is an inappropriate or contraindicated form of care.

Based on the above it is recommended that further studies investigate:

- The causality of the relationship between pathology classification and patient management.
- The causality of the relationship between specificity and sensitivity (when reading radiographs) and patient management.
- Specific patient management plans and their relationship to patient management plans when radiographs are included in the decision making process.

4.4.5 IDENTIFICATION

At Round One, the overall accuracy of identification was 63.9%. This increased to 73.3% at Round Two.

TABLE 4.11 Accuracy of Identification: Round One

		Accuracy Question Three Round One			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	1	16.7%	5	83.3%
	2	0	.0%	6	100.0%
	3	3	50.0%	3	50.0%
	4	1	16.7%	5	83.3%
	5	2	33.3%	4	66.7%
	6	1	16.7%	5	83.3%
	7	4	66.7%	2	33.3%
	8	6	100.0%	0	.0%
	9	4	66.7%	2	33.3%
	10	2	33.3%	4	66.7%
	11	4	66.7%	2	33.3%
	12	0	.0%	6	100.0%
	13	1	16.7%	5	83.3%
	14	2	33.3%	4	66.7%
	15	1	16.7%	5	83.3%
	16	0	.0%	6	100.0%
	17	1	16.7%	5	83.3%
	18	0	.0%	6	100.0%
	19	3	50.0%	3	50.0%
	20	0	.0%	6	100.0%
	21	5	83.3%	1	16.7%
	22	1	16.7%	5	83.3%
	23	5	83.3%	1	16.7%
	24	1	16.7%	5	83.3%
	25	5	83.3%	1	16.7%
	26	0	.0%	6	100.0%
	27	3	50.0%	3	50.0%
	28	6	100.0%	0	.0%
	29	2	33.3%	4	66.7%
	30	1	16.7%	5	83.3%
	Total	65	36.1%	115	63.9%

TABLE 4.12 Accuracy of Identification: Round Two

		Accuracy Question Three Round Two			
		Incorrect		Correct	
		Count	Row N %	Count	Row N %
RADIOGRAPH NO.	1	1	16.7%	5	83.3%
	2	1	16.7%	5	83.3%
	3	1	16.7%	5	83.3%
	4	0	.0%	6	100.0%
	5	1	16.7%	5	83.3%
	6	3	50.0%	3	50.0%
	7	2	33.3%	4	66.7%
	8	5	83.3%	1	16.7%
	9	1	16.7%	5	83.3%
	10	2	33.3%	4	66.7%
	11	1	16.7%	5	83.3%
	12	0	.0%	6	100.0%
	13	1	16.7%	5	83.3%
	14	0	.0%	6	100.0%
	15	1	16.7%	5	83.3%
	16	1	16.7%	5	83.3%
	17	2	33.3%	4	66.7%
	18	0	.0%	6	100.0%
	19	2	33.3%	4	66.7%
	20	0	.0%	6	100.0%
	21	5	83.3%	1	16.7%
	22	0	.0%	6	100.0%
	23	3	50.0%	3	50.0%
	24	0	.0%	6	100.0%
	25	3	50.0%	3	50.0%
	26	2	33.3%	4	66.7%
	27	2	33.3%	4	66.7%
	28	6	100.0%	0	.0%
	29	2	33.3%	4	66.7%
	30	0	.0%	6	100.0%
	Total	48	26.7%	132	73.3%

There was a significant difference between the accuracy of Round One and Round Two for identification (p=0.014). Therefore, the intervention of clinical history did improve the accuracy for identification.

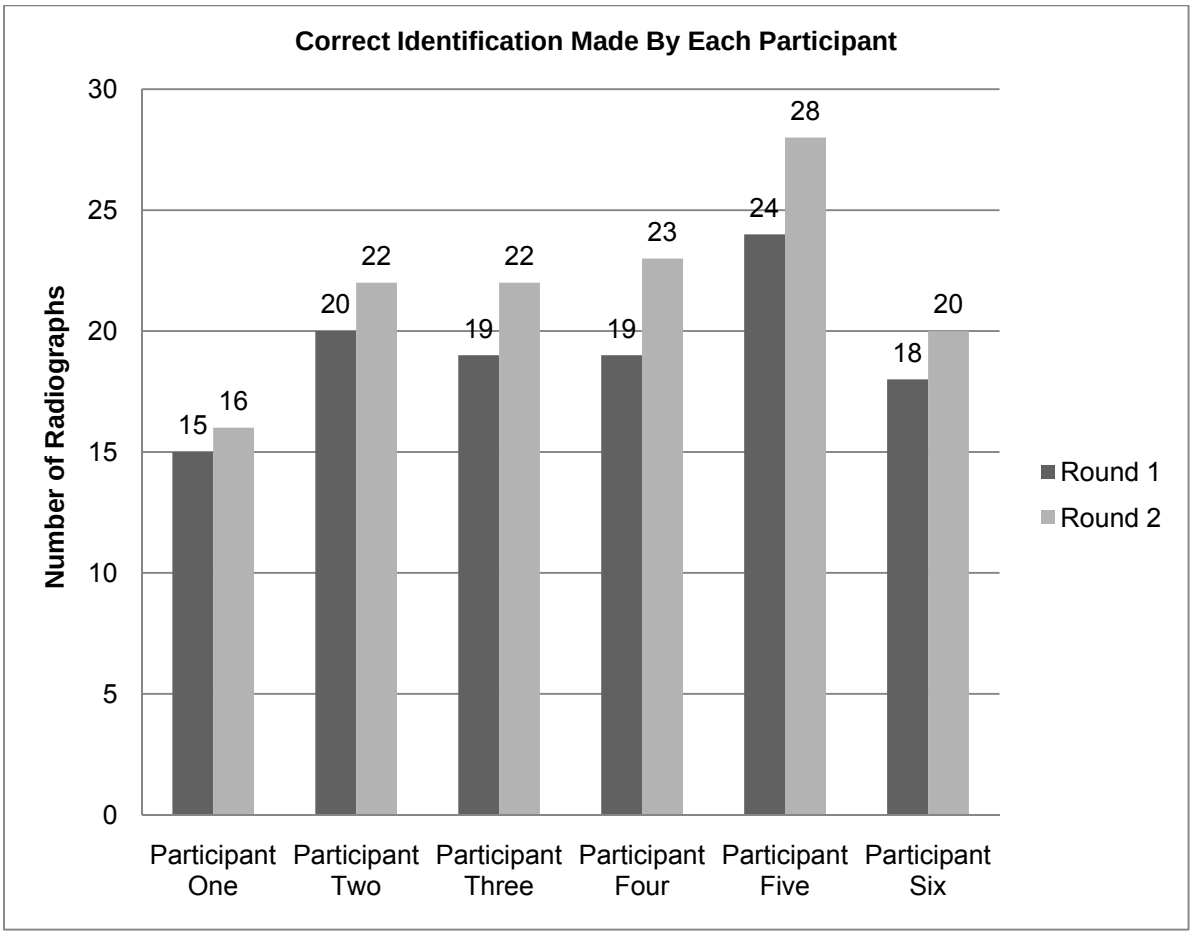
TABLE 4.13 Comparison of Accuracy of Identification at Round One and Two

		Accuracy Question Three Round Two		Total
		Incorrect	Correct	Incorrect
Accuracy Question Three Round One	Incorrect	35	30	65
	Correct	13	102	115
	Total	48	132	180

McNemar's chi square p=0.014

4.4.5.1 Discussion of Identification

From Graph 4.4, it can be seen that all participants improved accuracy of identification of pathology from Round One to Round Two. The graph also shows that participant five consistently achieved higher results in each round than all other participants, whilst participant one's results were the weakest.



GRAPH 4.4 Correct Identification Made by Each Participant

As previously mentioned (Section 4.5.3.1) and similar to findings by Robinson (1997), participants tended to agree more in the "easy" cases of gross or commonly seen pathology such as ankylosing spondylitis and metastatic disease, but disagreed on less common pathology such as agenesis of the posterior arch of the atlas and ossification of the posterior longitudinal ligament.

There was a significant difference between the accuracy of Round One and Round Two for identification (p=0.014). Therefore, the intervention of clinical history did improve the accuracy for identification which is consistent with results from several other studies (Aideyan, Berbaum and Smith, 1995; Tudor *et al.,* 1996; Robinson, 1997; Leslie, Jones and Goddard, 2000).

These results seem to contradict the outcomes of the specificity, classification, management results noted in Sections 4.5.2, 4.5.3 and 4.5.4 respectively as it would stand to reason that with decreased specificity and increased changes in classification, that the correct identification of pathology would decrease. This may however explain why the practitioners tended to be more accepting of increased SMT interventions in Round Two (management changes).

These results collectively then seem to suggest that the practitioners are more likely to identify the radiograph pathology in the context of the history, but that in some instances the history is responsible for indicating pathology where there may be none (reason for the change in specificity). This does however not allow for the explanation of why the practitioners would be more lenient in the application of SMT procedures when the numbers of pathological identifications increased. This latter confounder requires further study, and is currently beyond this study's frame of reference.

4.5 SUMMARY OF RESULTS

Inter-examiner reliability was poor (K = 0.1962) to fair (K= 0.2041) with classification as well as management (K=0.1996 to K=0.2036). Inter-examiner reliability of identification of pathologies remained fair although it decreased slightly from Round One (K=0.3113) to Round Two (K=0.2159). The decrease was not statistically significant.

There was no statistical improvement of accuracy in classification of pathology (p=0.243) or patient management (p=0.220) between rounds. Therefore the intervention of clinical history did not affect the accuracy for classification or patient management. There was a significant difference between the accuracy of Round One and Round Two for identification (p=0.014). This means that the intervention of clinical history did improve the accuracy for identification of pathologies.

In the context of the above results, the objectives are reviewed as follows:

4.6 REVIEW OF OBJECTIVES

1. To determine the inter- and intra-examiner reliability of cervical spine radiographic diagnoses.

   Null Hypothesis One

   Correlation of the inter- and intra-examiner reliability of cervical spine radiographic diagnoses would be low.

   Based on the data, this hypothesis was ***not rejected***.

2. To determine the influence of clinical history on cervical spine radiographic diagnoses and patient management.

   Null Hypothesis Two

   Clinical history would not significantly alter cervical spine radiographic diagnoses and patient management.

   Based on the data, this hypothesis was ***rejected***.

3. To assess the influence of identifying cervical spine radiographic contraindications on patient management.

   Null Hypothesis Three

   Cervical spine radiographic contraindications to chiropractic management would not significantly influence patient management.

   Based on the data, this hypothesis was ***rejected***.

4.7 CONCLUSION

Intra-examiner reliability of cervical spine radiographic diagnoses was fair in both Rounds One and Two. Clinical history did not statistically influence patient management, but instead highlighted areas where mismanagement may occur shown by decreased specificity. Clinical history however, did statistically improve radiographic diagnosis. The increase in identification of contraindications did not statistically improve patient management when compared to the reference standard and instead showed less agreement between participants. Final discussion of results will be concluded in Chapter five.

CHAPTER FIVE

5.1 INTRODUCTION

The aim of this study was to evaluate the inter- and intra-examiner reliability of chiropractor's reading cervical spine radiographs and the influence of clinical history on their results. This chapter will draw final conclusions from the previous chapter as well as discuss any recommendations that could be made based on the knowledge obtained while completing this dissertation.

5.2 CONCLUSION

Inter-observer variation amongst practitioners is recognised and should be kept to a minimum (Robinson, 1997; Tudor *et al*., 1997; Bono *et al.,* 2010), particularly as the variability of a test is measured by its reproducibility. However, this does not assure the accuracy of the test, as a reproducible test can reproduce incorrect results (Tudor *et* al., 1997; Scott and Mazhindu, 2005; Petrie and Sabin, 2009). In this study, inter-observer agreement was greater for abnormal radiographs than for normal radiographs as indicated by the high sensitivity in both rounds and by the 11.1% decrease in specificity from Round One to Round Two. This shows that more "normal" radiographs were incorrectly diagnosed as having pathology when a clinical history was available. This could lead to patient mismanagement and the patient being recommended for unnecessary and expensive tests as a result of what this study revealed in terms of the *"grey zone"*.

Therefore, it is recommended that chiropractors do not use radiographs as part of a routing screen or work-up as supported by Airaksinen *et al.,* (2006). Radiographs should only be taken when a thorough history, physical, orthopaedic and neurological examinations indicate it necessary.

In agreement with previous studies, observers did tend to agree more in more severe cases of gross pathology than in cases where signs of disease were less obvious (Robinson, 1997; Espeland *et al.*, 1998). This highlights the necessity of adequate films and interpretation techniques in order to avoid missing subtle signs of pathology.

This study reproduced results similar to previous studies and showed that the intervention of clinical history between the two rounds did improve diagnostic accuracy, (Sup Song *et al.*, 1992; Tudor, Finlay and Taub, 1997; Leslie, Jones and Goddard, 2000 and Loy and

Irwig, 2004) but seemed to have a minimal influence on patient management. Therefore it is important to have an extensive and accurate clinical history in order to reach an accurate diagnosis. However, further studies should look at improving patient management in the presence of an accurate diagnosis.

5.3 RECOMMENDATIONS

A larger focus group should be used in order to gather a wider perspective and substantiate the veracity of the reference standard.

A larger number of radiographs should be used to decrease both the standard error and the confidence intervals, making it easier to detect significant changes. It is also recommended that future studies look specifically at the effects of radiograph numbers and its effect on kappa as well as looking at the comparability of the studies that have been done previously (e.g. a meta- analysis or systemic review).

A person in no way related to the study should also be used to complete answer sheets on behalf of participants. In this way, the “scribe” can insist on only one answer being circled where appropriate and also eliminate potential errors due to illegible handwriting.

PERIPHERAL STUDIES:

There is no data available on chiropractor’s use of radiology and radiography in South Africa or their perceptions of such practices. Also of interest, are patient perceptions of radiography and radiology in chiropractic and further studies into these fields should be addressed.

It is recommended that future studies look specifically at the effects of radiograph numbers and its effect on kappa as well as looking at the comparability of the studies that have been compiled previously (e.g. a meta- analysis or systemic review).

CLINICAL PRACTICE:

Radiology is a useful tool in the detection of contraindications to spinal manipulative therapy, but should be used to confirm suspicions of pathology after a thorough history, physical, orthopaedic and neurological examinations.

Further studies into patient management should be done – what tests would a chiropractor send a patient for to confirm or refute possible pathology seen on radiographs.

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APPENDIX 1.1: Letter to Radiography Department requesting use of radiographs from archives

08 June 2010

Dear Mrs S. Naidoo
HoD: Department of Radiography

Dear Mam,

RE: Request for access to and use of x-rays in radiography archives

I am currently putting together my proposal for my Chiropractic Master's Thesis. In order to do so I am required to complete a focus group for which I will need about 50 cervical radiographic plates (not series) of varying pathologies and conditions.

Thereafter I would require the same plates for review by up to 10 practitioners in order to complete the data collection of my proposal (once approved).

In this light, my study should take approximately 3 months and all x-rays will be returned to your department upon completion of my data collection.

I would be quite prepared to sign these plates out and have one of your staff members check which I have taken and again check that these are all returned when I submit them for returning to the archives.

Your favourable consideration of this request would be much appreciated.

Kind regards

Carla Marais
Research student
Contact : 0823911384

Dr Charmaine Korporaal
Research supervisor
Contact : 0832463562 / 031 3732611

APPENDIX 1.2: DUT Patient Consent Form

DURBAN INSTITUTE of TECHNOLOGY

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CONFIDENTIAL PATIENT INFORMATION

Date: .....

Male/ Female:.....

Surname: ..... Title: .....

First name: ..... Initials: .....

Birthdate: ..... I.D..number: .....

Occupation: ..... Marital status: .....

Medical aid: ..... M/A number: .....

Med doctor: ..... Last visit: .....

Chiropractor: ..... Last visit: .....

Postal address: Residential address:

....

....

....

....

Tel - work: ..... Tel - home: .....

Cell number: .....

Employer: .....

Employer's address:

.....

.....

Student/Student-intern/Intern: ..... PTO

FINANCIAL INFORMATION

The current fee schedule of the Chiropractic Day Clinic is :

Student (5th Year Students)		**Student Intern (6thYear Students)**	
Initial visit:	**R 50.00**	Initial visit:	**R 70.00**
Subsequent visits	**R 40.00**	Subsequent visits	**R 60.00**

All consumables (e.g. needles) : Prices are available on request at the reception desk.

Medical Aid schemes pay in varying degrees for coverage of Chiropractic Services. This coverage is therefore medical aid dependant and we request that you check with your medical aid in this respect. **The DIT Chiropractic Day Clinic is contracted out of medical aid**, which means that we run on a **strictly cash only basis**, whereby you are requested to pay cash in advance of services rendered. You will be sent a monthly statement which you must submit to your medical aid for them to refund you directly. This statement will be sent out at the **end of each month.**
Charges are **not** applicable to **research patients**

Medico-Legal Reports:
As the Chiropractic Day Clinic is a teaching facility we are not in a position to generate any reports required for medico-legal purposes**,** claims that relate to injury on duty (IOD) or workman's compensation

Report of findings:
It is imperative that the student / student intern treating you explains fully your diagnosed condition, both as an educational requirement for the intern but also, **and more importantly**, such that you are able to make an informed decision about the type of treatment that you wish to receive.

Treatment options:
It is imperative that the student / student intern explains all treatment options that are available for you based on the diagnosed condition/(s) that was/ were given to you in respect of the above.

Risks/Benefits:
The student / student intern must explain to your satisfaction / understanding all risks and benefits in relation to treatment of your reported diagnosis / condition(s).

As a Patient at this, the Chiropractic Day Clinic, I understand that I am attending an educational facility and I give my permission to allow observation, and if necessary the video recording of supervised examination and treatment by Doctors of Chiropractic and Interns. In addition I, as the patient note, that information generated through my attendance of the clinic, may be used for research purposes (either through my direct participation in the research or alternatively through data collected in my patient file).

By signing this form I agree that

a) I understand and take full financial responsibility for consultations.
b) I understand that I cannot request records for medico legal reasons.
c) I understand that should I be on medical aid, that my diagnosis and treatment information will be shared for the purposes of medical aid reimbursing me according to that which I am contractually bound in terms of my medical cover (and that only a written request or instruction from myself will be accepted in terms of discontinuing this practice by my health care provider – the Chiropractic Day Clinic).
d) The student / student intern has discussed with me to my satisfaction, and I fully understand, my / my minor child's diagnosed condition(s) that I have.
e) The student / student intern has discussed with me to my satisfaction, and I fully understand all treatment and/or non treatment options and their relative successes and/or failures as applicable to the diagnosed condition(s).
f) I am making an informed decision with regard to, and will submit to / consent to my minor child being submitted to, the treatment protocol as explained.

Date: ..... **Patient Signature:** .....

Date: ..... **Parent / legal guardian signature:** .....
(in the case of patient's who are under the age of 21 years)

Relationship of guardian to the minor: .....

Date: ..... **Intern Signature:** .....

Date: ..... **Clinician Signature:** .....

APPENDIX 2: Patient Permission Form

Dear Patient,

My name is Carla Marais and I am completing my Master's thesis in Chiropractic.

The title of my study is "The inter- and intra-examiner reliability of chiropractors identifying contraindications to cervical spine manipulation from radiographic diagnosis."

In order for me to complete this study, I require radiographs (x-rays) as a basis for the chiropractors to be able to participate in my study. After careful consideration of all the x-rays that I have been able to obtain, I have found that your particular x-rays are suitable for the purpose of assisting me with my research.

As a result I am required to ask you for your permission to use your x-rays.

If you feel that you would be able to assist by letting me use your x-rays, please understand that:

- Your name and personal information will be concealed from the practitioners.
- There will be no repercussions for you, should you allow me to utilize your x-rays.
- Your x-rays will be returned to you at the completion of the study should you so request.

I am making an informed decision with regard to the submission of my x-rays for use in Carla Marais study: YES NO

I agree for Carla Marais to use my x-rays YES NO

Date: ..... **Patient Signature:** .....

Date: ..... **Parent / legal guardian signature:** .....

(in the case of patient's who are under the age of 21 years)

Relationship of guardian to the minor: .....

Date: ..... **Researcher Signature:** .....

Date: ..... **Supervisor Signature:** .....

APPENDIX 3: Internet References for Electronic Radiographs

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APPENDIX 4: Final Answer Sheet

Radiograph No: _____

Participant	1	2	3	4	5	6

QUESTION 1: CATEGORISATION
Which <u>one</u> of the following choices <u>best</u> categorises the radiographic finding?

A) No abnormal/pathological finding
B) Degenerative changes
C) Congenital/Normal variant
D) Inflammatory Arthritis
E) Trauma
F) Blood (haematological)
G) Infection
H) Tumour
I) Endocrine, nutritional, metabolic
J) Soft Tissue

QUESTION 2: MANAGEMENT
You are about to adjust this patient's spine (Gonstead, diversified etc) in the region of the spine that is depicted on the radiographs. Which one of the following management plans is most appropriate given the radiographic findings:

1. No pathological findings. Proceed with spinal manipulative therapy.

2. Abnormal findings of no/limited clinical significance.
   Proceed with precautionary spinal manipulative therapy above or below the lesion depicted.

3. Abnormal findings of clinical significance.
   Refer patient for consultation or further studies (laboratory and/or imaging). Proceed with precautionary spinal manipulative therapy above or below the lesion depicted.

4. Abnormal findings of great clinical significance.
   Refer patient for consultation or further studies (laboratory and/or imaging). Do not perform spinal manipulative therapy to region of the spine depicted on the radiograph.

QUESTION 3: IDENTIFICATION
If abnormal finding(s) are noted, what is the name of the condition or disease that they represent?

COMMENTS:

APPENDIX 5: Letter of Information and Informed Consent for Focus Group

Title: The inter- and intra-examiner reliability of chiropractors of radiographic skills.
Name of Researcher: Carla Marais (0823911384)
Name of Supervisor: Dr C Korporaal (0832463562)
Name of Institution: Durban University of Technology

Welcome to my focus group, and thank you for your interest and participation.

The purpose of a focus group is to stimulate members of a group's thinking, and encourage them to develop ideas about the topic (Salant and Dillman, 1994). This will enable unanimous agreement of the cervical radiographs required in this study, as well as to add to, delete from or modify for clarity, the corresponding answer sheet participants will be asked to complete for each radiograph.

Introduction:
Plain film radiography is the most common imaging technique requested by chiropractors to assist in the diagnosis and management of patients with musculoskeletal complaints (Marchiori, Adams and Henderson, 1999; Yochum and Rowe, 2005). Philips (1992) also mentions excluding pathology and biomechanical evaluation as reasons why chiropractors use x-rays.

Spinal manipulative therapy (SMT) requires a high-velocity, low amplitude force to the spinal vertebra and therefore certain absolute and relative contraindications to SMT exist (Gatterman, 2003; Haldeman, 2005). According to Peterson and Bergmann (2002), "manual therapy is contraindicated when the procedure may produce an injury, worsen an associated disorder or delay appropriate curative or life-saving treatment."

Several studies have focused on the inter- and intra-examiner reliability of certain professions on lumbar spine radiograph reading (Philips, Frymoyer, Mac Pherson and Newburg, 1986; Coste, Paolaggi and Spira, 1991; Assendelft, Bouter, Knipschild and Wilmink, 1997; De Zoete, Assendelft, Algra, Oberman, Vanderscheuren and Bezemer, 2002). No studies to date however have focused

specifically on chiropractors' accuracy of cervical radiographic diagnosis which this study aims to do.

Inter-observer variation in image interpretation is recognised and should be kept to a minimum in order to lead to a more consistent patient approach and management (Tudor, Finlay and Taub, 1997). This study will also assess South African chiropractors, practising in Durban, accuracy at diagnosing contraindications to cervical SMT. The study will be conducted over two rounds and six participants will diagnose 60 cervical spine radiographs in total (30 each round).

Procedure:

You will be given time to observe each radiograph and any comments made will be documented by the researcher. A discussion will then be held in order to reach a unanimous diagnosis for each radiograph. Once 30 radiographs have been selected, the focus group will be asked to assess an answer sheet which participants in the study will complete for all 30 x-rays and from which data analysis will occur. The purpose of the focus group will be to ensure the answer sheet adequately covers the range of radiographs used in the study and to ensure user friendliness.

The entire process should take approximately two hours and for reference and marking purposes will be filmed. Please be assured however, that any personal details as well as any information, which you furnish, will be treated confidentially and will not be published.

Thank you for your time.

For any further questions, please contact:

Researcher: Carla Marais (0823911384)
Supervisor: Dr C Korporaal (0832463562)

Statement of Agreement to Participate in the Research Focus Group:

I, ……..(subjects full name), ID number……., have read thus document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by Carla Marais to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences; and my future health and relationship with the Durban University of Technology Chiropractic Day Clinic will not be compromised. I, therefore, voluntarily agree to participate in this focus group.

Subject's name (print):…….
Subject's signature:……. Date:……..
Researcher's name: Carla Marais
Researcher's signature:……. Date:……..
Supervisor's Name: Dr. Charmaine Korporaal
Supervisor's signature:……... Date:……..

APPENDIX 6 – Code of Conduct Agreement for Focus Group

This form needs to be completed by every member of the Focus Group prior to the commencement of the focus group meeting.

As a member of this committee I agree to abide by the following conditions:

1. All information contained in the research documents and any information discussed during the focus group meeting will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.
2. None of the information shall be communicated to any other individual or organisation outside this specific focus group as to the decisions of this focus group.
3. The information from this focus group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

MEMBER'S NAME	SIGNATURE	CONTACT NUMBER

APPENDIX 7: Final List of Radiographs

CASE	VIEWS	CLASSIFICATION	DIAGNOSIS
1	1 Lateral	Trauma	"Teardrop" fracture of C5 with anterior dislocation of C6
2	2 AP and Lateral	NAD	NAD Loss of normal cervical lordosis; Minimal anterolisthesis of C2 on C3
3	2 AP and Lateral	NAD	NAD Loss of normal cervical lordosis
4	2 AP and Lateral	Trauma	"Burst" fracture of C5
5	5 AP; R + L Obliques; Flexion and Extension	NAD	NAD Spondylosis C4/C5
6	3 Open Mouth, AP and Lateral	NAD	NAD Spondylosis C4/C5
7	2 Flexion and Extension	Trauma	Subluxation on C2 onto C3 seen on extension view only; Marked cervical spondylosis
8	2 R + L Lateral	Tumour	Prevertebral mass at C1 – P.M report = Multiple Myeloma
9	5 AP; R + L Obliques, Swimmer's View	Trauma	Fracture of spinous process of T1
10	1 Lateral	Congenital	Agenesis of the Atlas Posterios Arch
11	1 Lateral	Congenital	Congenital vertebral fusion/block vertebrae of C6 and C7
12	1 Lateral	Congenital	Congenital vertebral fusion/block vertebrae of C2 and C3
13	2 AP and Lateral	Trauma	Fracture of neural arch (lamina) of C6 and Fractured spinous process of C7
14	2 AP and Lateral	Trauma	NAD Mild DJD; Marked loss of lordosis
15	1 Lateral	Congenital	Congenital vertebral fusion/block vertebrae of C2 and C3
16	2 AP and Lateral	NAD	NAD DJD of C5 and C6
17	1 Lateral	Trauma	Fracture of lamina and spinous process of C2 (Hangman's fracture)
18	1 Lateral	Trauma	Fracture of C2 lamina
19	4 Flexion and Extension; R + L Obliques	NAD	NAD
20	2 AP and Lateral	NAD	Degenerative C4 Anterolisthesis Major DJD
21	2 AP and Lateral	Congenital	Hypoplastic Posterior Arch of C1 and hypertrophy of C2
22	2 AP and Lateral	NAD	NAD
23	6 AP; Lateral; R+L Obliques; Flexion	NAD	NAD DJD at C6 and C7

	and Extension		
24	1 Lateral	Arthritis	Ankylosing Spondylitis
25	1 Lateral	Arthritis	Atlantoaxial Instability caused by RA
26	1 Lateral	Arthritis	Diffuse Idiopathic Skeletal Hyperostosis
27	2 Open Mouth and Lateral	Trauma	Type II Odontoid Fracture
28	1 Lateral	Arthritis	Ossification of the Posterior Ligament
29	1 Lateral	Trauma	Extension Teardrop Fracture of C2
30	1 Lateral	Tumour	Pathologic fracture of C4 vertebral body as a complication of Metastatic Disease

APPENDIX 8: Case Histories

CASE #	CASE HISTORY
1	A 36 year old male patient was brought to your clinic in a wheelchair after a MVA left him with paralysis in all four limbs, loss of pain, temperature and touch sensations, but preservation of position sense, motion and vibration.
2	A 21 old male patient presents to your clinic complaining of headaches and blurred vision. He attributes these symptoms to long hours at his desk study for exams and stress.
3	A 30yr old hairdresser complains of bilateral “shoulder” and neck pain. She is taking up to 8 Myprodol a day without much relief. She shows her pain to be over her trapezius regions bilaterally, between her shoulder blades and the back of her neck. She occasionally feels like her arms are weak, but attributes it to her profession and the way she stands while working. She was involved in a MVA when she was 18. She was in the front passenger seat. They were pulling off at a green light when they were hit on the right hand side by a car that jumped a red light.
4	A 26yr old house wife presents you your clinic complaining of terrible headaches and stiffness after being involved in an MVA 5 days prior to visiting your office. She was in the passenger seat and not wearing her seatbelt. She was flung from the vehicle and onlookers reported her landing head first before losing consciousness temporarily. She refused to go to hospital as she does not have medical aid and could not afford hospital bills. She has weakness in both upper limbs, with decreased sensation and reflexes.
5	A 53 year old African female patient presents to your clinic with neck and arm pain which she describes as a deep ache. She has had the neck pain intermittently for years, but the arm pain has only recently started. Previous treatment for her neck pain was pain killers prescribed to her by her medical doctor. She has been a personal assistant for ten years and spends many hours on the phone or working at her desk. She was involved in a MVA in her early 20s, but never received any treatment at the time.
6	A 38yr old horse riding instructor that you have been treating for chronic lower back and neck pain and stiffness for several years presents to your clinic after a particularly nasty fall from her horse the day before. She was wearing her riding helmet, but landed head first. She did not lose consciousness, but has had a severe headache since the fall.
7	A 60yr old Indian male patient tripped over a stone and fell directly onto his face two days ago. He now has weakness of all four limbs (quadriparesis). These radiographs were taken the day after the accident. He has a history of severe hypertension and smokes half a box of cigarettes a day, but is trying to quit.
8	A 62yr old African female patient presents to your practice with intermittent non-specific neck pain and stiffness of three weeks duration. She does not bring her previous radiographs with her, only the radiographers report which reports no abnormalities. Four months later she returns to you with the same complaint, except now the pain is continuous and she shows signs of anaemia and reports coughing up blood.

9	A 36 year old man comes in complaining of a burning “knife-like” pain at the base of his neck and between his shoulder blades. He gyms daily and part of his routine is 30 minutes of wrestling/grappling with his gym partner.
10	A 40 yr old African male comes to see you complaining of non specific neck pain. He has experienced the pain intermittently for “many years”. There is no history of trauma and neurological examination was negative.
11	A 35 year old African male farm worker is brought to your practice after falling off the back of a trailer and injuring his neck. He has a history of tuberculosis for which he is currently receiving treatment.
12	A 66 year old white retired teacher presents to your practice with intermittent non specific neck pain and headaches. She finds that her pain is worse in the morning but that it subsides as she starts to move around. The main reason she is coming to see you however is because she is finding it increasingly more difficult to drive as she battles to look over her shoulders. There is no history of any previous major trauma.
13	A 36yr old African male patient presents to your practice with a painful and stiff neck after been thrown from a motor vehicle during an accident.
14	A 31yr old white male who is an avid triathlete presents to your clinic with headaches and neck stiffness which has been getting progressively worse. There is no history of any major trauma, but he has fallen off his bike several times, hitting his head but never losing consciousness. He is also a financial consultant and spends many hours behind his desk at a computer and on the phone. The headaches start gradually during the day and the pain and stiffness is worse at night. He tries to avoid pain medication, but has been taking the occasional voltaren tablets to relieve some of the pain.
15	A 40 year old African male presents to your practice with a painful neck and pain in both his shoulders and both upper limbs for many years. Muscular weakness of both upper limbs was observed. There is no history of trauma. Neurological examinations and deep tendon reflexes are normal.
16	A 35 year old white male presents to your clinic with neck pain after straining to pick up a heavy box. He heard a “click” and then felt pain. There is no history of trauma. On examination he demonstrated slight muscle weakness bilaterally with shoulder abduction and elbow flexion and supination.
17	A 39yr old white female presents to your practice wearing a soft collar after being the third car in a six car pile-up on the highway a day ago. She was driving and wearing her seatbelt and on impact the airbag did deploy. She hit the car in front of her at approximately 70km/h and was then hit from behind several seconds later by another car also travelling approximately 70km/h.
18	A 25yr old inter-professional male rugby player presents to your practice after getting drunk with his friends at the beach over the weekend and diving into the ocean and hitting his chin on a rock. Since the accident, 2 days ago, he has had a severe headache and from the back of his neck, head and behind his eyes. He also complains of stiffness and a

	decreased range of motion.
19	A 45yr old white male presents to your practise. He has noticed increasing pain and numbness in his right arm over the last several weeks.
20	A 57 year old bar owner presents to you with neck and lower back pain. He has no history of trauma, but he does carry heavy boxes all day, drinks alcohol every night, smokes a pack of Texan daily and does no physical activity.
21	A 39 year old male started complaining of neck pain and stiffness after playing touch rugby with his friends while on holiday 2 weeks ago. The symptoms are dull and intermittent. There is no previous history of trauma and no neurological deficit evident.
22	A 33 year old white female presents to your clinic with severe headaches for "many years." She has no history of major trauma but was an avid hockey player in her younger days and had a few falls on the field. She takes Myprodol daily and the occasional migraine pack.
23	A 28 year old male patient presents to your practice complaining of migrane type headaches behind his right eye. He says that the right side face goes numb and droops a little. He also suffers with neck stiffness which is usually is worst when relaxing after any kind of physical activity or in the morning when crawling out of bed. He finds that 2 extra strength neurofen and 2 panados with half and hour rest relieves his headaches. He grew up on a farm and used to ride off road motorbikes and reports having several falls. He played "social" 4th team rugby at school and during one game was concussed.
24	A 25 year old provincial cricketer presents to your clinic with lower back and neck pain and stiffness. He is very active and at first thought the stiffness was caused by his activity. No matter how much he stretches though, the stiffness does not improve and in fact he feels that it is getting worse. He finds driving difficult as he cannot turn his head to check his blindspots.
25	A 48 year old female patient presents to your clinic with neck pain, tenderness and stiffness, particularly in the morning. She's noticed the morning stiffness for a few months but put it down to stress as she is currently going through a divorce. She has also noticed that her fingers are swollen as she cannot remove her wedding ring.
26	A 58 year old male with a history of diabetes presents to your clinic with generalised neck pain and morning stiffness. He also shows you his left Achilles tendon which is painful and appears to be swollen and has nodular masses on palpation. He also complains about having pain and difficulty swallowing at times.
27	A 44 year old male patient presents to your clinic complaining that his head feels unstable on his neck. He was involved in a head-on-collision 3 days ago. He was taken to the hospital where he had these x-rays taken. He was cleared by the radiologist of any pathology and released.
28	A 52 year old male presents to your clinic with spontaneous progressive weakness of all limbs of two months duration. There is no history of trauma. On examination the patient has sensory loss, is hyper-reflexic and muscle power is Grade IV.

29	A 58 year old female, suffering with influenza, presents to your clinic after fainting two days previously and hitting her forehead on a wall. She is complaining of neck pain, tenderness to palpation, especially posteriorly and limited range of motion.
30	A 31 year old female patient presents to your clinic with pain in her cervical spine area. There is familial history of breast cancer and several years prior to visiting your clinic, she herself had a mastectomy for carcinoma.

APPENDIX 9: Letter of Information and Informed Consent for Participants

TITLE OF RESEARCH STUDY: Chiropractors inter- and intra-examiner reliability of cervical spine pathologies identified on radiographs and their impact on clinical management of the patient.

Name of Researcher: Carla Marais (0823911384)
Name of Supervisor: Dr C Korporaal (0832463562)
Name of Institution: Durban University of Technology

Introduction and Purpose of study

Welcome to my study, and thank you for your interest and participation. The purpose of this study is to investigate inter- and intra-examiner reliability of chiropractors identifying radiographic diagnoses and the related patient management protocols. In addition the influence of clinical history on these radiographic diagnoses will be determined.

Plain film radiography is the most common imaging technique requested by chiropractors to assist in the diagnosis and management of patients with musculoskeletal complaints (Marchiori, Adams and Henderson, 1999; Yochum and Rowe, 2005). Inter-observer variation in image interpretation is recognised and should be kept to a minimum in order to lead to a more consistent, effective and safe approach to patient management (Tudor, Finlay and Taub, 1997). As a result of the importance of this, several studies have focused on the inter- and intra-examiner reliability of certain professionals on lumbar spine radiograph reading (Coste, Paolaggi and Spira, 1991; De Zoete, Assendelft, Algra, Oberman, Vanderscheuren and Bezemer, 2002). However there is a paucity of literature focused specifically on chiropractors' inter- and intra-examiner reliability of cervical radiographic diagnosis. This is of particular relevance when considering Philips (1992) and Peterson and Bergmann (2002), who state that manual therapy[1] is contraindicated when the procedure may produce an injury, worsen an associated disorder or delay appropriate curative / life-saving treatment. Therefore this study will assess South African chiropractors' (practising in Durban), inter- and intra-examiner reliability of their radiographic skills.

[1] Spinal manipulative therapy (SMT) requires a high-velocity, low amplitude force to the spinal vertebra and therefore certain absolute and relative contraindications to SMT exist (Gatterman, 2003; Haldeman, 2005).

Procedure:

You will be visited individually by the researcher. Films will be viewed on your premises while the researcher waits. All 30 radiographs will be handed to you and you will be allocated two hours to view the radiographs and complete the corresponding answer sheets. Answer sheets from each participant will be collected and sealed into blank envelopes to ensure anonymity. Round one's data collection and analysis will only begin once all envelopes have been collected. Round two will follow the same procedure.

Costs of the study: There will be no costs involved for you as a participant.

Confidentiality: Confidentiality will be maintained by each participant picking a number out of a box to which the researcher will be blinded. Only that number will be written on each answer sheet to ensure anonymity.

For any further questions, please contact:

Researcher: Carla Marais (0823911384)

Supervisor: Dr C Korporaal (0832463562)

Statement of Agreement to Participate in the Research Study:

I,.....……..(subjects full name) ID number……....., have read thus document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by Carla Marais to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences; and my future health and relationship with the Durban University of Technology Chiropractic Day Clinic will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subject's name (print):	……	
Subject's signature:	……	Date:……..
Researcher's name:	Carla Marais	
Researcher's signature:	……	Date:……..
Supervisor's Name:	Dr. Charmaine Korporaal	
Supervisor's signature:	……..	Date:…….

APPENDIX 10: Letter from Statistician

From: Glen home <glenhome@ensignship.com>
To: camarais@gmail.com

Date:Thu, Sep 2, 2010 at 8:55 PM
Subject: Protocol

Hi
It looks like a very good and well thought out study. I just had to make one small change to the stats analysis part.
See attached.
Regards
Tonya

Tonya Esterhuizen
Fax: 0865513770

APPENDIX 11: Ethics Clearance Certificate

DURBAN UNIVERSITY of TECHNOLOGY

Faculty of Health Sciences

ETHICS CLEARANCE CERTIFICATE

Student Name	CARLA MARAIS	**Student No**	20300544
Ethics Reference Number	040/10	**Date of FRC Approval**	11/10/2010
Qualification	**M.Tech Chiropractic**		
Research Title:	Chiropractors inter and intra-examiner reliability of cervical spine radiographic analysis and its impact on clinical management		

In terms of the ethical considerations for the conduct of research in the Faculty of Health Sciences, Durban University of Technology, this proposal meets with Institutional requirements and confirms the following ethical obligations:

1. The researcher has read and understood the research ethics policy and procedures as endorsed by the Durban University of Technology, has sufficiently answered all questions pertaining to ethics in the DUT 186 and agrees to comply with them.
2. The researcher will report any serious adverse events pertaining to the research to the Faculty of Health Sciences Research Ethics Committee.
3. The researcher will submit any major additions or changes to the research proposal after approval has been granted to the Faculty of Health Sciences Research Committee for consideration.
4. The researcher, with the supervisor and co-researchers will take full responsibility in ensuring that the protocol is adhered to.
5. ***The following section must be completed if the research involves human participants:***

	YES	NO	N/A
❖ Provision has been made to obtain informed consent of the participants	X		
❖ Potential psychological and physical risks have been considered and minimised	X		
❖ Provision has been made to avoid undue intrusion with regard to participants and community	X		
❖ Rights of participants will be safe-guarded in relation to: - Measures for the protection of anonymity and the maintenance of Confidentiality.	X		
- Access to research information and findings.	X		
- Termination of involvement without compromise	X		
- Misleading promises regarding benefits of the research	X		

[redacted]

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