Inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

By

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Dissertation submitted in partial compliance with the requirements for the Masterôs degree in Technology: Chiropractic Durban University of Technology

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

_____ _____

Zandile Mdakane Date

Approved for final submissions

_____ _____

Dr Zandile Twala Date

DEDICATION

To my parents: Thank you for the support throughout the years. It wasn't easy but you kept on believing in me. Thank you for the prayers.

To my sisters: Thank you for always encouraging me when I was down with no strength but you kept me going

To Mlungisi Mgaga: Thank you for the love and support you gave me. You never gave up on me instead you gave me a shoulder to cry on when Chiropractic was challenging me.

ACKNOWLEDGEMENTS

Dr Zandile Twala:	Thank you my supervisor. I wouldn't be here without your assistance. You kept pushing me in the right direction and showing me the light. Thank you.
Dr C. Korporaal:	Thank you for being there for me and helping me with anything I would ask for.
Miss Pillay:	Thank you for the administrative work you did for me. You never complained when I needed different letters all the time. Thank you.
Mr Singh Deepak:	Thank you for the statistics that we used for the study.
To my varsity friends:	We laughed and cried together throughout the years but we were always there for each other. Thank you.
My extended family:	Thank you for your prayers
Examiners:	Thank you for participating.

ABSTRACT

INTRODUCTION

Radiographs are the most commonly used modalities for the purpose of diagnosing skeletal disorders. Radiographs are important for chiropractors to exclude any contra-indications prior to spinal manipulative therapy. If contra-indications are found treatment is modified to what best suits each patient. There is a gap in the literature regarding chiropractors reading the same set of radiographs and agreeing on findings.

OBJECTIVES

The study investigated inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

METHODS

Inter- and intra-examiner examination of radiographs occurred in two rounds separated by two weeks. Six chiropractors read the same 30 radiographs and clinical history was only available in the second round.

RESULTS

Inter-observer agreement for categorisation for Round One was 96.78% and Round Two 89.49%. Inter-observer agreement in management was 96.45% in round one and 96.00% in Round two. Agreement between chiropractors had no statistically significant difference. Identification average improved from 0.09 to 0.89 kappa. Overall specificity was relatively high and sensitivity was relatively low.

CONCLUSION

Reliability/Agreement between chiropractors was strong in both rounds. Categorising of the diagnosis improved from poor to substantial from Round One to Round Two. Case history improved the accuracy of interpreting the radiographs although this change was not statistically significant.

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LIST OF ABBREVIATIONS

AHPCSA:	Allied Health Profession Council of South Africa
CASA:	Chiropractic Association of South Africa
DC:	Doctor of Chiropractic
M-Tech:	Masters of Technology
SMT:	Spinal Manipulative Therapy
ICC:	inter- and intra-class correlation coefficients
L:	Lumbar vertebra
S:	Sacral vertebra
MAD:	The mean absolute differences
DJD:	Degenerative Joint Disease

LIST OF DEFINITIONS

Adjustment: Any chiropractic therapeutic procedure that utilises controlled force, leverage, direction, amplitude and velocity that is directed at specific joints or anatomical regions. Chiropractors often use such procedures to influence joint and neurophysiological function (Gatterman 2005:136).

Cobb L1–S1 method: The angle between the superior endplate of L1 and the superior endplate of S1 (Young Hong et al. 2010:1552).

Cobb L1–L5 method: The angle between the superior endplate of L1 and the inferior endplate of L5 (Young Hong et al. 2010:1552).

Contra-Indication: A problem identified before a procedure is applied that would make the application of the treatment inadvisable because of the potential to cause harm or delay appropriate treatment (Peterson and Bergman 2002).

Centroid method: The vertebral body centroids were approximated by then intersections of the body diagonals using all four vertebral body corners (L1, L2, L5). The intersection of the perpendicular lines drawn from the proximal line (Young Hong et al.2010:1552).

Inter-examiner reliability: The degree that results correspond between one examiner and another, using the same patient (Haldeman 2005:303).

Inter-rater reliability/ inter-rater agreement: The degree of agreement among raters (Gwet 2014:4).

Manipulation: A manual procedure that involves a directed thrust to move a joint past the physiological range of motion, without exceeding the anatomical limit (Gatterman 2005:136).

Manual therapy: Procedures by which the hands directly contact the body to treat the articulations and/or soft tissues (Gatterman 2005:136).

Mobilisation: Movement applied singularly or repetitively within or at the physiological range of joint motion, without imparting a thrust or impulse with a goal of restoring joint mobility (Gatterman 2005:136).

Null Hypothesis: The statement that relates to population and assumes no effect in the population (Petrie 2010:1193).

Posterior tangent L1–S1 method: Posterior tangent lines are drawn through the posterior-superior and posterior-inferior body corners of L1and S1. The angles are constructed by intersecting the tangents on the cranial and caudal segment of the curve (Young Hong et al.2010:1552).

Red Flag: Warning of danger (Stevenson and Waite 2011).

Reliability: A general term which encompasses repeatability, reproducibility and agreement of the same thing (measurement) which will result in similar results (Gwet 2014:4).

TRALL method: The largest perpendicular distance to the posterior longitudinal ligament from a line connecting the posterior-inferior of S1 and the superior-posterior body corner of L1isused to locate the lumbar curve apex. This apex point is used for the vertex of the angle with the L1 and S1sides (Young Hong et al.2010:1552).

CHAPTER 1 :INTRODUCTION

1.1 INTRODUCTION

Radiography and radiology have been part of the chiropractic curriculum ever since 1910 (Gatterman 2005: 117). Linaker (2015: 1-8) stated that Chiropractic schools trained for 300-400 hours in three to four years where they are trained on radiation physics, radiation protection, normal radiographic anatomy, bone pathology and soft tissue pathology. In training the chiropractors acquired skills of interpreting plain film radiograph and to have better understanding of reports from radiologist (Linaker 2015:1-8). Chiropractors need the training and skills of radiographs to adequately interpret images when radiologist is not available and to know what imaging modality to order for specific disorders (Linaker 2015: 1-8). Taylor and Resnick (2000: 218) mentioned that red flags may be missed during history taking, physical examination, orthopaedic and neurological testing. Therefore, taking radiographs allow visualisation of the red flags that will make the diagnosis and management of patients more appropriate (Taylor and Resnick 2000: 228-327). Radiographs do not always come with a report which is why interpretation of radiographs by chiropractors must be accurate (Taylor 1990: 30). This chapter will include the background, aims and objectives of this study.

1.2 BACKGROUND

Ammendolia et al. (2008: 414) and Rowe and Yochum (2005: 1) stated that radiography is the imaging modality that is used most often to diagnose skeletal disorders and guide appropriate management of musculoskeletal disorders. It is easily available and relatively inexpensive (Rowe and Yochum 2005: xxvii). Radiographs are important for chiropractors to exclude any possible contra-indications to spinal manipulative therapy to prevent serious injuries to patients or delay of necessary treatment (Gatterman 2005: 116). Chiropractors must be able to interpret the radiographs and see contra-indications (Jackson 2001: 27).

Interpretation of radiographs by chiropractors is important if they have their own radiographic machines (Jackson 2001: 27). When these chiropractors refer patients they must be able to interpret radiographs to prevent misunderstandings between chiropractors and radiologists (Berlin 1999: 1516). Misunderstanding in regards to radiologistsô meaning may be as a result of not being transmitted correctly to the referring chiropractor or any other physician (Berlin 1999: 1516). Tudor, Finlay and Taub (1997: 235) stated that they have recognised errors in interpretation of plain film radiographs and Nesterova et al. (2009: 179) agreed that interpretation errors were more common in paediatrics intensivists. Errors in interpretation lead to change in patientôs management (Nesterova et al. 2009: 179). To this end, Robinson (1997: 1085) contends that common causes of misinterpretation of radiographs include limitations of technique, unavailability of previous studies or reports, false positive errors on radiographs, incomplete scanning of patients, misinterpretation of findings by physicians, lack of knowledge with regards to interpreting radiographs, errors in judgement of radiographs or a combination of these factors. Tudor, Finlay and Taub (1997: 236) also mention that knowledge of clinical history increased accuracy in the interpretation of radiographs. Good et al. (1990: 712) indicate that even if clinical history does not improve accuracy for detection of diseases or interpretation of radiographs it may have an important role to play in determining the specific nature and significance of detected abnormalities.

Contra-indications found on radiographs may affect management of patients in terms of spinal manipulative therapy (SMT) (Oliver, Timchur and McCarthy 2007: 119-121). Management of patients will depend on whether it is an absolute contra-indication and no thrust is used or relatively contra-indicated where thrust is used with caution this will depend on the stage of disorder (Peterson and Bergman 2011: 92). When a chiropractor does a manual therapy to a contra-indicated spine it may lead to injury or worsen the disorder (Peterson and Bergman 2011: 92). Contra-indications are best viewed in radiographs and they help determine diagnosis and management (Rowe and Yochum 2005: 1). Therefore, there is a lack of literature specifying that chiropractors are consistently able to interpret the same radiographs when given a particular set of lumbar spine radiographs, this study aimed to investigate inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

1.3 AIM AND OBJECTIVES OF THE STUDY

To investigate inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

1. To determine inter-examiner reliability of lumbar spine radiograph analysis by chiropractors.
2. To establish intra-examiner reliability of lumbar spine radiograph analysis by chiropractors.
3. To determine if clinical history alters inter-examiner reliability and alters intra-examiner reliability of lumbar spine radiograph diagnoses.
4. To determine the influence of identifying lumbar spine radiographic contra-indications on patient management.

1.4 NULL HYPOTHESES

1. Correlation of inter- and intra-examiner reliability of lumbar spine radiographs will be low.
2. Clinical history will not significantly alter the intra- and inter-examiner reliability of lumbar spine radiograph diagnoses.
3. Contra-indications of lumbar spine radiographs to chiropractic management will not influence management.

1.5 SCOPE OF THE STUDY

Six qualified chiropractors with an average of ten years of experience practising as a chiropractor, and residing in eThekwini district area, participated in the study. A set of radiographs which met the inclusion criteria were viewed in two rounds. Patient clinical history was only available in the second round.

1.6 DELIMITATIONS

1. The study was limited by using lumbar spine radiographs which did not have corresponding patient files.
2. This study relied on participants being open and honest when completing data sheets.
3. Only Chiropractors in eThekwini district were included in the study.

1.7 CONCLUSION

It is, therefore, evident that emphasis is being placed on the reliability and validity of the ability to read radiographs as this has an impact on clinical practice. Plain film radiographs are important in a chiropractorôs life for the safety and benefit of the patient in ruling out pathologies (Peterson and Bergman 2002: 79). Chiropractors must see the same things on radiographs to treat the patient appropriately and in the same way (Wilke et al. 2006:720-730). Inter-examiner variation in image interpretation should be kept to a minimum at all times between practitioners (Tudor, Finlay and Taub 1996:235). Therefore, this study sets out to investigate inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

CHAPTER 2 : REVIEW OF THE LITERATURE

2.1 INTRODUCTION

This chapter will focus on the literature surrounding the history and use of radiographs, and the importance of radiographs in patients with contra-indications to spinal manipulative therapy, the influence of clinical history on diagnosis and management of patients, misinterpretation in reporting and previous literature on radiograph interpretation.

2.2 HISTORY OF RADIOGRAPHS AND THEIR USE

Radiographs were accidentally discovered by Wilhelm Conrad Roentgen in 1895 (Rowe and Yochum 2005: xxvii). Roentgen was a professor in the University of Wurzburg in Germany when he was doing an experiment in his laboratory related to a cathode ray tube when he noticed a plate covered with barium platinocyanide located at a distance away beginning to fluoresce. The rays were named x-ray, the ñxò relating to the unknown and invisible rays from the cathode tube. Roentgen conducted an X-ray of his wifeôs hand in 1895 (Rowe and Yochum 2005: xxvii).In 1934 Sausser, a chiropractor, was the first to produce single exposures of anteroposterior full spine radiographs.

Gatterman (2005: 117) reported that in 1910 the Palmer School of Chiropractic in Davenport, Iowa, bought the first radiographic machine. Since then, radiography and radiology have been part of chiropractic curriculum (Gatterman 2005: 117). According to Ammendolia et al. (2008: 556), undergraduate chiropractors spend an average of 300 hours training on interpreting and taking radiographs. Chiropractic schools use evidence based diagnostic imaging practice guidelines and the curriculum consists of monthly half day training sessions that focus on specific skills either instructional designs, teaching skills or professional development, self-improvement activities involving reflection and completion of faculty development

projects (Bussieres, Taylor and Peterson 2007: 686). Chiropractors always attend continuing education classes on radiology where they include pathology, metabolic, development degeneration, anomalies and biomechanics (Murphy 2013:1-8). Development and implementation of technology has made it easier for students to learn and instructors to teach in the same way (Rush and Boone 2009: 43). Ever since 2004 radiographs anatomy class averages improved from level C and now it is significantly higher (Rush and Boone 2009: 43). Radiographs are used to detect abnormalities and lead to more effective treatment (Rowe and Yochum, 2005: 1).

Plain film radiographs are one of the most affordable imaging techniques used to diagnose skeletal disorders and guide the management of musculoskeletal disorders (Rowe and Yochum 2005: 1). Even though there was advancement of technology to computed tomography (CT) scans and magnetic resonance imaging (MRI), radiographs are still the examination of choice due to easy availability and affordability (Rowe and Yochum 2005: xxxvii).Peterson and Bergmann (2011: 79) concur with Gatterman (2005: 116) when he stated that chiropractors utilised radiograph to establish clinical (pathologic) diagnosis, to evaluate biomechanics and posture, identify anomalies or structural changes that will modify adjustment, screen for contra-indications and monitor degenerative processes. Gatterman (2005: 116) also reported that chiropractors send for radiographs for nonclinical reasons too, namely force of habit, medicolegal advantage and patient education.

There are several views requested by chiropractors for the lumbar spines which are listed in Appendix L (Rowe and Yochum 2005: 50-67).Views of lumbar spine include:

- Anteroposterior Lumbopelvic Projection which views lumbar vertebrae, pelvis, hips, proximal femora and soft tissues of abdomen.
- Lateral Lumbosacral Projection which views lumbar vertebrae, sacrum, coccyx and soft tissue of pelvis, abdomen and lower chest.
- Oblique Projection which views the scotty dog ï transverse processes, pedicle, articulating processes, facet joint, pars interarticularis and lamina and additional view of vertebrae body and abdominal soft tissues.
- Anteroposterior Lumbosacral Spot Projection which views L5 vertebra and disc, upper sacrum and sacro-iliac joints.

- Lateral Lumbosacral Spot Projection which viewsL5 vertebra and disc, upper sacrum and adjacent soft tissues.

Radiographs are important for chiropractors to exclude any possible contra-indications to spinal manipulative therapy to prevent serious injuries to patients or delaying of necessary treatment (Gatterman 2005: 116).

2.3 THE IMPORTANCE OF RADIOGRAPHS IN PATIENTS WITH CONTRA-INDICATION TO SPINAL THERAPY

Peterson and Bergmann (2011: 85) agreed with Gatterman (2005: 136) that spinal manipulative therapy (SMT) is a manual procedure that involves a directed thrust to move a joint past the physiological range of motion without exceeding the anatomical limits. According to Gatterman (2005: 136) adjustment is any chiropractic therapeutic procedure that uses controlled force, leverage, direction, amplitude and velocity that is directed at a specific joint or anatomical region. Manipulation is utilised to treat neuromuscularskeletal system by decreasing pain, improve joint range and quality of motion (Peterson and Bergmann 2011: 84). Gatterman (2005: 137) states that SMT may have the following effects:

- Mechanical effects:
  - Joint alignment;
  - Dysfunction of motion;
  - Spinal curvature dynamics; and
  - Entrapment of synovial fold.
- Soft tissue effects:
  - Changes in the tone and strength of supporting musculature; and
  - Influencing the dynamics of supportive capsule-ligamentous connective tissue.
- Neurological effects:
  - Reduction in pain;
  - Altering motor and sensory function; and
  - Influencing autonomic nervous system regulation.
- Physiological effects:
  - Placebo effect

- Patient satisfaction

Not all conditions will benefit from SMT especially if dysfunction associates with conditions that contra-indicate it (Peterson and Bergmann 2011: 92). According to Peterson and Bergman (2011: 92) a contra-indication is a problem identified before the procedure is applied and it makes the treatment inadvisable due to potential harm that can occur or because it could delay appropriate treatment. When there is absolute contra-indication a patient must be referred to the appropriate doctor and when it is relatively contra-indicated caution should be used in applying manipulative therapy (Peterson and Bergmann 2011: 92). Lumbar spine complications may include disc related complications, vascular complications from thrombosis, fracture in the presence of osteoporosis, rib fracture, inguinal and abdominal hernias(Peterson and Bergmann 2011: 103) (see Appendix M for a list of conditions that are contra-indicative or require modification to spinal therapy).

As mentioned above, chiropractic treatment may have adverse effects when treating a patient with a contra-indication; radiographs assist in identifying the red flags which may be missed during history taking, physical examination, orthopaedic and neurological testing (Resnick and Taylor 2000; Redwood and Cleveland 2003: 237). There has been advancement in technology with MRI and CT scans however radiographs are still the most common skeletal imaging technique requested by chiropractors (Gatterman 2005: 116; Redwood and Cleveland 2003: 253). Radiographs allow visualisation of the red flags that will make the diagnosis and management of patients more appropriate. Gatterman (2005: 116) proposed criteria for radiograph examination which included patients older than 50 years; a history of significant trauma; neuromotor deficits; unexplained weight loss; suspicion of inflammatory arthropathies; a history of drugs or alcohol misuse; a history of cancer; hypertension; diabetes mellitus; use of corticosteroids; pyrexia of unknown origin; failure to respond to prior treatment and patients seeking compensation for low back pain. Gatterman (2005: 116) agrees with Philips (1992: 47) who stated that these guidelines assist in improving decision making regarding the use of radiographs. Radiographs allow individuals to visualise internal structures of the body especially bony tissue (Gatterman 2005: 125). Chiropractors refer for radiographs and therefore

should be able to interpret radiographs of the musculoskeletal system (Taylor and Resnick 2000).

2.4 INTERPRETAION OF RADIOGRAPHS

Interpretation of radiographs by chiropractors is important because radiologist reports do not always accompany radiographs (Taylor 1990: 30). According to Gatterman (2005: 117) radiographs are used to exclude any possible contra-indication to spinal manipulative therapy to prevent serious injuries and delay to treatment. There may be misinterpretation by practitioners due to limitation of technique, misleading or incomplete clinical data, unavailability of previous studies or report, false positive errors, incomplete scanning of radiographs, misinterpretation of perceived findings, lack of knowledge and errors in judgement (Robinson 1997: 1085, Pinto and Brunese 2010: 37; Tins and Cassar-Pullicino 2004: 865). When interpreting radiographs there is a need for chiropractors to agree on findings because this can have a major impact on treatment protocols (Redwood and Cleveland 2003: 240-241).

2.5 CLINICAL HISTORY

Clinical history may have an effect on radiograph interpretation by increasing sensitivity and decreasing specificity of interpretation (Doubilet and Herman 1981: 1055). Good et al. (1990: 712) disagree with Doubilet and Herman (1981: 1055) when they stated that there is no significant difference in interpretation with or without clinical history. Berbaum et al. (1989: 1221-1224) and Berbaum et al. (1994: 217-223) concluded that clinical history affected perception in interpreting radiographs. Tudor, Finlay and Taub (1997: 236) mentioned that knowledge of clinical history increased accuracy in interpreting of radiographs. Interpretation of radiographs may assist with patient management (Luk et al. 2014: 324).

2.6 MANAGEMENT

According to Luk et al. (2014: 324) taking radiographs has a huge utility in clinical decision making and managing scoliosis patients. Nesterona et al. (2010: 179) Lufkin, Smith and Brunett (1998: 202-207) stated that there are few management

changes that were made after the interpretation of radiographs by radiologist. Nesterona et al. (2010: 179) reported that patient management change son the basis of radiologist input. Nesterona et al. (2010: 179) agreed with Grosvenor et al. (2003: 719) that radiology reporting has a direct impact on patient management.

2.7 PLAIN FILM READING PERFOMANCE STUDY DESIGNS AND POSSIBLE VARIATIONS OR BIAS

According to Breally and Sally (2001: 307-316) radiographers and other medical professions are increasingly involved in radiological reporting. Biases may affect result of validity and lead to misinterpretation of result

Breally and Sally (2002: 203-210) stated that plain film reading performance studies and these biases are divided into three categories namely:

- Diagnostic accuracy: To assess the reading performance of one group of observers in controlled conditions.
- Diagnostic performance: To assess the reading performance of one group of observers during clinical practice.
- Diagnostic outcome: To assess the film reading performance of two or more groups of observers during clinical practice.

This study falls under diagnostic accuracy study where films are carefully selected to assess radiographersô ability to interpret (Breally and Sally 2002: 203-210). Such a study examines:

- Film filtering bias.
- Inter- and intra-observer bias and is concerned with decision making of the same observer on different occasions in terms of sensitivity and specificity.
- Arbiter comparator bias where there is knowledge of who was responsible for the report which could affect the arbiterôs judgement.

2.8 PREVIOUS STUDIES PERFORMED ON INTER- AND INTRA-EXAMINER RELIABILITY

Murphy (2013: 1-10) conducted a study where five chiropractors, three chiropractic radiologists and five medical radiologists read a set of 300 blinded lumbosacral radiographs, 50 of which showed an abnormality, in two sessions. The results were expressed in terms of reliability and validity. The results were such that the authors concluded that the small differences between the groups were of ñlittle clinical relevanceò and concluded with the statement that state ñAll the professional groups could adequately detect contraindications to chiropractic treatment on radiographs. For this indication, there is no reason to restrict interpretation of radiographs to medical radiologistsò (Murphy 2013: 1-10). Young Hong et al. (2010: 1552) conducted a study regarding reliability analysis for radiographic measures of lumbar lordosis in adult scoliosis, this was a case-control study comparing six methods. The inter- and intra-class correlation coefficients (ICCs) in CobbL1ï S1, the centroid and posterior tangent L1ï S1 methods were C0.60 (fair to good) in the high-grade group. Only the Cobb L1ï L5 and posterior tangent L1ï L5 methods showed consistently high ICCs in the high-grade group (C0.86, excellent). In addition, the Cobb L1ï L5 and posterior tangent L1ï L5 methods consistently demonstrated lower mean absolute difference for comparisons in all groups. In the TRALL method, the ICCs were C0.76 (excellent) in all three groups, although these were lower than ICCs of Cobb.

Hubbard, Vowles and Forest (2010: 60) conducted a study on inter- and intra-examiner reliability of the Blair protractoview method, examination of a chiropractic radiographic technique where a total of 25 participants analysed 100 films, 22 of whom analysed the films twice over the course of a conference, giving 47 readings of the radiographs. The study included 7 chiropractic students and 18 chiropractors. The k value for inter-examiner reliability of average participant was substantial at 0.61 (intra-examiner=0.81 and for certified Blair chiropractors also substantial at 0.74(intra-examiner=0.92). This showed that the Blair method was a reliable tool to analyse occopitoatlantal articulation for misalignment. Overall, participants showed good inter- and intra-examiner reliability of analysis using the Blair method.

Inter- and intra-examiner reliability of footprint pattern analysis obtained from diabetics using the Harris Mat method has been produced (Cisneros et al. 2010: 200). The weighted kappa coefficient was excellent (K-w>0.80) for the inter- and intra-examiner analyses for most of the points studied on both feet.

Inter- and intra-examiner reliability of single and composites of selected motion palpation and pain provocation tests for sacroiliac joint could be used in practice (Arab et al. 2009: 213). Arab et al. (2009: 213) stated that their data indicated fair to substantial reliability for the individual tests (Patrick FABERE, Posterior shear, Resisted abduction, Standing flexion, sitting flexion and Gillet test).

Pretty et al. (2002: 105-109) conducted a study to examine inter- and intra-examiner reliability of quantitative light-induced fluorescence (QLF) analyses involving three attempts of each examiner. Only one examiner (a novice at the technique) demonstrated differences between all three attempts and two demonstrated difference between two attempts. When the mean scores were compared to determine the inter-examiner reliability, only one examiner's results were statistically different when compared with the two others.

Peterson et al. (2007: 85-90) conducted a study on inter- and intra-examiner reliability in identifying and classifying degenerative marrow changes on lumbar spine magnetic resonance scans. The overall kappa value for the inter-examiner agreement of diagnosing the present /absence of modic changes for entire lumbar spine was 0.52 which was moderate with agreement of 71%.

Haneline and Young (2009: 379-86) conducted a review of intra-examiner and inter-examiner reliability of static spinal palpation to appraise the quality of these studies. They generated 343 citations and found acceptable levels of reliability and no significant differences between methods of palpation. The overall agreement was very low.

Intra- and inter-examiner reliability of a positional diagnostic screen for the lumbar spine study was conducted by Spring, Gibbons and Tehan (2001: 47-55) where osteopaths and other practitioners of manual medicine did a variety of procedures in assessing a patient in order to determine a diagnosis and subsequent treatment plan. The result of intra-examiner reliability ranged from less than chance to slight

agreement (K= -0.14 to 0.16). The inter-examiner reliability showed slight agreement with a kappa of 0.04. There was no real agreement between the examiners.

Marais (2011) conducted a study on inter- and intra-examiner reliability of cervical spine radiographic analysis and its impact on clinical management. This leaves a room for research on inter- and intra-examiner reliability on the lumbar spine. Marais (2011: 34) found that ñcategorisation and management for round 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 statically significant. These findings are consistent where studentsô demonstrated similar aptitudes for categorising and managing pathologic conditions.ò Marais (2011: 35) stated that kappa for identification of pathology was fair for both rounds even though it decreased slightly and based on these result it couldnôt be assumed that clinical history impacted the results between round one and round two.

Even though inter- and intra-examiner reliability studies regarding the lumbar spine have been conducted, there is no evidence in the literature of inter- and intra-examiner reliability of lumbar spine radiographic analysis by chiropractors. Therefore, there is a gap in the literature regarding chiropractorsô consistency in reading and interpreting lumbar spine radiographs which is why this study was aimed at investigating inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management.

2.9 CONCLUSION

Chiropractors should be able to interpret radiographs because not all radiographs come back with reports. Radiographs are important to view conditions which are contra-indicated to chiropractic SMT. Contra-indications may be more reliably identified if case history is available and this may change patient management (Douglas et al. 2012: 16-18).

CHAPTER 3 : MATERIALS AND METHODS

3.1 INTRODUCTION

In this chapter, the main methodological factors will be discussed in order to validate the basis for the data collection process. This chapter will be divided into the following subheadings: study design, participant recruitment, sampling, inclusion criteria, exclusion criteria, research procedure, measurement tools, data analysis and ethical considerations.

3.2 STUDY DESIGN

The research was designed as a quantitative; non-experimental clinical cohort study. Data was collected doing inter- and intra-examiner reliability test and retest study of chiropractors analyzing lumbar spine radiographs and the impact of this analysis on clinical management. Participants were blinded they did not know that they were viewing same radiographs in both rounds. Ethical clearance to conduct this study was obtained from the Faculty of Health Sciences Research Committee and the Institutional Research Ethics Committee at the Durban University of Technology.

The study consisted of two phases.

3.2.1 Phase One

This included identification of possible radiographs for use in the study. Radiographs were selected to represent a selection of diseases e.g. degenerative changes (congenital, inflammatory, arthritis etc.) and then were randomly selected. These radiographs were given to the expert group to be analysed using a template (Appendix B) developed by Marais (2011) to record the evaluation of the radiographs. The expert group assisted in identifying components required for a diagnosis as well as compiling the final template for 30radiographs for use in the study.

3.2.2 Phase Two

Participants were then requested to report on the same set of radiographs over two separate rounds. In the first reporting round the participants had access to radiographs only to make diagnoses. There was a second reporting round which took place two weeks later. The participants had access to radiographs and clinical history. Participants were unaware that they were viewing the same radiographs in both rounds.

3.3 RECRUITMENT

Phase one

Radiographs:

The researcher wrote a letter to the Chiropractic Clinic Director and Head of Department (Appendix A) to ask for permission to access the clinic files and radiographs that the researcher might use. Approval was granted.

Expert group:

Emails were sent to ask chiropractors requesting them tobe part of the expert group. The letter of information (Appendix D) and consent form (Appendix E) were given to the expert group. The expert group assisted in identifying important components required for a diagnosis as well as compiling the final template for the 30 radiographs used in the study (Appendix B). The radiographs which satisfied the inclusion criteria were set aside and stored in the Chiropractic Department boardroom.

Phase two

The participants were recruited using contact details in the Chiropractic Association of South Africa (CASA) handbook (Chiropractic Association of South Africa [CASA] 2014: 40-43). Permission for using the CASA handbook was granted to the researcher (Appendix J). The chiropractors were called and asked questions (Appendix k) to see if they met the inclusion criteria. A meeting was arranged with participants in their practice rooms to explain the study to them. The participants were given a letter of information (Appendix G) and consent form (Appendix H) to read and sign.

3.4 SAMPLING

Population size

Number of chiropractic raters: The researcher used six chiropractors because more than two raters strengthen the kappa values (personal communication on 28/03Esterhuizen 2014).

3.4.1 Sample characteristics

Phase One

Radiographs

Plain film radiographs were collected from the DUT Chiropractic Day Clinic with permission from the HOD and the clinic director (Appendix A). Radiographs included T12-S1 and were viewed by an expert group before being viewed by participants. Radiographs which were used were of good quality.

Expert group

The expert group members were required to be qualified chiropractors with either a Master in Technology of Chiropractic or Doctor of Chiropractic and registered with the Allied Health Professions Council of South Africa (AHPCSA).

Phase Two

In order to take part in the study, participants had to meet the following criteria: participants were required to be qualified chiropractors with either a Master or Doctorate of Chiropractic. The participant had to reside in the eThekwini district and be registered with the AHPCSA. They had to sign a letter of information (Appendix G) and informed consent form (Appendix H).

No group allocation was required.

3.4.1.1 Inclusion and exclusion criteria

Inclusion criteria for admission to the expert group

1. The expert group members were required to be qualified chiropractors with either a Master in Technology of Chiropractic or Doctor of Chiropractic and registered with AHPCSA.
2. Should have used/ did a study on radiographs, with practice experience of ten years and/or lecturing radiography.

Inclusion criteria for admission to the participant group:

1. Participants were required to be qualified chiropractors with either a Master or Doctor of Chiropractic.
2. Participants residing in the greater eThekwini district and registered with the AHPCSA.
3. Participants were required to have had a minimum of 10 years clinical experience.
4. Participants had to sign a letter of information (Appendix G) and informed consent form (Appendix H).

Exclusion criteria for the expert group

1. Chiropractors not willing to participate in the expert group

Exclusion criteria for the participants

1. Chiropractors were excluded if they were not willing or unable to participate in the study.
2. Chiropractors who participated in the expert group.

3.4.1.2 Sample selection

Phase One

Expert group

The randomisation hat method was used (Trochim 2006); names from the CASA handbook of chiropractors living in the eThekwini district were written and placed in a hat. Names (20) which were picked from the hat were contacted and asked to

participate in an expert group. Only five chiropractors agreed to participate in the expert group.

Phase Two

Participant group

The randomisation hat method was used (Trochim 2006); names from the CASA handbook of chiropractors living in the eThekwini district were written and placed in a hat. Participants were chosen randomly by using the hat method to assure all members of the population an equal probability of being chosen (Trochim 2006). They were then asked questions (Appendix K) to see if they met the inclusion criteria; if not their names were removed from the list of names selected from the hat. If they did meet the inclusion criteria, they were asked to participate in the study.

Table1 lists shows the questions asked during the telephonic interview and the desired responses.

Table 1: questions asked during the telephonic interview and the desired responses

1. Are you able and willing to participate in this study?	Yes
2. Are you a qualified Chiropractor with either M-tech or DC degree?	Yes
3. Do you have a minimum of ten yearsô experience?	Yes
4. Did you further your knowledge in radiology after completing university?	No
5. Were you part of the Focus group?	No

3.5 RESEARCH PROCEDURE

3.5.1 Phase One

Radiographs were randomly chosen from files of the DUT Department of Chiropractic Day Clinic. These radiographs were given to the expert group to be analysed using a template (Appendix B) developed by Marais (2011) to record the evaluation of the radiographs.

Expert Group Procedure

Expert groups are conducted for different reasons. Expert group discussions allow for the emergence of data that presents the collective views of a group (Oikonomidoy2007:19). The expert group in the context of this research included:

1. Discussion about radiographs for agreement on diagnoses for all radiographs shown to expert group.
2. Commenting on the template (Appendix B) and providing ideas on what should be added to the template (developed by Marais in 2011).

On arrival at the expert group venue all participants were given the letter of information (Appendix D) and consent form (Appendices E) to sign.

Expert groupôs role in identifying the radiographs

The researcher placed three sets of radiographs in a viewing box. The expert group participants viewed and discussed the radiographs individually. Clinical histories were available to the expert group to ensure accurate diagnosis with all radiographs. The comments from the expert group were noted by the researcher. Radiographs which didnôt meet the inclusion criteria were excluded. The radiographs which satisfied the inclusion criteria were set aside and stored in the Chiropractic Department board room.

The process continued until 30 radiographs were selected and approved by everyone in the expert group. Patientôs details associated with each radiograph were recorded on the patient confidentiality coding sheet. A code was assigned to each patientôs name. Coding sheets and data sheets were kept in a file in the Chiropractic Department boardroom.

Expert groupôs role in correction of answer sheet

The template used as an answer sheet (Appendix B) was originally developed by Marais (2011) and was used with permission (Appendix C). The expert group only added ñwhich views will you ask for to clarify the conditionòto the template (Appendix B).

The research instrument consisted of 20 items, with a level of measurement at a nominal level. The questionnaire was divided into three sections which measured various themes as follows:

- Section A: ñWhich one of the following best categorises the radiographic findings?ò
- Section B: ñWhat view if any would you request to further clarify the category above?ò
- Section C: ñManagementò

  Pilot study of the tool was not conducted since the researcher used the same tool as Marais (2011).

3.5.2 Phase Two

Round One

A date and time was set up with each participant to make sure they had sufficient time to interpret the radiographs. The researcher went to each participantôs practice. The researcher explained the study to participants and answered any questions. The participants were given the letter of information (Appendix G) and consent form (Appendix H) to read and sign. All the radiographs were viewed using the same viewing box, as arranged by the researcher. The participant had to comment on obvious radiological signs, which further view they would request (if any), clinical management and diagnosis. The researcher used numbers to code for each participant to ensure confidentiality at all times.

Each participant was given 90minutes to interpret all of the radiographs and fill in the data sheet provided. Extra time was given to allow time wasted changing the radiographs. Participants were not allowed to look up any information or refer to any documentation that may have helped in their diagnosis. Once they had completed the task all answer sheets were placed into envelopes 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. Each participant selected one number from six in a box. This number was then written on their answer sheets and placed into a sealed envelope.

After all participants had completed the first round, round two then commenced two weeks later.

Round Two

Round two followed the same procedure as round one and the use of researcherõs viewing box. This round had inclusion of a basic patient clinical history (Appendix I), related to each radiograph. The clinical history was printed on corresponding answer sheets and included gender, age, main complaint and mechanism of injury (where applicable).

All radiographs were re-numbered and placed in a different order from Round One. Only once all the participants had completed Round Two, was the data analysed.

3.6 MEASUREMENT TOOLS

Permission to use and modify the template used in Marais (2011) study was arranged (Appendix C).

3.7 MEASUREMENT FREQUENCY.

One answer sheet per participant and per radiograph was used for each of the two rounds with the rounds having had a period of two weeks between them.

3.8 DATA ANALYSIS

When interviewed on 8 March 2016, Singh (DUT statistian) stated that the accuracy of response was used to measure inter-rater reliability of each question at each round using Fleiss Kappa. Kappa is a measurement of agreement; Cohenõs Kappa measures the agreement between the two raters and Fleissõs Kappa measures agreement between all the raters. The guidelines in terms of interpreting kappa scores are<0.00 is poor and has less than a chance agreement, 0.01-0.20 slight and has slight agreement, 0.21-0.4fair with fair agreement, 0.41-0.60 moderate with moderate agreement, 0.61-0.80 substantial with substantial agreement and 0.81-0.99 almost perfect with almost perfect agreement Viera and Garrett 2005: 360-363). The 95% of confidence interval is Kappa +/- 1.96 SE.

Comparison between the rating of the same assessor in Round One and Round Two provided the intra-rater agreement. Comparing all assessors in each round e.g.Examiner1 with Examiner2, Examiner1 with Examiner3, Examiner1 with Examiner4, Examiner1 with Examiner5 and Examiner1with Examiner6 gave the inter-rater agreement.

Data was captured on an Excel spreadsheet and imported andanalysed with SPSS version 23.0.The results are presented using descriptive statistics in the form of graphs, cross tabulations and other figures for the quantitative data that was collected. Inferential techniques include the use of correlations and chi square test values which are interpreted using the p-values.

3.9 ETHICAL CONSIDERATIONS

The researcher asked for permission (Appendix A) to use the clinic radiographs from the HOD and clinic director. Letters of information (Appendix D) and consent forms (Appendix E) were given to the expert group and participants (Appendix G and Appendix H) to ensure confidentiality at all times. Consent forms were signed. Radiographs of patients who had visited the DUT Chiropractic Day Clinic were used. With every initial visit patients sign a consent form stating that their information may be used for research purposes. The identities of the participants were not revealed in the write up of the study, only the researcher and the supervisor had access to the data. Data obtained will be stored in the chiropractic department and shredded after five years to ensure confidentiality of the patients and participants. Participants were allowed to stop participating at any time.

The identities of the participants were not revealed in the research process; only the researcher and the supervisor had access to the data. Patient names were given codes and did not appear in any data sheets or this dissertation.

3.10 CONCLUSION

Radiographs were selected from DUT chiropractic clinic and given to the expert for viewing. Radiographs that met the inclusion criteria were given to participants for viewing which occurred in two rounds separated by two weeks. An identity of expert

group and examiner participants were not revealed and confidentially was kept at all times during data collection.

CHAPTER 4 : STUDY RESULTS

4.1 INTRODUCTION

This chapter presents the results of the study and interpretation and discussion thereof. There is primary and secondary data. Primary data included knowledge received from examiners of the study in the form of completed answer sheet. Secondary data included knowledge collected from various books, personal communication with the statistician. The primary tool used by the researcher was a questionnaire to collect data which was distributed to chiropractors in the eThekwini district. The results are divided into three categories based on answer sheet namely categorization of radiographic findings, radiographic views requested by examiners, patient management and identification of any disease. Inter- and intra-examiner results are discussed for both rounds in each question.

4.2 ABBREVIATIONS AND DEFINITIONS FOR THIS CHAPTER

E1: Chiropractor/ Examiner 1

E2: Chiropractor/ Examiner 2

E3: Chiropractor/ Examiner3

E4: Chiropractor/ Examiner 4

E5: Chiropractor/ Examiner 5

E6: Chiropractor/ Examiner 6

CI: Confidence Interval

SE: Standard Error

TFRC: Too few rating categories

Sensitivity: The sensitivity clinical test refers to the ability of the test to correctly identify those patients with the disease (Lalkhen and McCluskey 2008: 221).

Specificity: The specificity clinical test refers to the ability of the test to correctly identify those patients without the disease (Lalkhen and McCluskey 2008: 221).

4.3 THE EXAMINERS

In total, six participant (30 radiographs×2 rounds) questionnaires were dispatched and six (30 × 2)were returned. The chiropractors are qualified with Masters in Chiropractic and registered under Allied Health with minimum of ten years.

4.4 RESULTS

The scoring patterns of the examiners per variable per section were analysed. The results are first presented using summarised frequencies for the variables that constitute each section, for each of the six examiners (Appendix M). Results are then further analysed according to the importance of the statements. The results include inter-examiner reliability, intra-examiner reliability, whether clinical history alters inter- and intra-examiner reliability and the influence of identifying lumbar spine radiographic contra-indications on patient management.

Radiographs reflected the following diagnostic categories:

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

Of the 30 radiographs, four were normal, 12showed degenerative changes, seven showed congenital/normal variants and seven showed trauma. These radiographs were collected from the DUT Chiropractic Day Clinic. During expert group meetings radiographs that had no variety of diagnosis and those which were not good images were excluded. The disorders/diagnoses that were not included in the study

radiographs were included in the questionnaire as options to see if the practitioners could differentiate between diagnoses

4.4.1 Inter-examiner reliability

Table 2 below indicates the guidelines for interpretation of kappa scores.

Table 2: Guidelines for interpretation of kappa scores

Interpretation of Kappa		
Kappa Value		
< 0.00	Poor	Less than chance agreement
0.01 to 0.20	Slight	Slight agreement
0.21 to 0.40	Fair	Fair agreement
0.41 to 0.60	Moderate	Moderate agreement
0.61 to 0.80	Substantial	Substantial agreement
0.81 to 0.99	Almost Perfect	Almost perfect agreement

Source: Viera & Garrett, 2005, Understanding interobserver agreement: The Kappa statistic. Family Medicine.

Categorisation Round One

Overall Kappa: 0.0912

SE : 0.0737

95%CI : 0.0175 to 0.1649

There was a slight agreement between the examiners.

Categorisation Round Two

Overall Kappa: 0.6100

SE : 0.3789

95%CI : 0.0737 to 0.1474

There was a substantial agreement between the examiners.

Request for additional view Round One

Overall Kappa: 0.0134

SE : 0.1079

95%CI : 0.2231 to 0.4462

There was a slight agreement between the examiners.

Request for additional view Round Two

Overall Kappa: 0.5252

SE : 0.0538

95%CI : 0.1337 to 0.2674

There was a moderate agreement between the examiners. Agreement is better than from Round One.

Management Round One

Overall Kappa : 0.0023

SE : 0.073

95%CI : 0.1432 to 0.2864

The agreement was poor between the examiners.

Management Round Two

Overall Kappa : 0.005

SE : 0.1449

95%CI : 0.2847 to 0.5694

There was a slight agreement between the examiners. There was an improvement from Round One but it was not statistically significant.

Identification Round One

Overall Kappa : 0.0211

SE : 0.0141

95%CI : 0.0279 to 0,0558

Agreement between the examiners was slight.

Identification Round Two

Overall Kappa : 0.4210

SE : 0.2101

95%CI : 0.5002 to 0.8143

Agreement between the examiners improved from slight to moderate.

Table 3: Kappa for the Inter-Examiner Reliability table 3

	Overall Kappa Round One	Overall Kappa Round Two	CI Round One	CI Round Two
Question one Categorisation	0.0912	0.6100	0.0175-0.1649	0.0737-0.1472
Question 1.2 Request for additional view	0.0134	0.5252	0.2231-0.4462	0.1337-0.2674
Question 2 Management	0.0023	0.005	0.1432-0.2864	0.2847-0.5694
Question 3 Identification	0.0211	0,4210	0.0279-0.0558	0.5002-0.8143

4.4.1.1 Discussion of inter- and intra-examiner reliability

According to Haas, Taylor and Gillette (1999) reliability may be considered in clinical usefulness and assessment procedures and may measure repeatability and

indicates consistency and precision. This is shown by relatively small random measurement error. Assessment of reliability for radiographic analysis is essential because chiropractors usually send patients for radiographic analysis. In email communication on 1 February 2016, the Statistician indicated that overall there were no significance differences between the examiners. There were no significant intra-examiner differences in Round Two. The examiners all provided similar readings in both rounds and had minimal changes, which is recommended in terms of reliability (Tudor, Finlay, Taub 1997: 235; Bono et al. 2010: 1206-1210). Despite different answers in some questions, chi square tests revealed that overall there were no significant differences. In general, intra-examiner reliability was better than inter-examiner reliability which was consistent with the study conducted by De Zoete et al. (2002: 1235) regarding reliability of lumbar spine radiograph reading by chiropractors. In this study agreement between participants was good for abnormal radiographs and for normal radiographs the sensitivity (degree of change) increased in both rounds. Most of the normal radiographs were misdiagnosed due to the degree of change. Categorising of the radiograph findings between the examiners in Round Onethe overall was poor even though agreement between the examiners ranged from 88% to 94%. The findings between examiners in Round Two were substantial agreement which ranged from 83% to 92%. All results improved from poor to substantialfor correct answers from round one to round two.This was compatible with the study conducted by Arab et al. (2009: 213) on inter- and intra-examiner reliability regarding motion palpation and pain provocation.

Statistical analysis indicated no significant difference. These findings are consistence with Kunac et al. (2006: 196-201) where a study for inter- and intra-examiner reliability for classification of medicationwas done. There were no studies found which looked at catergorisation. Request for additional view improved from slight in Round One to moderate in Round Two. Management improved from poor to fair agreement from Round One to Round Two and this finding was consistentwith that of Marchiori, Adams and Henderson, 1999: 63-74. Kappa for identification of pathology improved from fair tomoderate even though it was not statistically significant.

Based on these result it can be assumed that case history did have a mininal effect on the result between Round One and Round Two. Comparing examiners to each other in Round Two with the case history the examiners improved minimally when interpretating. There were other factors that influenced interpreting of radiographs for categorisation, managing and identification of diagnosis, including room lighting, viewing box, the way case history is written and the number of radiograghs observed. The more radiographs there are to interpret the lower the standard error measurement and the confidence interval making it easier to detect any significant changes (Sauro 2012:1). A study conducted by Hubbard, Vowles and Forest (2010: 60) used 100 films of radiographs and inter-examiner reliability was substantial at 0.61 (intra-examiner=0.81). De Zoete et al. (2002:17) used 300 radiographs and found kappa to be 0.58 which represents moderate agreement. When interpreting results the researcher needs to be aware of number of radiographs since this can affect sensitivity and specificity.

4.4.2 Categorisation

In Round One the overall percentage of correct categorisation was 72% with some radiographs having as low as 0% correct (radiograph 24) and as high as 100% correct (radiographs 1, 2, 4, 9, 13, 15, 18, 19, 23, 26 and 28) (Table 4). Overall percentage of correct categorisation at Round Two increased slightly to 73%(Table5).

Table 4: Round One accuracy table

Radiographs no.	Incorrect count	Incorrect Row N%	Correct count	Correct Row N%
1	0	0%	6	100%
2	0	0%	6	100%
3	3	50%	3	50%
4	0	0%	6	100%
5	2	33.3%	4	66.7%
6	3	50%	3	50%
7	4	66.7%	2	33.3%
8	2	33.3%	4	66.7%
9	0	0%	6	100%
10	4	66.6%	2	33.3%
11	1	16.7%	5	83.3%
12	2	33.3%	4	66.7%
13	0	0%	6	100%
14	2	33.3%	4	66.6%
15	0	0%	6	100%
16	2	33.3%	4	66.6%
17	5	83.3%	1	16.7%
18	0	0%	6	100%
19	0	0%	6	100%
20	1	16.7%	5	83.3%
21	2	33.3%	4	66.6%
22	3	50%	3	50%
23	0	0%	6	100%
24	6	100%	0	0%
25	3	50%	3	50%
26	0	0%	6	100%
27	4	66.6%	2	33.3%
28	0	0%	6	100%
29	2	33.3%	4	66.6%
30	3	50%	3	50%
Total	51	28%	129	72%

Table 5: Accuracy percentage for Round Two

Radiographs No	Incorrect Count	Incorrect Row N%	Correct Count	Correct Row N%
1	1	16.7%	5	83.3%
2	1	16.7%	5	83.3%
3	5	83.3%	1	16.7%
4	0	0%	6	100%
5	1	16.7%	5	83.3%
6	2	33.3%	4	66.7%
7	3	50%	3	50%
8	2	33.3%	4	66.7%
9	1	16.7%	5	83.3%
10	2	33.3%	4	66.7%
11	0	0%	6	100%
12	3	50%	3	50%
13	1	16.7%	5	83.3%
14	0	0%	6	100%
15	2	33.3%	4	66.7%
16	1	16.7%	5	83.3%
17	2	33.3%	4	66.7%
18	2	33.3%	4	66.7%
19	0	0%	6	100%
20	3	50%	3	50%
21	3	50%	3	50%
22	1	16.7%	5	83.3%
23	0	0%	6	100%
24	5	83.3%	1	16.7%
25	2	33.3%	4	66.7%
26	0	0%	6	100%
27	3	50%	3	50%
28	0	0%	6	100%
29	1	16.7%	5	83.3%
30	2	33.3%	4	66.7%
Total	49	27%	73%	

There was animprovement of correct answers in Round Two even though they are not statistically significant difference between Round One and Round Two results. Therefore clinical history only minimally affected the accuracy of categorisation.

4.4.1.2 Discussion of categorisation

Appendix N is a summary of the frequencies of categorisation of the examiners in the first and second rounds. Note: ôYesôrefers to answers that were chosen by the examiners in Appendix B and ôNoôrefers to answers that were left blank.E1, E2, E3, E4, E5 and E6 refers to examiners. 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I and 1J refers to the diagnostic categories; 1.2.1 ï 1.2.5 refers to extra views requested; _2.1 ï _2.4 refers to management options. Appendix M shows the summary of frequencies of Round One and Round Two which includes all questions from 1 to 2.4.

A graphical display of examiner answers per question is shown in Figure 1.Due to the large number of options available, the displays reflect only the positive responses of the examiners per reading for question one. The accuracy for correct answers per radiograph were stated in Tables 4 and 5.

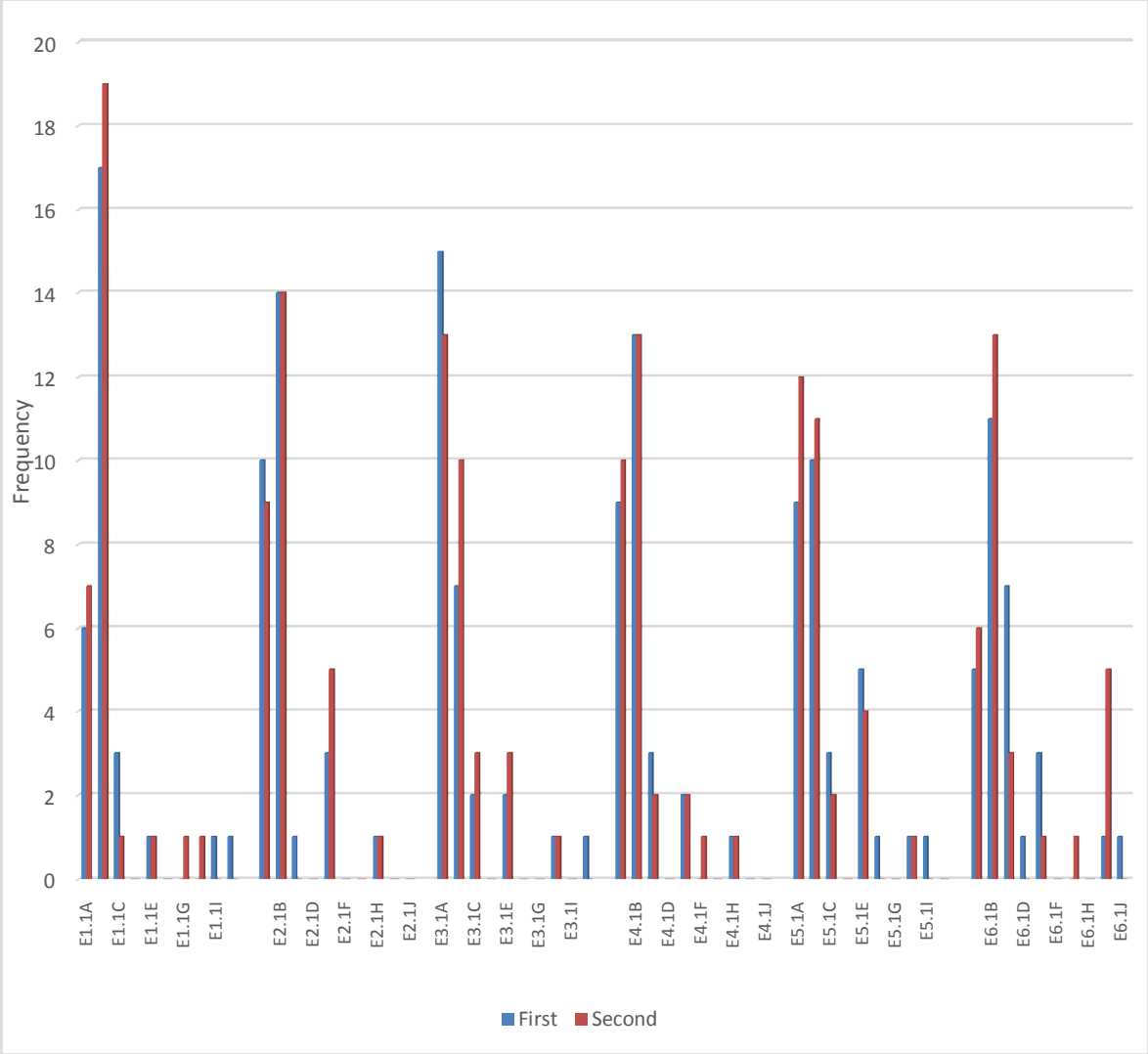

Figure 1: Positive responses of the examiners per reading

The following patterns were observed in Figure 1:

- E1, E2, E4 and E6 had highest counts for B;
- E3 had the highest count for A;
- E5 had similar levels for A and B;
- E1, E2, E4 and E6 had the second highest count for A;
- E3 had the second highest count for B;
- E1, E3, E4 and E6 had the third highest count for C;
- E2, E5 had the third highest count for E; and
- The levels were similar and low for the other options.

Table 6 compares the agreement between the examiners and agreement between Round One and Round Two in terms of percentagein relation to question one.

Table 6: Comparison of Round One and Round Two averages of question 1.1

	Agreement1	Agreement2	Expected Agreement1	Expected Agreement2	Kappa1	Kappa2
E1	92.67	83.33	90.66	84.00	-0.0249	-0.0354
E2	91.33	91.33	89.24	91.62	0.1457	0.0239
E3	91.33	92.50	89.24	92.50	0.1457	0.5000
E4	92.67	91.33	89.24	91.62	0.1550	-0.0239
E5	94.00	92.50	94.00	92.50	0.0000	0.5000
E6	88.67	86.00	85.66	86.62	0.1254	-0.0361

The inter-examiner reliability for categorization was strong between the examiners in categorising in Round One with the agreement ranging from 88.67% to 92.67%. Reliability of examiners in Round Two was also strong ranging from 85.66% to 90.66%. Comparing Round One and Round Two the agreement was strong between the examiners.

As shown in Appendix N categories D, E, F G, and J changed the least from Round One to Round Two, indicating participantsô confidence of diagnosis of those categories. Inflammatory arthritis, infections, blood and soft tissue pathologies are covered very well in third year Diagnostics and Systematic Pathology. In fourth year the above mentioned disorders are covered in Clinical Chiropractic. The practitioners had confidence answering in relation to infections because they are aware of infections due to living in South Africa, and because infections and inflammatory arthritis are very common in practice (Chiropractic Day Clinic directory, personal comunication March 16 2016). Clinical historyhad no statistical significant difference between Round One and Round Two. Diagnosis of no abnormal/ no pathological findings(A)was poor and worsened in Round Two when case histories were also provided. Degenerative changes (B), congenital/ normal variants (C),Tumour(H) and Endocrine(I) radiographs were read relatively well. The overall specificity for D, E, F, G, and J for was high in both Round One and Round Two.

4.4.3 Choice of additional views

4.4.3.1 Views practitioners would ask for in Round One and Round Two

The chi square results for extra views requested are shown in Table 7.

Table 7: Chi square test for extra views requested

Chi-square	
Chi-square, df	0.6101, 5
P value	0.9875
P value summary	ns
One- or two-sided	NA
Statistically significant? (alpha<0.05)	No
Data analysed	
Number of rows	6
Number of columns	2

The test results show that overall there is no difference between the readings by each examiner from the first round to the second round ($p > 0.05$).

To be able to see basic lumbar radiographs and what the radiographs demonstrates please refer to Appendix L. The views of the 30 radiographs in the study are described in Appendix F. These views were:

1. AP
2. Lateral
3. Oblique
4. Flexion
5. Extension

To view the radiographs requested by examiner refer to appendix O. Examiners E1 and E5 requested oblique views most frequently and the oblique views requested by them increased from Round One to Round Two.Examiners E3 and E6 requestedoblique views most frequently and the oblique views requested by them remained the same in Round One and Round Two. Examiners E2 and E4 requested oblique views most frequently and the oblique views requested by them decreased from Round One to Round Two. The next most frequently requested views were AP

and lateral views being 2nd and 3rdrespectively. The agreement between the examiners in Round One was weak with an average of 55,22%. The agreement between the examiners in Round Two was strong with an average of 72.66%. Comparing both rounds one can see that the case history did effect the request for radiographs and assisted in increased agreement between the examiners. With the request of radiographs the researcher did not do the accuracy test because asking for radiographs depended on the individual. Radiographs requested also depended on the university each individual attended because other chiropractors use radiographs for general screening.

Results per examiner:

- E1:Changes on question 2.3 from Round One to Round Two ï increasingthe request for oblique views by 2. The changes were from AP to oblique viewsin radiograph 3 and 18 because the examiner wanted to check for degenerative joint disease (DJD) changes.
- E2:Changes on question 2.3from Round One to Round Two, the request for oblique views decreased by one. The examiner wanted to check for DJD changes and in Round Two the diagnosis changed to normal. Other changes were that AP viewsrequested decreased in Round Two by two.
- E3: AP views decreased from Round One to Round Two by four. On identification, the examiner wanted to view DJD features on all four radiographs in Round One.Lateral views increased by six from Round One to Round Two.The examiner wanted to view the congenital anomalies in three views and in the other three to confirm that there were no abnormalities/pathological findings.
- E4: There was a decrease in AP by two from Round One to Round Two and the examiner asked for lateral views which increased by fourbecause they wanted to confirm that there were no abnormalities in two radiographs. In the other two radiographsthe examiner wanted to see DJD features. With the oblique views in the first round the participant wanted to check for DJD features. The oblique views decreased by seven from Round One to Round Two.
- E5: There was an increase in AP views by three from Round One to Round Two;in those three radiographs the examiner wanted to confirm that there was

no abnormality and on one radiograph to check DJD features. The lateral views decreased by four from Round One to Round Two because the examiner wanted to verify the congenital anomalies.

- E6: AP views decreased by one from Round One to Round Two. AP views changed because the examiner wanted to observe DJD features. Lateral views increased from Round One to Round Two; the examiner wanted to observe ankylosing hyperostosis.

Participants asked for the following extra views for reasons of confirmation: oblique view to confirm DJD features, lateral view if they wanted to confirm congenital anomalies and for no abnormalities, AP to confirm no pathologies and for DJD features.

A graphical display of examiner requests for extra views per question is shown in Figure 2.

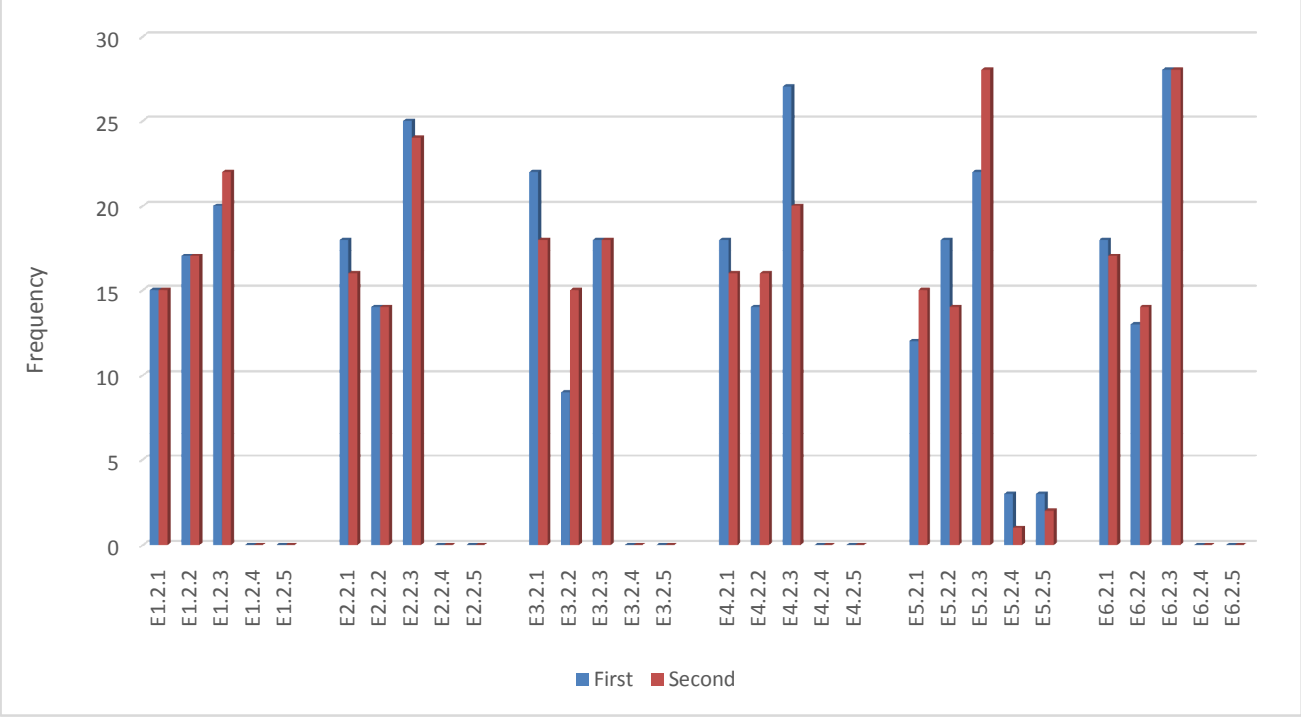

Figure 2: Examiner requests for extra views

The following patterns were observed:

- E1, E2, E4, E5 and E6 had the highest counts for 2.3;
- E3 had the highest count for 2.1;

- E1, E5 had the second highest count for 2.2;
- E2, E4, and E6 had the second highest count for 2.1;
- E3 had second the highest count for 2.3;
- E1 and E5 had the third highest count for 2.1;
- E2, E3, E4, E6 had the third highestcount for 2.2; and
- eighty three percentof examinersasked for oblique views to clarify Q1 and 16.7% asked for AP.Fifty percent of examiners asked for AP, 33.3% asked for lateral and 16.6% would asked for oblique as asecond option.

4.4.4 Management

Round One ofthe correct management was identified to be 69.44% of radiographsTable 8. Round Two result wereincreased to72.22% (Table 9).

Table 8: for Accuracy of management in Round One

	Incorrect count	Incorrect Row N%		Correct count	Correct Row N%
Radiograph No1	3	50%		3	50%
2	2	33.3%		4	66.6%
3	0	0%		6	100%
4	1	16.66%		5	83.3%
5	3	50%		3	50%
6	1	16.66%		5	83.3%
7	3	50%		3	50%
8	2	33.3%		4	66.6%
9	1	16.66%		5	83.3%
10	1	16.66%		5	83.3%
11	3	50%		3	50%
12	2	33.3%		4	66.6%
13	1	16.66%		5	83.3%
14	2	33.3%		4	66.6%
15	2	33.3%		4	66.6%
16	2	33.3%		4	66.6%
17	3	50%		3	50%
18	2	33.3%		4	66.6%
19	1	16.66%		5	83.3%
20	4	66.6%		2	33.3%
21	0	0%		6	100%
22	1	16.66%		5	83.3%
23	0	0%		6	100%
24	6	100%		0	0%
25	1	16.66%		5	83.3%
26	3	50%		3	50%
27	2	33.3%		4	66.6%
28	1	0%		5	100%
29	2	0%		4	100%
30	0	0%		6	100%
Total	55	30.55%		125	69.44%

Table 9: of Accuracy for management in Round Two

	Incorrect count	Incorrect Row N%	Correct count	Correct Row N%
Radiograph No1	0	0%	6	100%
2	2	33.33%	4	66.6%
3	4	66.6%	2	33.33%
4	1	16.66%	5	83.3%
5	0	0%	6	100%
6	1	16.66%	5	83.3%
7	2	33.33%	4	66.6%
8	2	33.33%	4	66.6%
9	1	16.66%	5	83.3%
10	1	16.66%	5	83.3%
11	1	50%	5	50%
12	1	16.66%	5	83.33%
13	3	50%	3	50%
14	0	0%	6	100%
15	4	66.6%	2	33.33%
16	2	33.33%	4	66.6%
17	0	0%	6	100%
18	2	33.33%	4	66.6%
19	1	16.66%	5	83.3%
20	4	66.6%	2	33.33%
21	0	0%	6	100%
22	1	16.66%	5	83.3%
23	2	33.33%	4	66.6%
24	2	33.33%	4	66.6%
25	1	16.66%	5	83.3%
26	4	66.66%	2	33.33%
27	2	33.33%	4	66.6%
28	3	50%	3	50%
29	3	50%	3	50%
30	2	33.33%	4	66.6%
Total	50	27.77%	130	72.22%

Singh(2016) stated that there was no significant difference between each examiner for Round One and Round Two. Comparing Round One and Round Two the agreement slightly increased even though it was not significant.

4.4.4.1 Discussion of management

Figure 3 represents the positive answers for clinical management between examiners for Round One and Round Two.

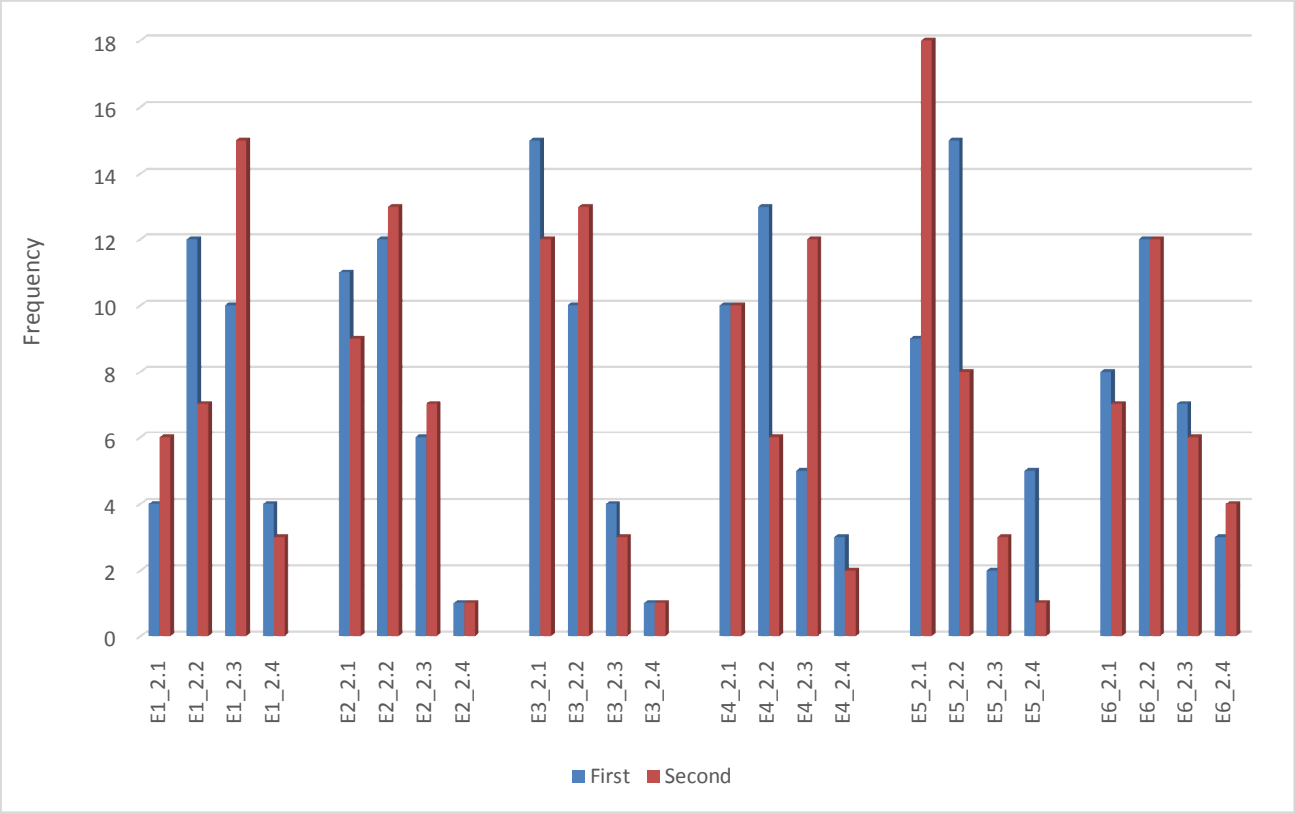

Figure 3: Clinical management of patients

For the first round result were seen in graph 4.3:

- E1, E2, E4, E5 and E6 had the highest counts for 2.2;
- E3 had the highest counts for 2.1
- E1 had the second highest count for 2.3
- E2, E4, E5 and E6 had the second highest count for2.1
- E3 had the second highest count 2.2
- E1had the third highest count for 2.4 which was equal to 2.1
- E2, E3, E4, and E6 had the third highest count for 2.3
- E5 had third highest count for 2.4
- E2, E3, E4, and E6 had fourth highest count for 2.4
- E5 had fourth highest count for 2.3

For the second round result were:

- E1 and E4 had the highest count for 2.3

- E5 had the highest count for 2.1
- E1 and E5 had the second highest count for 2.2

- E1 had the third highest count for 2.1
- E2, E3, E5 and E6 had the third highest count for 2.3
- E4 had the third highest count for 2.2
- All participants had the fourth highest count for 2.4

Table 10 represents the agreement between each examiner in Round One and Round Two. This includes agreement regardless of being wrong or correct.

Table 10: Comparison of Round One and Round Two averages of question 2

	Agreememt1	Agreement 2	Expected agreement1	Expected Agreement2	Kappa1	Kappa2
E1	96.67	95.33	96.67	95.35	0.0000	-0.0068
E2	96.67	96.67	96.67	96.67	0.0000	0.0000
E3	96.67	95.33	96.67	95.40	0.0000	-0.0103
E4	96.00	96.67	96.04	96.67	-0.0069	0.0000
E5	96.00	96.67	96.04	96.67	-0.0069	0.0000
E6	96.67	95.33	96.67	95.40	0.0000	-0.0103

The study objective was to identify if practitioners would apply SMT to lumbar spine where an absolute or relative contra-indication to SMT was present on the radiograph.The study radiographs had eight out of 30 contra-indications which required modification of spinal manipulative therapy. To be able to see general lumbar contra-indication to SMT refer to Appendix M. General agreement between examiners was 96.00%-96.67% in Round One and in Round Two the agreement slightly decreased to 95.33%-96.66(Table 10). The possible reasons for differences in decisions to manipulate between practitioners were DJD and limbus vertebrae. Highest agreement regarding contra-indications for SMT were for aortic calcification, compression wedge fracture, retrolesthesis, spinae bifida and osteoporosis. With the above mentioned contra-indicationsbecoming more evident in the second round,

management of patients was changed.Examiners E1, E4 and E5 (50% of participants) initially had high abnormal findings of great clinical significance and on the second round with case history being available this decreased (refer to Appendix O). The case histories assisted the examiners to recognise severe diagnosis. This also helped in changing management to the patientsô benefit. Examiners (33%) stayed the same on abnormal with great clinical significance in both the first and second round (refer to Appendix O). Examiners (16%) increased the abnormal with great clinical significance from Round One to Round Two. Most of the examiners were conservative regarding patientsômanagement. Management from Round One to Round Two remained poor according to kappa statistics and there was no significant difference.

Overall agreement on management was strong in both rounds. Even though there were minor differences these were not statistically significant. Management agreement ranged from 96.00%-96.67% in Round One and 95.33%-96.67% in Round Two. Management for patients changed when the examiners noted contra-indications, fine-tuned for patient requirements. Luk et al. (2014: 324) said taking radiographs or interpreting them played a huge role in clinical decision making on how to manage patients. Nesterona et al. (2010: 179) and Grosvenor et al. (2003: 719) stated that interpretation of radiographs had a direct impact on patient management. In conclusion inter- and intra-examiner reliability/agreement was excellent, and clinical history altered the intra-examiner reliability and contra-indications influenced the management of patients.

In this study the case history assisted the practitioners to diagnose the radiographs and altered the management to the best possible for the particular radiograph. Berbaum et al. (1989: 1221-1224) and Berbaum et al. (1994: 217) stated that case history affects the perception and interpretation of radiographs which then improves the way the practitioner will manage the patient. Tudor, Finlay and Taub (1997: 236) concurred with Berbaum et al. (1989 and 1994) by stating that case history increased accuracy of interpreting of radiographs.

The Round One accuracy of identification was 65% (Table 11) and accuracy increased to 67.22% in Round Two (Table 12).

Table 11: Round One accuracy of identification

	Incorrect count	Incorrect Row N%	Correct Count	Correct Row N%
Radiograph No				
1	0	0%	6	100%
2	1	16.6%	5	83.3%
3	1	16.6%	5	83.3%
4	2	33.3%	4	66.6%
5	3	50%	3	50%
6	2	33.3%	4	66.6%
7	4	66.6%	2	33.3%
8	3	50%	3	50%
9	2	33.3%	4	66.6%
10	5	83.3%	1	16.6%
11	3	50%	3	50%
12	0	0%	6	100%
13	2	33.3%	4	66.6%
14	1	16.6%	5	83.3%
15	0	0%	6	100%
16	2	33.3%	4	66.6%
17	4	66.6%	2	33.3%
18	1	16.6%	5	83.3%
19	2	33.3%	4	66.6%
20	1	16.6%	5	83.3%
21	1	16.6%	5	83.3%
22	3	50%	3	50%
23	0	0%	6	100%
24	0	0%	1	16.6%
25	5	83.3%	1	16.6%
26	2	33.3%	4	66.6%
27	3	50%	3	50%
28	4	66.6%	2	33.3%
29	1	16.6%	5	83.3%
30	2	33.3%	4	66.6%
Total	62	34.4%	118	65.5%

Table 12: Round Two accuracy of identification

	Incorrect Count	Incorrect Row N%	Correct Count	Correct Row N%
Radiograph No 1	0	0%	6	100%
2	1	16.66%	5	83.3%
3	1	16.66%	5	83.33%
4	0	0%	6	100%
5	3	50%	3	50%
6	2	33.3%	4	66.6%
7	4	66.6%	2	33.3%
8	3	50%	3	50%
9	2	33.3%	4	66.6%
10	5	83.3%	1	16.6%
11	3	50%	3	50%
12	2	33.3%	4	66.6%
13	2	33.3%	4	66.6%
14	1	16.6%	5	83.3%
15	3	50%	3	50%
16	2	33.3%	4	66.6%
17	4	66.6%	2	33.3%
18	0	0%	6	100%
19	1	33.3%	5	66.6%
20	2	33.3%	4	66.6%
21	3	50%	3	50%
22	2	33.3%	4	66.6%
23	0	0%	6	100%
24	5	83.3%	1	16.6%
25	2	33.3%	4	66.6%
26	2	33.3%	4	66.6%
27	3	50%	3	50%
28	1	16.6%	5	83.3%
29	0	0%	6	100%
30	0	0%	6	100%
Total	59	32.7%	121	67.22%

4.4.5 Identification

In the current study identification of pathology improved from Round One to Round Two due to case history availability, which is consistent with Berbaum et al. (1994: 217), Tudor, Finlay and Taub (1997: 236) and Robinson (1997: 1085-1098). This means that the examiners are able to identify pathology when case history is

included. According to the accuracy table the identification on Round One between examiners was good and the normal radiographs were identified correctly. The overall accuracy increased from Round One to Round Two which differs with the findings of Good et al. (1990:712) who stated that case history does not improve accuracy when interpreting radiographs. Accuracy for normal radiographs decreased with case history. Identification for normal radiographs may be affected by that the examiners always look for something on the radiographs even if there is nothing. This provides a reason why examiners are mostly careful when applying SMT.

4.4.6 Sensitivity and specificity

According to Lowry (2016: 338-341) test sensitivity is a conditional probability that the test will be positive if the condition is present and specificity is a conditional probability that the test willbe negative if the condition is absent. In simple terms sensitivity is the proportion of individuals with the pathology that are correctly identified and specificity the proportion of radiographs without pathology that are correctly identified by examiners. Akobeng (2006: 338-341) stated that a test with high sensitivity is useful for ruling out a pathology if a person (radiograph) tests negative and high specificity is useful for ruling in a pathology if a person (radiograph) is positive.

According to Cunningham (2001: 884-885) the higher the sensitivity the better because that will indicate how effective an examiner is in identifying radiographs with pathology. Cunningham (2001:884-885) also stated that the higher the specificity the better because that will indicate how effective the examiner is in identifying radiographs without pathology. Sensitivity and specificity raise questions regarding positive radiographs of the likelihood of it having the pathology and for the negative radiographs of the likelihood of it not having pathology. When interviewed on the 5th of August 2016 Singh (DUT Statistitian) stated that for this study higher sensitivity would be prefered more than higher specificity which disagrees with Cunningham (2001: 884-885) who preferred both sensitivity and specificity to be higher. The reasoning for Singh was that the higher the sensitivity the higher the likelihood that the test for correctly identifying radiographs with pathology. Correctly identifying pathology will assist examiner to manage patients accordingly.

According to Lowryôs caculater the sensitivity for identifying pathology was 95.82% in Round One and Round Two it decreased to 93.43% which means they correctly identified pathology on the radiographs in the first round and in the second round it decreased because the normal radiographs were detectedas having pathology. Specificity was 70% in Round One and decreased to 65.3% in Round Two. This means that fewer radiographs that did not have pathology in Round Onewere correctly identified and in Round Two they were identified as if they had pathology.This raised a concern that case histories affected the examiners decisions by producing false positive results in Round Two. The way case histories were written caused the examiners to be more cautious and they then identified pathology where the radiographs were normal. Interpretaion of radiographs affects management of patients (Luk et al.2014: 324; Lufkin, Smith and Brunett 1998:202-207); Grosvenor 2003: 719; Nesterona 2010:179) but the specificity and sensitivity results in this study show that practitioners do sometimes get the diagnosis incorrect. When comparing this study to the sensitivity and specificity results of Marais (2011) one can see that the sensitivity and specificity had increased. Maraisôs (2011) specificity was 94.4% in Round One and 93.8% in Round Two and specificity 61.1% in Round One 50% in Round Two. This shows the improvement of identifying pathology correctly by the examiners.

The following tables include agreement, expected agreement, kappa, standard error and prob> z for each question. The tables compare each participant to the other participants so that an average can be calculated and be used at the end. This is where the agreement for the examiners was calculated from. Overall kappa and standard error was also taken from here for inter- and intra-examiner reliability.

4.4.6.1 Round One Question 1.1

Table 13: Round One Question 1.1

E1	Agreement	Expected Agreement	Kappa		Standard error	Prob>z
E2	93.33	93.56	-0.0345		0.1826	0.5749
E3	90.00	90.44	-0.0465		0.1711	0.6071
E4	96.67	90.44	0.0000		0.0000	0.5000
E5	96.67	96.67	0.0000		0.0000	0.5000
E6	86.67	82.22	-0.0435		0.1338	0.6274
Total	463.34	453.33	-0.1245		0.4875	2.8094
Average	92.668	90.666	-0.0249		0.0975	0.5619
E1	93.33	93.56	-0.0345		0.1826	0.5749
E3	90.00	90.44	-0.0465		0.1711	0.6071
E4	90.00	90.44	-0.0465		0.1711	0.6071
E5	96.67	96.67	0.0000		0.0000	0.5000
E6	86.67	87.22	-0.0435		0.1338	0.6274
Total	456.67	458.27	-0.171		0.6586	2.9165
Average	91.334	91.654	-0.0342		0.1317	0.5833
E1	90.00	90.44	-0.0465		0.1711	0.6071
E2	90.00	90.44	-0.0465		0.1711	0.6071
E4	93.33	87.56	0.4643		0.1826	0.0055
E5	93.33	93.33	0.0000		0.000	.
E6	90.00	84.44	0.3571		0.1528	0.0097
Total	456.66	446.21	0.7284		0.6776	1.2294
Average	91.332	89.242	0.1457		0.1355	0.2459
E1	96.67	90.44	0.0000		0.0000	0.5000
E2	90.00	90.44	-0.0465		0.1711	0.6071
E3	93.33	87.56	0.4643		0.1826	0.0055
E5	93.33	93.33	0.0000		0.0000	.
E6	90.00	84.44	0.3571		0.1528	0.0097
Total	463.33	446.21	0.7749		0.5065	1.2541
Average	92.67	89.24	0.1550		0.1013	0.2508
E1	96.67	96.67	0.0000		0.0000	0.5000
E2	96.67	96.67	0.0000		0.0000	0.5000
E3	93.33	93.33	0.0000		0.0000	.
E4	93.33	93.33	0.0000		0.0000	.
E6	90.00	90.00	0.0000		0.0000	.
Total	470	470	0.0000		0.0000	1

Average	94	94	0.0000		0.0000	0.2
E1	86.67	82.22	-0.0435		0.1338	0.6274
E2	86.67	87.22	-0.0435		0.1338	0.6274
E3	90.00	84.44	0.3571		0.1528	0.0097
E4	90.00	84.44	0.3571		0.1528	0.0097
E5	90.00	90.00	0.0000		0.0000	.
Total	443.34	428.32	0.6272		0.5732	1.2742
Average	88.668	85.664	0.1254		0.1146	0.2548

4.4.6.2 Round One Question 1.2

Table 14: Round One Question 1.2

E1	Agreement	Expected agreement	Kappa	Standard error	Prob>z
E2	50.00	54.67	-0.1029	0.1323	0.7818
E3	60.00	50.00	0.2000	0.1549	0.0984
E4	56.67	59.11	-0.0598	0.0744	0.7891
E5	46.67	49.78	-0.0619	0.0951	0.7427
E6	56.67	59.11	-0.0598	0.0744	0.7891
Total	270.01	272.56	-0.0844	0.5311	3.2011
Average	54.002	54.51	-0.0169	0.1062	0.6402
				-	
E1	50.00	54.67	-0.1029	0.1323	0.7818
E3	63.33	59.56	0.0934	0.1424	0.2560
E4	80.00	81.00	-0.0526	0.1191	0.6707
E5	76.67	67.44	0.2833	0.1111	0.0054
E6	80.00	81.00	-0.0526	0.1191	0.6707
Total	350	343.67	0.1686	0.6240	2.3846
Average	70	68.73	-0.0337	0.1248	0.4769
E1	60.00	50.00	0.2000	0.1549	0.7818
E2	63.33	59.56	0.0934	0.1424	0.2560
E4	63.33	65.44	-0.0611	0.0865	0.7599
E5	50.00	54.56	-0.1002	0.0963	0.8512
E6	70.00	65.44	0.1318	0.0865	0.0638
Total	306.66	295	0.2639	0.5666	2.7127
Average	61.33	59	0.0528	0.1133	0.5425

E1	56.67	59.11	-0.0598	0.0744	0.7891
E2	80.00	81.00	-0.0526	0.1191	0.6707
E3	63.33	65.44	-0.0611	0.0865	0.7599
E5	80.00	77.44	0.1133	0.0720	0.0578
E6	93.33	93.56	-0.0345	0.1826	0.5749
Total	373.33	376.55	-0.0947	0.5346	2.8524
Average	74.666	75.31	-0.0189	0.1069	0.5705
E1	46.67	49.78	-0.0619	0.0951	0.7427
E2	76.67	67.44	0.2833	0.1111	0.0054
E3	50.00	54.56	-0.1002	0.0963	0.8512
E4	80.00	77.44	0.1133	0.0720	0.0578
E6	76.67	77.44	-0.0345	0.0720	0.6840
Total	330.01	326.66	0.2	0.4465	2.3411
Average	66.002	65.332	0.04	0.0893	0.4682
E1	56.67	59.11	-0.0598	0.0744	0.7891
E2	80.00	81.00	-0.0526	0.1191	0.6707
E3	70.00	65.44	0.1318	0.0865	0.0638
E4	93.33	93.56	-0.0345	0.1826	0.5749
E5	76.67	77.44	-0.0345	0.0720	0.6840
Total	376.67	376.55	-0.0496	0.5346	2.7825
Average	75.33	75.31	-0.0099	0.1069	0.5565

4.4.6.3 Round One Question 2

Table 15: Round One Question 2

E1	Agreement	Expected Agreement	Kappa	Standard error	Prob>z
E2	TFRC				
E3	TFRC				
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	TFRC				
Total	193.34	193.34	0.0000	0.0000	1.0000
Average	96.67	96.67	0.0000	0.0000	0.2
E1	TFRC				
E3	TFRC				
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000

E6	TFRC				
Total	193.34	193.34	0.0000	0.0000	1.0000
Average	96.67	96.67	0.0000	0.0000	0.2
E1	TFRC				
E2	TFRC				
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	TFRC				
Total	193.34	193.67	0.0000	0.0000	1.0000
Average	96.67	96.67	0.0000	0.0000	0.2
E1	96.67	96.67	0.0000	0.0000	0.5000
E2	96.67	96.67	0.0000	0.0000	0.5000
E3	96.67	96.67	0.0000	0.0000	0.5000
E5	93.33	93.56	-0.0345	0.1826	0.5749
E6	96.67	96.67	0.0000	0.0000	0.5000
Total	480.01	480.24	-0.0345	0.1826	2.5749
Average	96.002	96.048	-0.0069	0.0365	0.5150
E1	96.67	96.67	0.0000	0.0000	0.5000
E2	96.67	96.67	0.0000	0.0000	0.5000
E3	96.67	96.67	0.0000	0.0000	0.5000
E4	93.33	93.56	-0.0345	0.1826	0.5749
E6	96.67	96.67	0.0000	0.0000	0.5000
Total	480.00	480.24	-0.0345	0.1826	1.0749
Average	96.002	96.048	-0.0069	0.0365	0.2150
E1	TFRC				
E2	TFRC				
E3	TFRC				
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
Total	193.34	193.34	0.0000	0,0000	1.0000
Average	96.67	96.67	0.0000	0.0000	0.2

4.4.6.4 Round Two

Agreement, expected agreement, kappa, standard error and prob>z were calculated to get an overall average of Round Two. In this way Round One and Round Two were compared to each other.

4.4.6.5 Round Two Question 1.1

Table 16: Round Two Question 1.1

E1	Agreement	Expected Agreement	Kappa	Standard error	Prob>z
E2	83.33	84.00	-0.0417	0.1109	0.6464
E3	86.67	86.67	0.0000	0.0000	.
E4	83.33	84.00	-0.0417	0.1109	0.6464
E5	86.67	86.67	0.0000	0.0000	.
E6	76.67	78.67	-0.0938	0.1398	0.7487
Total	416.67	420.01	-0.1772	0.3616	2.0415
Average	83.334	84.002	-0.0354	0.0723	0.6805
E1	83.33	84.00	-0.0417	0.1109	0.6464
E3	96.67	96.67	0.0000	0.0000	0.5000
E4	93.33	93.56	-0.0345	0.1826	0.5749
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	86.67	87.22	-0.0435	0.1338	0.6274
Total	456.67	458.12	-0.1197	0.4273	2.8487
Average	91.334	91.62	0.0239	0.0855	0.5697
E1	86.67	86.67	0.0000	0.0000	.
E2	96.67	96.67	0.0000	0.0000	0.5000
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	TFRC				
E6	90.00	90.00	0.0000	0.0000	.
Total	370.01	370.01	0.0000	0.0000	1.0000
Average	92.50	92.50	0.0000	0.0000	0.5000
E1	83.33	84.00	-0.0417	0.1109	0.6464
E2	93.33	93.56	-0.0345	0.1826	0.5749
E3	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	86.67	87.22	-0.0435	0.1338	0.6274
Total	456.67	458.12	-0.1197	0.4273	2.8487
Average	91.334	91.62	-0.0239	0.0855	0.5697
E1	86.67	86.67	0.0000	0.0000	.
E2	96.67	96.67	0.0000	0.0000	0.5000
E3	TFRC				
E4	96.67	96.67	0.0000	0.0000	0.5000
E6	90.00	90.00	0.0000	.	.
Total	370.01	370.01	0.0000		1.0000

Average	92.50	92.50	0.0000		0.5000
E1	76.67	78.67	-0.0938	0.1398	0.7487
E2	86.67	87.22	-0.0435	0.1338	0.6274
E3	90.00	90.00	0.0000	.	.
E4	86.67	87.22	-0.0435	0.1338	0.6274
E5	90.00	90.00	0.0000	.	.
Total	430.01	433.11	-0.1808	0.4074	2.0035
Average	86.00	86.62	-0.0361	0.1358	0.6678

4.4.6.6 Round Two Question 1.2

Table 17: Round Two Question 1.2

E1	Agreement	Expected Agreement	Kappa	Standard error	Prob>z
E2	73.33	70.67	0.0909	0.1348	0.2501
E3	83.33	62.00	0.5614	0.1761	0.0742
E4	73.33	64.00	0.2593	0.1794	0.0742
E5	73.33	75.33	-0.0811	0.1172	0.7555
E6	70.00	73.33	-0.1250	0.1429	0.8092
Total	373.32	345.33	0.7055	0.7504	1.9632
Average	74.66	69.07	0.1411	0.1501	0.3926
E1	73.33	70.67	0.0909	0.1348	0.2501
E3	66.67	62.67	0.1071	0.1214	0.1887
E4	70.00	65.33	0.1346	0.1261	0.1429
E5	83.33	81.11	0.1176	0.1093	0.1409
E6	76.67	78.44	-0.0825	0.1233	0.7482
Total	370	358.22	0.3677	0.6149	1.4708
Average	74	71.644	0.0735	0.1230	0.2942
E1	83.33	62.00	0.5614	0.1761	0.0742
E2	66.67	62.67	0.1071	0.1214	0.1887
E4	76.67	59.33	0.4262	0.1820	0.0096
E5	63.33	66.33	-0.0891	0.0984	0.8175
E6	60.00	65.00	-0.1429	0.1247	0.8740
Total	350	315.33	0.8627	0.7026	1.9640
Average	70	63.07	0.1725	0.1405	0.3928

E1	73.33	64.00	0.2593	0.1794	0.0742
E2	70.00	65.33	0.1346	0.1261	0.1429
E3	76.67	59.33	0.4262	0.1820	0.0096
E5	66.67	69.33	-0.0870	0.1042	0.7980
E6	63.33	67.78	-0.1379	0.1307	0.8543
Total	350	325.77	0.5952	07224	1.8790
Average	70	65.15	0.1190	0.1445	0.3758
E1	73.33	75.33	-0.0811	0.1172	0.7555
E2	83.33	81.11	0.1176	0.1093	0.1409
E3	63.33	66.33	-0.0891	0.0984	0.8175
E4	66.67	69.33	-0.0870	0.1042	0.7980
E6	90.00	84.33	0.3617	0.1391	0.0047
Total	376.66	376.43	0.2224	0.5682	2.5166
Average	75.33	75.29	0.0444	0.1136	0.5033
E1	70.00	73.33	-0.1250	0.1429	0.8092
E2	76.67	78.44	-0.0825	0.1233	0.7482
E3	60.00	65.00	-0.1429	0.1247	0.8740
E4	63.33	67.78	-0.1379	0.1307	0.8543
E5	90.00	84.33	0.3617	0.1391	0.0047
Total	360	368.88	-0.1266	0.6607	3.2904
Average	72	73.78	-0.0253	0.1321	0.6581

4.4.6.7 Round Two Question 2

Table 18: Round Two Question 2

E1	Agreement	Expected Agreement	Kappa	Standard error	Prob>z
E2	96.67	96.67	0.0000	0.0000	0.5000
E3	93.33	93.44	-0.0169	0.0897	0.5749
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	93.33	93.44	-0.0169	0.0897	0.5749
Total	476.67	476.89	-0.0338	0.1794	2.6498
Average	95.33	95.38	-0.0068	0.0359	0.5300
E1	96.67	96.67	0.0000	0.0000	0.5000
E3	96.67	96.67	0.0000	0.0000	0.5000
E4	TFRC				
E5	TFRC				
E6	96.67	96.67	0.0000	0.0000	0.5000
Total	290.01	290.01	0.0000	0.0000	1.5000

Average	96.67	96.67	0.0000	0.0000	0.5000
E1	93.33	93.44	-0.0169	0.0897	0.5749
E2	96.67	96.67	0.0000	0.0000	0.5000
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
E6	93.33	93.56	-0.0345	0.1826	0.5749
Total	476.67	477.01	-0.0514	0.2723	2.6498
Average	95.33	95.40	-0.0103	0.0545	0.5300
E1	96.67	96.67	0.0000	0.0000	0.5000
E2	TFRC				
E3	96.67	96.67	0.0000	0.0000	0.5000
E5	TFRC				
E6	96.67	96.67	0.0000	0.0000	0.5000
Total	290.01	290.01	0.0000	0.0000	1.5000
Average	96.67	96.67	0.0000	0.0000	0.5000
E1	96.67	96.67	0.0000	0.0000	0.5000
E2	TFRC				
E3	96.67	96.67	0.0000	0.0000	0.5000
E4	TFRC				
E6	96.67	96.67	0.0000	0.0000	0.5000
Total	290.01	290.01	0.0000	0.0000	1.5000
Average	96.67	96.67	0.0000	0.0000	0.5000
E1	93.33	93.44	-0.0169	0.0897	0.5749
E2	96.67	96.67	0.0000	0.0000	0.5000
E3	93.33	93.56	-0.0345	0.1826	0.5749
E4	96.67	96.67	0.0000	0.0000	0.5000
E5	96.67	96.67	0.0000	0.0000	0.5000
Total	476.67	477.01	-0.0514	0.2723	2.6498
Average	95.33	95.40	-0.0103	0.0545	0.5300

4.5 SUMMARY OF RESULTS

Inter-examiner agreement with categorisation, management, identification was acceptable. Categorisation improved from slight (0.0912) in Round One to substantial (0.6100) in Round Two. Requests for views identification improved from slight to moderate. Management improved from poor to slight.

The changes were not statistically significant even though changes were observed in various readings. This proved that clinical history had an effect because intra-examiner was always better than the inter-examiner reliability.

4.6 REVIEW OF OBJECTIVES

1. To determine inter-examiner reliability of lumbar spine radiograph analysis by chiropractors.

2. To establish intra-examiner reliability of lumbar spine radiograph analysis by chiropractors.

3. To determine if clinical history alters inter-examiner reliability and alters intra-examiner reliability of lumbar spine radiograph diagnoses.

4. To determine the influence of identifying lumbar spine radiographic contra-indication on patient management.

4.6.1 Null Hypotheses

Correlation of inter- and intra-examiner reliability of lumbar spine radiographs will be low. Based on analysis of the data this hypothesis is rejected.

Clinical history will not significantly alter the intra-and inter-examiner reliability of lumbar spine radiograph diagnoses. Based on analysis of the data this hypothesis is rejected.

Contra-indication of lumbar spine radiographs to chiropractic management will not influence management. Based on the data this hypothesis is rejected.

CHAPTER 5 : CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of this study was to investigate inter- and intra-examiner reliability of lumbar spine radiograph analysis by chiropractors and its impact on clinical management. This chapter will state final conclusions and recommendations based on the experience and knowledge obtained while completing the research study.

5.2 CONCLUSION

Participants will see if they can interpret radiographs and how well they can do it. Determining if clinical history has impact on interpretation and patientôs management would encourage chiropractic students to take case history properly. The researcher will present with recommendations to address any challenges faced by participants to chiropractic department. This will improve the interpretation of radiographs by participants and help the department to see where the participants are lacking in terms of interpretation e.g. participant are always looking for something even if there is nothing wrong with the radiographs.

According to chapter 4 inter- and intra-examiner reliability was strong between examiners in both rounds. Even though there were minor differences between the rounds, these were statistically insignificant. Case history assisted the practitioners to recognise severe diagnoses.Identifying the diagnosis improved from poor to substantial with case histories. Case histories should be written carefully in detail because if it is not properly done it could sway the practitioner in the wrong direction. Radiographs should only be taken when there is a suspected serious pathology and not for general screening. Luk (2014: 324) agreed that when a radiograph is correctly diagnosed or interpreted it assists the chiropractor to choose management which is most beneficial forthe patient even if it remained poor according to kappa. The

interpreting accuracy is critical and this skill should ideally be perfected to be as close to 100% as possible

5.3 RECOMMENDATIONS

1) A larger focus group which includes chiropractors and radiologists is needed. Radiologists will check the diagnosis given by chiropractors.

2) Increase the number of participants in the study and also include more areas other than the eThekwini district to be able to make broader conclusions regarding chiropractors in South Africa.

3) Increase the number of radiographs and have a variety of radiographs to make it easier for participants to detect significant changes.

4) Use case histories with greater detail regarding why patients were sent for x-rays. Adequate case histories are required.

5) It would be ideal to include a radiologist in any future studies.

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APPENDIXES

APPENDIX A: Permission to do x-rays

Chiropractic department

P.O.Box 1334

Durban

4001

04 March 2015

To: Dr. A. Docrat (Chiropractic HOD)

Dr. C. Korporaal (Clinic director)

RE: Permission to use x-rays in The Chiropractic Day Clinic for research purposes

Aim: To investigate inter and intra-examiner reliability of lumbar spine radiographic analysis by chiropractors and its impact on clinical management.

-To determine inter-examiner reliability of lumbar spine radiographic analysis by chiropractors
-To determine intra-examiner reliability of lumbar spine radiographic analysis by chiropractors
-To determine if clinical history alters inter-examiner reliability of lumbar spine radiographic diagnosis
-To determine if clinical history alters intra-examiner reliability of lumbar spine radiographic analysis

Reason for requesting to use the x-rays

I require access to the x-rays as I am in the process of completing my PG4 document. In order for me to complete the PG4 and proceed with my research, I will need to have a selection of the relevant x-rays to be used in my study by chiropractors. This study will have two phases. Phase one will include identification of x-rays by the researcher. X-rays that will be selected must represent a selection of diseases. Focus group will than assist in identifying important components required for diagnoses as well as approving or approving with corrections the final template for x-rays which will be used in the study.

Phase two participants will be requested to report on the same set of radiographs over two separate rounds. The first reporting round participant will have access only to radiographs in order to make a radiographic diagnosis. There will be a second reporting round which will take place after two weeks with the participants having

access to both radiographs and clinical history. Participants will be unaware that they are viewing the same x-rays in both rounds.

Confidentiality will be maintained by blocking off the patients name on the x-ray. I will return all x-rays once my study has been completed.

Zandile Mdakane (20804331)Date: _____Signature:_____

(Researcher 079 104 3052)

Dr. A. Docrat Date: _____Signature:_____

(Chiropractic HOD)

Dr. C. Korporaal Date: _____ Signature:_____

(Clinic director)

APPENDIX B: Template for categorisation of radiographs and patient management

Source: Marais, 2011

Participant	1	2	3	4	5	6	7	8	

Question 1: Categorization

Which one of the following choices best categorizes 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

What view if any would you request to further clarify the category above?

1) AP 2) Lateral 3) Oblique 4) Flexion

5) Extension

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 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:

APPENDIXC: Permission letter from Marais

APPENDIX C

Hi Zandile

Yes, I give you full permission to use my final answer sheet, statement of agreement to participant in focus group, code and conduct agreement for focus group and final list of radiographs. It would be my pleasure! I'm glad someone can derive benefit from my thesis.

Best wishes for the future and may your thesis go forward smoothly! If you have any questions, please feel free to email or call.

Regards

Carla

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M.Tech: Chiropractic

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APPENDIX D: Confidentiality statement – expert group

CONFIDENTIALITY STATEMENT – EXPERT GROUP

IMPORTANT NOTICE:

THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE EXPERT GROUP, BEFORE THE EXPERT GROUP MEETING CONVENES.

DECLARATION

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

A) All information in the research document and any information discussed during the expert group meeting will be confidential. Especially any information that may identify any of the participants in the research process.
B) No information will be communicated to any other individual outside this expert group.
C) The information from the expert group will be made public in terms of journal publication which will not identify any participant of the research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Expert Group Member:_____ Signature: _____

Witness Name: _____ Signature: _____

Researcherôs Name: _____ Signature: _____

Supervisorôs Name: _____Signature: _____

APPENDIXE: Letter of information and informed consent for expert group

Appendix E

Letter of information and informed consent for expert group.

DEAR PARTICIPANT

Welcome to my expert group. Thank you for your interest in participating in my study.

TITLE OF RESEARCH STUDY:

Inter and intra- examiner reliability of lumbar spine radiographic analysis by chiropractors and its impact on clinical management.

Principle Investigator: Dr Zandile Ndlovu

Co-Investigator: Zandile Mdakane

Introduction and Purpose of the study:

Radiograph is the imaging modality that is used most to diagnose skeletal disorders and guide appropriate management of musculoskeletal disorders. It is easily available and relatively inexpensive. Red flags may be missed when using diagnostic tools like history taking, physical examination, orthopedic and neurologic testing and radiographs may help to detect red flags. The study will also assess chiropractors in eThekwini district, accuracy at diagnosing contra-indication to lumbar spine SMT. The study will be conducted over two rounds and participant will diagnose lumbar spine radiograph.

Procedure

On the arrival chiropractors will be given this letter of information and informed consent to read. Should you agree to participate in this study you will now be asked to sign this letter of information and informed consent. The procedure of the meeting will be explained by the researcher.The expert group will assist in identifying important components required for a diagnosis as well as compiling the final template for thirty radiographs for use in the study. The radiographs which don't satisfy inclusion criteria will not be included in the study. The radiographs which satisfy the inclusion criteria will be placed aside in the Chiropractic board room.

Risks and discomforts

None should be expected from the study

Benefits

Participants will see if they can interpret radiographs and how well they can do it.

To determine if clinical history has impact on interpretation and patient's management.

Theresearcher will present with recommendations to address any challenges faced by participants to chiropractic department. This will improve the interpretation of radiographs by participants.

Reason why Subject may be withdrawn from the study.

The subject may be withdrawn from the study if they are ill and when they don't want to participate anymore. There will be no adverse consequences for the subject

Cost: Your participation in this research is free of charge.

Confidentiality:

Your personal information will remain confidential by the use of a coding system for data analysis and reporting. Identity will not be revealed in the write up. Your participation in this study is voluntary and refusal to participate will not result in any adverse consequences. You are free to withdraw from the study at any time.

Should there be a research related injury:None to be expected from the study.

Persons to contact in the event of any Problems or Queries:

Researcher Zandile Mdakane (Chiropractic Intern) (0791043052)

Surpervisor Dr Zandile Ndlovu(M-tech Chiropractic) (0731993577)

IREC (031 373 2900)

Complain to DVC : Tip, Prof F Ontieno (031 373 2382)

Statement of Agreement to Participate in the Research Study:

I, ...

Subjectõs full name

.....(ID number) have read this document in it is entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by Zandile Mdakane 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 care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subjectõs name (print) .....

Subjectõs signature. .....

.Date .....

Researcherõs name (print) .....

Researcherõs signature .....

Date .....

Witness name (print) .....

Witness signature .....

Date .....

APPENDIX F: Number, view, diagnosis of the 30 radiographs

APPENDIX F

Number of Radiograph	View of Radiograph	Diagnosis of Radiograph
1	Lateral	Osteoathritis, Degenerative desease (DJD)
2	Lateral	L5, S1 retrolistheseis and Degenerative desease (DJD)
3	AP	Normal
4	Lateral	DJD, Calcification/Atheroma
5	AP	Scoliosis, Rational tilt
6	Lateral	DJD with Scoliosis
7	Lateral	Compression wedge fracture
8	Lateral	Lumbarisation
9	Oblique	DJD
10	AP	Congenital
11	Lateral	Retrolesthesis, Osteopenia, Osteoporosis, Calcification
12	AP	Normal
13	Lateral	Osteopenia and Calcification (Atheroma)
14	Lateral	Mild DJD
15	Lateral	Normal
16	Lateral	Lumbarisation
17	Lateral	DJD (fracture)
18	AP	DJD
19	Lateral	DJD
20	AP	Normal/Scoliosis
21	AP	DJD
22	AP	Congenital/ Trauma
23	AP	S1 spinal bifida, Scoliosis
24	Lateral	Limbus vertebra
25	AP	Spinal bifida, Lumbarisation
26	AP	Clasp knife syndrome, Spinal bifida
27	AP	Paget disease, Calcification of aorta/Atheroma
28	Lateral	DJD
29	Oblique	DJD
30	Lateral	Early DJD/ Osteopenia

APPENDIX G: Confidentiality statement, participants

APPENDIX G

CONFIDENTIALITY STATEMENT – PARTICIPANTS

IMPORTANT NOTICE:

THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE MAIN STUDY, BEFORE THE PARTICIPANTS MEETING CONVENES.

DECLARATION

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

D) All information in the research document and any information discussed will be confidential. Especially any information that may identify any of the participants in the research process.

E) No information will be communicated to any other individual concerning the research.

F) The information from the participant will be made public in terms of journal publication which will not identify any participant of the research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Participant Group Member: _____

Signature :_____

Witness Name: _____

Signature: _____

Researcherôs Name: _____

Signature: _____

Supervisorôs Name: _____

Signature: _____

APPENDIX H: Letter of information and informed consent for participants

Letter of information and informed consent for participant

DEAR PARTICIPANT

Welcome to my main study group. Thank you for your interest in participating in my study.

TITLE OF RESEARCH STUDY:

Inter and intra- examiner reliability of lumbar spine radiographic analysis by chiropractors and its impact on clinical management.

Principle Investigator: Dr Zandile Ndlovu

Co-Investigator: Zandile Mdakane

Introduction and Purpose of the study:

Radiograph is the imaging modality that is used most to diagnose skeletal disorders and guide appropriate management of musculoskeletal disorders. It is easily available and relatively inexpensive. Red flags may be missed when using diagnostic tools like history taking, physical examination, orthopedic and neurologic testing and

radiographs may help to detect red flags. The study will also assess chiropractors in eThekwini district, accuracy at diagnosing contra-indication to lumbar spine SMT. The study will be conducted over two rounds and participant will diagnose lumbar spine radiograph.

Procedure

On the arrival chiropractors will be given this letter of information and informed consent to read. Should you agree to participate in this study you will now be asked to sign this letter of information and informed consent. The procedure of the meeting will be explained by the researcher. Participants will than be requested to report on radiographs over two separate rounds. The researcher will have to organise a viewing box so that everyone will use the same viewing box. When the researcher arrives to their practice room and they are still busy the researcher will have to wait at the waiting room area. The participant will have to comment on obvious radiological signs, which view they would request for if any, clinical management and diagnosis. In the first reporting round the participants will have access to radiographs to make diagnoses. The researcher will use numbers to code for each participant to ensure confidentiality at all times. The data will be compared between participants. There will be a second reporting round which will take place after two weeks.

Risks and discomforts

None to be expected from the study

Benefits

Participants will see if they can interpret radiographs and how well they can do it.

To determine if clinical history has impact on interpretation and patient's management.

Theresearcher will present with recommendations to address any challenges faced by participants to chiropractic department. This will improve the interpretation of radiographs by participants.

Reason why Subject may be withdrawn from the study.

The subject may be withdrawn from the study if they are ill and when they don't want to participate anymore. There will be no adverse consequences for the subject

Cost: Your participation in this research is free of charge.

Confidentiality:

Your personal information will remain confidential by the use of a coding system for data analysis and reporting. Identity will not be revealed in the write up. Your participation in this study is voluntary and refusal to participate will not result in any adverse consequences. You are free to withdraw from the study at any time.

Should there be a research related injury: None to be expected from the study.

Persons to contact in the event of any Problems or Queries:

Researcher Zandile Mdakane (Chiropractic Intern) (079 104 3052)

Surpervisor Dr Zandile Ndlovu(M-tech Chiropractic) (073 199 3577)

IREC (031 373 2900)

Complain to DVC : Tip, Prof F Ontieno (031 373 2382)

Statement of Agreement to Participate in the Research Study:

I,

.....Subjectôs full name

.....(ID number) have read this document in it is entirely

And understand its contents. Where I have had any questions or queries, these have been explained to me by Zandile Mdakane 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 care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subjectôs name (print) .....

Subjectôs signature. .....

Date .....

Researcherôs name (print) .....

Researcherôs signature .....

Date .....

Witness name (print) .....

Witness signature .....

Date .....

APPENDIX I: Case histories of patients associated with each radiograph

APPENDIX I

Number of X-rays	Case history of patients
1	40 year old female complained of low back pain located at T12-L2. It was associated with leg pain which started at the knee and it goes down the calf. Pain is stretching and pulling in nature.
2	A 46 year old male presented to Chiropractic Clinic complaining of low back pain. Sciatica with leg pain.
3	A 25 year old female came in complaining of aching low back pain.
4	A 56 year old female presented with low back pain which was nagging, progressive in nature. Leaning forward, standing and sitting without support increased pain.
5	57 year old male presented with L2 right pain which was aching in nature.
6	57 year old male presented with L2 right pain which was aching in nature.
7	47 year old male presented with bilateral low back pain with bilateral leg pain.
8	40 year old male came I complaining of 1week LBP which is hard in nature
9	50 year old male came in complaining of bilateral LBP. Gradual onset and throbbing in nature.
10	50 year old male presented with sharp pain
11	80 year old male presented with LBP which was worse on the left side. Pain worse in the morning which is dull and achy in nature. He also complained of numbness of dorsum in both feet.
12	64 year old male presented to chiropractic clinic complaining of pain starting from L5, S1 to posterior thigh pain which was cramping type of pain.
13	66 year old male presented with low back pain for 6months which is relieved by panados. Pain is felt on lateral aspect of legs after walking.
14	21 year old male presented to Chiropractic clinic complaining of LBP. Medication helped for few hours.
15	23 year old female presented to clinic with low back pain. It has been there for 7 years. Pain is worse when standing and it sharp and dull with certain movements.
16	39 year old female presented with LBP above the pelvis. Associated signs and symptoms included pain down left leg which was sharp electric type of pain.

17	78 year old male complained of low back pain of 1 week duration, orthopeadic test for nerve root entrapment was positive bilaterally.
18	40 year old male came in complaining of LBP which moved to the knee and down the calf.
19	40 year old male came in complaining of LBP which moved to the knee and down the calf.
20	58 year old male presented with low back pain over the posterior-lateral thigh and calf on the left. It has duration of 4months. Patient had diabetes mellitus for 15 years. Pain is electric like in nature but valsava was negative.
21	78 year old male complained of low back pain of 1 week duration, orthopeadic test for nerve root entrapment was positive bilaterally.
22	22 year old male presented to clinic with low back pain for 5 years, it was thought to be caused by motorbike, water skiing and bicycle accidents. 7 Years ago when he was playing rugby he felt stabbing discomfort.
23	27 year old male presented with L4 and L5 pain which was dull and achy in nature.
24	46 year old male presented to chiropractic clinic complaining of Right LBP which moved to Right buttock area then to anterior thigh and ends at the Right knee. Her pain was dull ache in nature.
25	27 year old male presented to chiropractic clinic complaining severe low back pain after falling from a motorbike. Orthopeadic test for nerve root entrapment was positive bilaterally.
26	27 year old female presented to chiropractic clinic complaining of LBP bilaterally. Pain moved to her knees (pain was worse with activities) and she had numbness of 4^{th} toe (improved with activities).
27	28 year old male presented to chiropractic clinic complaining of stiffness and bone pain. Pain was felt on lateral aspect of legs after walking. He had lost 8kg in 6weeks.
28	68 year old female presented with anteriorlateral left leg pain which was stabbing and throbbing in nature.
29	68 year old female presented with anteriorlateral left leg pain which was stabbing and throbbing in nature.
30	34 year old male complained of low back pain. He experienced pulling feeling which was worse when hiking and after long distance bilaterally.

APPENDIX J: Permission letter from CASA to use information booklet

APPENDIX J

Dear Zandile
You have our permission to use the informative booklet as requested. We wish you well with your project.
Best Wishes
Dr Reg

Dr Reg Engelbrecht
Chief Executive Officer
Chiropractic Association of South Africa
Africa Representative for WFC
P O Box 706, Bethlehem 9700
SOUTH AFRICA
Tel & Fax: +27 0583034571

APPENDIX K: Screening questionnaire participants

APPENDIX K

PARTICIPANTS QUESTIONS AND EXPECTED ANSWERS

QUESTIONS	EXPECTED ANSWERS
1. Are you able and willing to participate in this study?	Yes
2. Are you a qualified Chiropractor with either M-tech or DC degree?	Yes
3. Do you have a minimum of ten years experience?	Yes
4. Did you further your knowledge in radiology after completing in university?	No
5. Were you part of Focus group?	No

APPENDIX L: Basic lumbar spine projections

BASIC VIEW	DEMONST RATES	CLINICORADIOLOGIC CORRELATION
Anteroposterior Lumbopelvic Projection	Lumbar vertebrae,pelvis, hips, proximal femora and soft tissues of abdomen	Alignment: Scoliosis, and pelvis obliquity Bone: All vertebrae components should be located neural arch (spinous process, lamina, pedicle,articular process, transverse processes, parsintercularis), vertebral body (end plates and centrum), the sacrum, ilium and lower ribs should also be observed. Cartilage: intervertebral disc spaces, facets joints, sacro-iliac, pubic, and hip joint should be assessed for joint space thickness and integrity of the articular surfaces. Soft tissue: Psoas shadow.
Lateral Lumbosacral Projection	Lumbar vertebrae, sacrum, coccyx and soft tissue of pelvis, abdomen and lower chest.	Alignment: Lordosis, sacral base angles and gravity weight bearing lines. Posterior vertebral line should be in line. Bone: All vertebrae components should be located neural arch (spinous process, lamina, pedicle,articular process, transverse processes, pars intercularis), end plates and intervertebral foramen, observe landmarks of sacrum, sacral base and promontory. Cartilage:Facet joint, intervertebral disc. Soft tissue: Hemidiaphragm curves anteriorly over the thoracolumbar junction. Colonicgas, calcified aortic atherosclerotic plaques anterior to L3 and L4 vertebral bodies.
Oblique Projection	The scotty dog ï transverse processes, pedicle, articulating processes, facet joint, pars interarticularis and lamina. Additional view of vertebrae body and abdominal soft tissues.	Alignment:Facet joint from L1 to L5 form virtually a straight line, each facet should be parallel to each other and aligned at their edges. Bone: Pars interaticularis inspect for collar sign. The remainder of scotty dog should be identified especially the pedicle which is favour site for malignancy Cartilage: Facet joints for arthritis.
Anteroposterior Lumbosacral Spot Projection	L5 vertebra and disc, upper sacrum and sacro-iliac joints.	Alignment: relationship of L5 to sacral base. Bone: Sacrum, sacral pedicles, sacral bony endplates, cortical margins of sacral foramen. Cartilage: Sacro-iliac joint for uniform joint cavity.
Lateral Lumbosacral Spot Projection	L5 vertebra and disc,upper sacrum and adjacent soft tissues.	This isa supplemental view obtained when lumbosacral joint is unexposed on the routine lateral lumbar film.

Source: Adapted from Rowe and Yochum 2005:50-67

APPENDIX M: Summary of the frequencies by reading of the examiners first and second round

	Reading			
	First		Second	
	Yes	No	Yes	No
E1.1A	6	24	7	23
E1.1B	17	13	19	11
E1.1C	3	27	1	29
E1.1D	0	30	0	30
E1.1E	1	29	1	29
E1.1F	0	30	0	30
E1.1G	0	30	1	29
E1.1H	0	30	1	29
E1.1I	1	29	0	30
E1.1J	1	29	0	30
E1.2.1	15	15	15	15
E1.2.2	17	13	17	13
E1.2.3	20	10	22	8
E1.2.4	0	30	0	30
E1.2.5	0	30	0	30
E1_2.1	4	26	6	24
E1_2.2	12	18	7	23
E1_2.3	10	20	15	15
E1_2.4	4	26	3	27
E2.1A	10	20	9	21
E2.1B	14	16	14	16
E2.1C	1	29	0	30
E2.1D	0	30	0	30
E2.1E	3	27	5	25
E2.1F	0	30	0	30
E2.1G	0	30	0	30
E2.1H	1	29	1	29
E2.1I	0	30	0	30
E2.1J	0	30	0	30
E2.2.1	18	12	16	14
E2.2.2	14	16	14	16
E2.2.3	25	5	24	6
E2.2.4	0	30	0	30
E2.2.5	0	30	0	30
E2_2.1	11	19	9	21
E2_2.2	12	18	13	17
E2_2.3	6	24	7	23
E2_2.4	1	29	1	29
E3.1A	15	15	13	17

E3.1B	7	23	10	20
E3.1C	2	28	3	27
E3.1D	0	30	0	30
E3.1E	2	28	3	27
E3.1F	0	30	0	30
E3.1G	0	30	0	30
E3.1H	1	29	1	29
E3.1I	0	30	0	30
E3.1J	1	29	0	30
E3.2.1	22	8	18	12
E3.2.2	9	21	15	15
E3.2.3	18	12	18	12
E3.2.4	0	30	0	30
E3.2.5	0	30	0	30
E3_2.1	15	15	12	18
E3_2.2	10	20	13	17
E3_2.3	4	26	3	27
E3_2.4	1	29	1	29
E4.1A	9	21	10	20
E4.1B	13	17	13	17
E4.1C	3	27	2	28
E4.1D	0	30	0	30
E4.1E	2	28	2	28
E4.1F	0	30	1	29
E4.1G	0	30	0	30
E4.1H	1	29	1	29
E4.1I	0	30	0	30
E4.1J	0	30	0	30
E4.2.1	18	12	16	14
E4.2.2	14	16	16	14
E4.2.3	27	3	20	10
E4.2.4	0	30	0	30
E4.2.5	0	30	0	30
E4_2.1	10	20	10	20
E4_2.2	13	17	6	24
E4_2.3	5	25	12	18
E4_2.4	3	27	2	28
E5.1A	9	21	12	18
E5.1B	10	20	11	19
E5.1C	3	27	2	28
E5.1D	0	30	0	30
E5.1E	5	25	4	26
E5.1F	1	29	0	30
E5.1G	0	30	0	30

E5.1H	1	29	1	29
E5.1I	1	29	0	30
E5.1J	0	30	0	30
E5.2.1	12	18	15	15
E5.2.2	18	12	14	16
E5.2.3	22	8	28	2
E5.2.4	3	27	1	29
E5.2.5	3	27	2	28
E5_2.1	9	21	18	12
E5_2.2	15	15	8	22
E5_2.3	2	28	3	27
E5_2.4	5	25	1	29
E6.1A	5	25	6	24
E6.1B	11	19	13	17
E6.1C	7	23	3	27
E6.1D	1	29	0	30
E6.1E	3	27	1	29
E6.1F	0	30	0	30
E6.1G	0	30	1	29
E6.1H	0	30	0	30
E6.1I	1	29	5	25
E6.1J	1	29	0	30
E6.2.1	18	12	17	13
E6.2.2	13	17	14	16
E6.2.3	28	2	28	2
E6.2.4	0	30	0	30
E6.2.5	0	30	0	30
E6_2.1	8	22	7	23
E6_2.2	12	18	12	18
E6_2.3	7	23	6	24
E6_2.4	3	27	4	26

APPENDIX N: Conditions that arecontra-indicative or require modification to high velocity-low amplitude spinal therapy

CONDITION	POTENTIAL COMPLICATION FROM MANIPULATION	METHOD OF DETECTION	MANAGEMENT MODIFICATIONS
Atherosclerosis of major blood vessels	Blood vessel rapture (haemorrhage) Dislodged thrombi	Palpation Auscultation X-ray Examination Visualisation Doppler ultrasound	Soft tissue and mobilising technique with light or distractive adjustments Referral to vascular surgeon
Vertebrobasilar insufficiency	Wallenberg syndrome Brainstem stroke	History Doppler ultrasound Angiography MRA	No cervical thrusting techniques Referral to vascular surgeon
Aneurysm	Rapture Haemorrhage	Irregular pulse Abdominal palpation Auscultation X-ray	Referral to vascular surgeon
Tumours	Metastasis to spine Pathologic fracture Disease progression	Palpation X-ray Laboratory findings MRI CT	Referral
Fractures	Increased instability Delayed healing	Radiograph CT	Referral
Severe sprains	Increased instability	Stress x-ray Motion palpation	If severe referral If not manipulation of areas of fixation
Osteoarthritis (late stage)	Neurologic compromised Increased pain	Radiograph	Mobilisation Gentle manipulation Distractive adjustment
Uncarthrosis	Vertebral artery Compromise or dissection	Radiograph	Gentle traction Mobilizing and soft tissue techniques
Clotting disorders	Spinal hematoma	History of anticoagulant therapy Pulse Bruises	Forceful manipulation contra-indicated
Osteopenia (osteoporosis)	Pathologic fractures	History of long standing steroid therapy Postmenopausal females Malabsorption syndrome Nutritional deficiency Anticonvulsive medication X-ray	Forceful manipulation contra-indicated Mobilizing technique with light distractive adjustments
Space-occupying lesions	Permanent neurologic deficits	MRI CT (myelography)	Referral
Diabetes (neuropathy)	Unresponsive to pain	Laboratory findings Examination of lower extremities Skin (trophic changes) Pulse	Referral
Malingering Hysteria Hypochondriasis	Prolonged treatment Treatment dependency	Symptom amplification Waddell scale Libman test	Referral for psychological evaluation Active care

Alzheimer disease	Inappropriate response or unresponsivenessto pain or treatment	Mental status evaluation	Gentle manipulation Mobilizing and soft tissue techniques

Source:(Peterson and Bergmann 2011:93

APPENDIX O: Categorisation of Round One and Round Two

	First	Second
E1.1A	6	7
E1.1B	17	19
E1.1C	3	1
E1.1D	0	0
E1.1E	1	1
E1.1F	0	0
E1.1G	0	1
E1.1H	0	1
E1.1I	1	0
E1.1J	1	0
E2.1A	10	9
E2.1B	14	14
E2.1C	1	0
E2.1D	0	0
E2.1E	3	5
E2.1F	0	0
E2.1G	0	0
E2.1H	1	1
E2.1I	0	0
E2.1J	0	0
E3.1A	15	13
E3.1B	7	10
E3.1C	2	3
E3.1D	0	0
E3.1E	2	3
E3.1F	0	0
E3.1G	0	0
E3.1H	1	1
E3.1I	0	0
E3.1J	1	0
E4.1A	9	10
E4.1B	13	13
E4.1C	3	2
E4.1D	0	0
E4.1E	2	2
E4.1F	0	1

E4.1G	0	0
E4.1H	1	1
E4.1I	0	0
E4.1J	0	0
E5.1A	9	12
E5.1B	10	11
E5.1C	3	2
E5.1D	0	0
E5.1E	5	4
E5.1F	1	0
E5.1G	0	0
E5.1H	1	1
E5.1I	1	0
E5.1J	0	0
E6.1A	5	6
E6.1B	11	13
E6.1C	7	3
E6.1D	1	0
E6.1E	3	1
E6.1F	0	0
E6.1G	0	1
E6.1H	0	0
E6.1I	1	5
E6.1J	1	0

APPENDIXP: Views examiners asked for

	First	Second
E1.2.1	15	15
E1.2.2	17	17
E1.2.3	20	22
E1.2.4	0	0
E1.2.5	0	0
E2.2.1	18	16
E2.2.2	14	14
E2.2.3	25	24
E2.2.4	0	0
E2.2.5	0	0
E3.2.1	22	18
E3.2.2	9	15
E3.2.3	18	18
E3.2.4	0	0
E3.2.5	0	0
E4.2.1	18	16
E4.2.2	14	16
E4.2.3	27	20
E4.2.4	0	0
E4.2.5	0	0
E5.2.1	12	15
E5.2.2	18	14
E5.2.3	22	28
E5.2.4	3	1
E5.2.5	3	2
E6.2.1	18	17
E6.2.2	13	14
E6.2.3	28	28
E6.2.4	0	0
E6.2.5	0	0

APPENDIX Q: Management choices

	First	Second
E1_2.1	4	6
E1_2.2	12	7
E1_2.3	10	15
E1_2.4	4	3
E2_2.1	11	9
E2_2.2	12	13
E2_2.3	6	7
E2_2.4	1	1
E3_2.1	15	12
E3_2.2	10	13
E3_2.3	4	3
E3_2.4	1	1
E4_2.1	10	10
E4_2.2	13	6
E4_2.3	5	12
E4_2.4	3	2
E5_2.1	9	18
E5_2.2	15	8
E5_2.3	2	3
E5_2.4	5	1
E6_2.1	8	7
E6_2.2	12	12
E6_2.3	7	6
E6_2.4	3	4