THE IMPACT OF THORACIC SPINE RADIOGRAPHS IN THE DIAGNOSIS AND MANAGEMENT OF PATIENTS WHO PRESENT WITH THORACIC SPINE PAIN AT THE CHIROPRACTIC DAY CLINIC AT THE DURBAN UNIVERSITY OF TECHNOLOGY

By

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic
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I, Henri Myburgh, do hereby declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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DEDICATION

I dedicate this dissertation to:

My beautiful wife, Elzanne Myburgh, my parents, Henk and Louise Myburgh, my sister, my grandma and all my special friends.

Thank you for your love, support and encouragement throughout my academic career. I am who I am today because of your influence and support.

My savior, the Lord Jesus Christ, “through Him anything is possible”.

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ABSTRACT

Background:

Thoracic spine pain (TSP) is a very common condition and can be just as disabling as cervical and lumbar pain. The causes of thoracic spine pain are numerous, ranging from less serious non-specific mechanical causes to serious specific underlying pathology. Chiropractors used to request routine radiographs as part of their diagnostic work-up, however limited correlation currently exists between radiographical findings and clinical symptoms in non-specific mechanical thoracic spine pain. The overutilization of plain film radiographs worldwide emphasises the need to investigate which clinical conditions in patients with TSP are sent for radiographs and if they were ethically indicated. Literature is currently limited on the role of thoracic spine x-rays and their influence on the management of patients with TSP.

Objectives:

The objectives of this retrospective study were:

1) to record the consultation at which thoracic spine radiographs were requested by the student or clinician and the reasons therefore,

2) to determine the number of incidental radiographic findings in the selected patients' radiographs,

3) to determine the suspected clinical diagnosis and management of the selected patients prior to referral for thoracic spine radiographs,

4) to determine any change in the clinical diagnoses and management following radiographic reporting of the selected patient's radiographs,

5) to determine the correlation between the suspected clinical diagnosis and the radiographic diagnosis of patients with thoracic spine pain.

Method:

The archives of the Chiropractic Day Clinic (CDC) at the Durban University of Technology (DUT) were searched for all available thoracic spine radiographs and corresponding patient files of patients who presented to the clinic with thoracic spine pain from 1 January 1997 to 31 December 2014. The ABCS (Alignment, Bone, Cartilage, Soft tissue) System was utilised to record data of the radiographs without any knowledge of the patient's main compliant. The corresponding patient files were then evaluated with selected clinical variables being recorded. Statistical analysis and interpretation included frequency counts, percentages, mean, standard deviation and ranges for the descriptive objectives. The radiographic and clinical diagnoses were then compared in a two-by-two table to determine any possible relationships in diagnoses of patients with thoracic spine pain.

Results:

Thirty clinical files and their corresponding thoracic spine radiographs were analysed in this study. The mean age of the patients was 43.6 (± 19.1) years with a gender distribution of 40% males and 60% females. Statistical testing using paired *t*-tests in order to assess the correlation between the clinical and radiological diagnoses was not possible, as the categories were too different. The most frequent primary radiological diagnosis was both old trauma and scoliosis at 33.3%, followed by thoracic spondylosis at 20%. The majority of thoracic spine radiographs were requested at the initial consultation. The most common reasons for radiographic referral were severe, progressive TSP at 58.6%, trauma at 48.3% and persistent, localised TSP for more than four weeks at 37.9%. The diagnosis remained unchanged in 70% of the patients following radiographic examination. However, in 30% of the cases the clinical diagnosis was changed following radiographic examination. Most patients were diagnosed with non-specific mechanical causes of thoracic spine pain. A wide variety of treatment modalities were utilised before and after radiographic examination, including soft tissue therapy, electro modalities, spinal manipulative therapy and dry needling. A total of 66.6% of the patients in the study had changes made to their management protocol following radiographic evaluation. There was a greater use of spinal manipulative therapy, following

radiographic evaluation at 56.7% versus only 26.7% of cases prior to radiographic imaging.

Conclusion:

Thoracic spine radiographs have little impact on the diagnosis and management of patients with thoracic spine pain as the majority of clinical diagnoses were non-specific mechanical causes of thoracic spine pain. Thoracic spine radiographs were influential in the diagnosis and management of 30% of the cases. Thoracic spine radiographs may therefore be over-utilised at the DUT CDC. However, the use of spinal manipulative therapy more than doubled following radiographic evaluation of the thoracic spine in patients with thoracic spine pain.

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LIST OF DEFINITIONS

Chiropractic:

A health care profession concerned with the diagnosis, treatment and prevention of the neuromuscular system and the effects of these disorders on general health. There is an emphasis on manual techniques, including joint adjustment and/or manipulation, with a particular focus on joint dysfunction (World Federation of Chiropractic, 2012).

Complicated thoracic spine pain:

Thoracic spine pain with the presence of red flags (Bussiéres *et al.,* 2008).

Degeneration:

Progressive, mechanical, non-inflammatory disease in which pathological changes occur in the articular cartilage and its related components (Yochum and Rowe, 2005). The term is used interchangeably with spondylosis.

Incidental findings:

Any abnormality not related to the illness or causes that prompted the diagnostic imaging test (Lumbreras *et al.,* 2010).

Modalities:

A form of application or employment of a therapeutic agent or regimen (Stedman's Medical Dictionary, 2008).

Plain film radiographs:

Examination of any part of the body for diagnostic purposes by means of x-rays with the record of the findings usually exposed onto photographic film (Medilexicon Dictionary, 2006).

Radicular pain:

Pain along the pathway of a spinal nerve (Stedman's Medical Dictionary, 2008).

Radiographic latent period:

The time interval from when a pathological process or traumatic event manifest clinically until when it becomes visible radiographically (Yochum and Rowe, 2005).

Red flags:

Features of potential serious underlying pathology and are recognised through subjective and objective assessments (Henschke *et al.,* 2013).

Referred pain:

Pain from deep structures perceived as arising from a surface area remote from its actual origin; the area where the pain is appreciated is innervated by the same spinal segment(s) as the deep structure (Medilexicon Dictionary, 2006).

Spinal manipulative therapy:

Manual method of osseous movement using high-velocity techniques that take the joint beyond the passive-range end barrier (without exceeding the anatomic limit) to what is known as the paraphysiologic space (Stedman's Medical Dictionary, 2008).

Spondylosis:

A term applied to the degenerative changes of the spine (Yochum and Rowe, 2005). The term is used interchangeably with degeneration.

Thoracic facet syndrome:

Pain or dysfunction that arises primarily at the facet joints (Gatterman, 2005).

Thoracic spine:

The thoracic region of the vertebral column; the thoracic vertebrae (T1-T12) as a whole; that part of the vertebral column that enters into the formation of the thorax (Medilexicon Dictionary, 2006).

Thoracic spine pain:

Pain perceived anywhere in the region bounded superiorly by a transverse line through the tip of the spinous process of T1, inferiorly by a transverse line through the tip of the spinous process of T12, and laterally by vertical lines tangential to the most lateral margins of the erector spinae muscles. This area can be divided into upper, middle and lower thirds (Merskey and Bogduk., 1994).

Uncomplicated thoracic spine pain:

Non-traumatic thoracic spine pain without neurological deficits or indicators of potentially serious pathologies (Bussiéres *et al.,* 2008).

LIST OF ABBREVIATIONS AND SYMBOLS

ABCS	Alignment, bone, cartilage and soft tissue
AP	Antero-posterior
CAM	Complementary and alternative medicine
CDC	Chiropractic Day Clinic
CRP	C-Reactive Protein
CT	Computed Tomography
DEXA	Dual Energy X-ray Absorptiometry
DISH	Diffuse idiopathic skeletal hyperostosis
DJD	Degenerative joint disease
DUT	Durban University of Technology
DMR	Dermatomes, myotomes and reflexes
ESR	Erythrocyte sedimentation rate
ECG	Electrocardiogram
FBC	Full blood count
HIV	Human immunodeficiency virus
IFC	Interferential current therapy
IV	Intravenous
IVD	Intervertebral disc
lb	Pound
MFPD	Myofascial pain and dysfunction
mm/h	millimeters per hour

MRI Magnetic resonance imaging

n Sample size or count

NSAID Non-steroidal anti-inflammatory drug

PET Positron emission tomography

PNF Proprioceptive neuromuscular fascilitation

SD Standard deviation

SMT Spinal manipulative therapy

SOAPE Subjective, objective, assessment, plan and education

SSPS Statistical Package for the Social Sciences

TB Tuberculosis

TENS Transcutaneous electrical nerve stimulation

TSP Thoracic spine pain

US Ultrasound

< Less than

> More than

°C Degrees Celsius

CHAPTER 1 : INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Thoracic spine pain (TSP) is a very common condition experienced across the lifespan of various individuals who commonly present to primary healthcare clinical practices (Briggs *et al*., 2009) and can be just as disabling as cervical and/or lumbar pain (Edmonston and Singer, 1997). Approximately 7-15% of all spinal pain in the general population is of thoracic spine origin (Linton *et al.,* 1998 as cited in Giles and Singer, 2000; Niemelainen *et al.,* 2006; Briggs *et al.,* 2009). The causes of thoracic spine pain are numerous, ranging from less serious non-specific mechanical causes to serious specific underlying pathology of which the latter is more common in the thoracic spine compared to the neck or lower back (Briggs *et al*., 2009). Chiropractors usually reach a diagnosis by taking a full clinical history, performing physical and regional examinations and ordering or performing specific investigations, such as plain film radiographs, when indicated, to detect ‘red flags’ (Pederson*,* 2005). Red flags are features of potential serious underlying pathology and are recognised through subjective and objective assessments (Henschke *et al.,* 2013).

Plain film radiographs have a 90% sensitivity in the ability to detect neoplasms, infections, fractures and degenerative and inflammatory diseases at their later stages of development in high-risk populations (Deyo and Diehl, 1986 as cited in Mootz *et al.,* 1999). Plain film radiographs are therefore usually considered as a first line investigation to rule out red flags (Peterson and Hsu, 2005; Yochum and Rowe, 2005). However, plain film radiographs may falsely reassure clinicians as important causes of back pain, especially in the early stages of these diseases, may go unnoticed due to the lack of sensitivity of plain film radiographs (Bussiéres *et al.,* 2008). In addition to detecting pathology, some chiropractors also request routine radiographs for the purpose of detecting postural and biomechanical abnormalities as part of their diagnostic workup (Peterson and Hsu, 2005). These biomechanical abnormalities are referred to as spinal ‘malpositions’ or ‘subluxations’ (Peterson and

Hsu, 2005). A subluxation is defined as an articular lesion that is less than a dislocation. It is referred to as a spinal motion segment in which the alignment, movement integrity, and/or physiological function are altered although the contact between the joint surfaces remain partially in contact (Gatterman, 2005). The primary source of pain associated with a spinal subluxation is considered to be facet joint pain (Erwin, 2005). However, using plain film radiographs in this manner as part of the diagnostic workup, seems contradictory considering the fact that numerous investigative radiographic studies have failed to produce radiographic findings that correlate with clinical symptoms in mechanical non-specific TSP (Schultz and Bassano, 1999; Lutz *et al.,* 2003; Erwin, 2005; van Kleef *et al.,* 2011). Although some chiropractors still request radiographs in this manner, the emphasis of the majority have shifted to the diagnosis or exclusion of serious underlying pathology (Peterson and Hsu, 2005). According to Beck *et al.* (2004), any radiographic anomalies are considered unimportant unless they have clinical relevance. To have clinical relevance, the findings must provide additional information beyond the history taking and physical examination, as well as leading to significant changes in patient management and benefits (Beck *et al.*, 2004). Investigations such as spinal radiographs can make important observations possible that may verify the clinical diagnosis; change the management of the patient and allow patient outcomes to improve (Beck *et al.,* 2004; Butt *et al*., 2007).

Occasional incidental findings on radiographs may also require alterations in the treatment protocols (Beck *et al.,* 2004). These findings, and the associated alterations in treatment protocols, can be beneficial especially for chiropractors, due to the nature of their treatment (which often involves a high-velocity low-amplitude thrust into the joint) which may potentially cause injury to a diseased area if not picked up before treatment. Chiropractors may thus be more likely to request plain film radiographs than their medical counterparts (Peterson and Hsu, 2005). Various studies in recent years have started to show the dangers associated with ionising radiation, such as the increasing risk of developing malignancies with the increased numbers of radiographic exposures (Andrieu *et al.,* 2006; Butt *et al.,* 2007; Pijpe *et al.,* 2012). The harmful effects from the use of diagnostic radiographs has led to the development of the justification principal, by the International Commission on Radiology, where the benefits of the plain film radiographs must exceed the risks

(Faulkner, 2004). Guidelines and rules have also been developed to help primary care health practitioners recognise indicators and non-indicators for plain film radiographs (Yochum and Rowe, 2005). Many chiropractors fail to adhere to these guidelines due to routine plain film radiograph requests as part of the diagnostic workup to detect postural and biomechanical abnormalities. According to Yochum and Rowe (2005), routine biomechanical assessments are non-indicators for plain film radiography and might contribute to the overutilization of plain film radiographs worldwide (Ammendolia *et al.,* 2008).

The current lack of correlation between radiological findings and clinical symptoms in non-specific mechanical TSP (Schultz and Bassano, 1999; Lutz *et al.,* 2003; Erwin, 2005; Manchikanti *et al.,* 2009), as well as the overutilisation of plain film radiographs (Ammendolia *et al.,* 2008), emphasises the need to develop some form of correlation between the radiological diagnosis and clinical diagnosis. This may justify the ordering of thoracic spine radiographs in patients with non-specific mechanical TSP and ensure more accurate diagnoses and management protocols (Beck *et al.,* 2004; Butt *et al*., 2007). Literature is currently limited on the role of thoracic spine radiographs and its influence on the management of patients with TSP (Mootz *et al.,* 1999). This study will not only investigate the role of thoracic spine radiographs in determining the management protocol of patients with TSP but also how radiographic findings, additional to the case history and physical examination, may guide a practitioner in determining a change in the management protocol.

1.2 AIMS AND OBJECTIVES

1.2.1 THE AIMS OF THE STUDY

To establish the correlation between the clinical and radiological diagnoses of thoracic spine pain and how thoracic spine radiographs affect the diagnosis and management plan of a patient that presents with thoracic spine pain to the Durban University of Technology (DUT) Chiropractic Day Clinic (CDC).

1.2.2 THE OBJECTIVES OF THE STUDY

a) To record the consultation at which thoracic spine radiographs were requested by the student or clinician and the reasons therefore;

b) To determine the number of incidental findings in the selected patients' thoracic spine radiographs;
c) To determine the pre-radiographic clinical diagnosis and management of the selected patients prior to referral for thoracic spine radiographs;
d) To determine any change in the pre-radiographic clinical diagnoses and management following radiographic reporting of the selected patient's radiographs; and
e) To determine the relationship between the suspected pre-radiographic clinical and the radiological diagnoses of patients with thoracic spine pain.

1.3 SCOPE OF THE STUDY

A total number of 30 thoracic spine radiographs with corresponding patient files that satisfied the inclusion and exclusion criteria were extracted from the DUT CDC archives. Purposive sampling was used and all the radiographs and corresponding patient files were discussed in this dissertation. Each patient signed a consent form during their initial consultation allowing their clinical and radiographic records to be utilised for research purposes. Patient confidentiality was maintained by the utilization of an alpha numerical coding system as well as limiting access to the patient files and radiographs to only the researcher and supervisors. The supervisor verified the clinical and radiographic findings that were recorded by the researcher.

1.4 LIMITATIONS OF THE STUDY

The study was limited to all the thoracic spine radiographs and corresponding patient files that satisfied the inclusion and exclusion criteria within the DUT CDC archives within the time period from 1 January 1997 to 31 December 2014. The study may therefore not be the true representative of all the patients with TSP that were sent for radiographs as many of them might have taken the radiographs home with them and others might have been removed from the archives for test and/or examination purposes.

The patients needed to be sent for thoracic spine radiographs during their treatment at the DUT CDC, patients that thus presented to the DUT CDC with thoracic spine radiographs at the first consult were excluded from the study as they might have already influenced the diagnosis and management of the patient.

Some examiners may interpret findings or details in the history and physical examination differently to others which may have led to some information being left out of the documentation. Therefore, as this study is retrospective, it is thus limited to the details already recorded in the patient history and physical examination and can therefore not be verified or clarified.

CHAPTER 2 : LITERATURE REVIEW

2.1 INTRODUCTION TO THORACIC SPINE PAIN

Thoracic spine pain (TSP) is a common condition experienced across the lifespan of various individuals who commonly present to primary healthcare clinical practices (Briggs *et al*., 2009) and can be just as disabling as cervical and lumbar pain (Edmonston and Singer, 1997). Approximately 7%-15% of all spinal pain in the general population is of thoracic spine origin (Linton *et al.,* 1998; Niemelainen *et al.,* 2006; Briggs *et al.,* 2009). According to Manchikanti *et al.* (2009) the incidence of TSP ranges from 3%-26%, while the prevalence of TSP ranges from 5%-34%. A local retrospective cross sectional survey of thoracic cases at the DUT Chiropractic Day Clinic from 1996 to 2005 recorded an overall prevalence of 3.5% of thoracic complaints (Benjamin, 2007). An estimated 5% of patients with thoracic spine pain are referred to outpatient pain clinics (van Kleef *et al.,* 2011).

Thoracic spine pain is defined by the International Association for the Study of Pain (IASP) as pain perceived anywhere in the region bounded superiorly by a transverse line through the tip of the spinous process of T1, inferiorly by a transverse line through the tip of the spinous process of T12, and laterally by vertical lines tangential to the most lateral margins of the erector spinae muscles. This area can be divided into upper, middle and lower thirds. Pain felt lateral to this area is defined as posterior chest wall pain, and does not constitute thoracic spinal pain (Merskey and Bogduk, 1994).

Thoracic spine pain can be acute, subacute or chronic. Acute pain has a duration of less than three months, while chronic pain is present for more than three months (Merskey and Bogduk, 1994). Subacute pain is a sub-phase of the acute-phase and is described as pain being present for at least six weeks but less than three months (van Tulder *et al.,* 1997). Acute, non-traumatic TSP symptoms are typically unilateral sharp pain that may radiate around the chest wall or directly to the anterior chest. The onset of the acute pain can be associated with a sudden movement or following a sustained position while sleeping and usually causes constant pain in the short term. Chronic TSP symptoms are initially more insidious and episodic of nature and may vary from a cramp-like sensation or intense localised fatigue to a constant dull ache (Singer and Edmondston, 2000). Chronic TSP is further classified as either primary, secondary, referred or psychogenic pain. Primary pain is the most common and refers to all the spine related structures that can cause TSP such as bone, joints, ligaments, muscles, vessels or meninges, while secondary pain occurs as result of compression or degeneration of a nerve that projects pain to the skin (Stolker and Groen, 2000). Spinal pain is often felt in more than one segment, pain may overlap, pain patterns are non-specific, and can be referred in a dermatomal distribution due to the design of the innervation of the spine (Stolker and Groen, 2000). Visceral pathology may refer pain to the thoracic spine. These pain syndromes include, but are not limited to, sources from the cardiovascular, respiratory and gastrointestinal system (Singer, 2000). Psychogenic aetiological factors of spinal pain are not well understood but are mostly prevalent in patients with psychological, social and environmental risk factors, referred to as 'yellow flags'. Examples of 'yellow flags' include: poor expectations of treatment outcomes, beliefs that pain and injury is uncontrollable and likely to worsen, emotional disturbances such as worry, anxiety, fear and poor pain coping strategies (Nicholas *et al.,* 2011). It is therefore important for clinicians to understand the role of psychosocial factors in back pain (Giles, 2000).

Poor pain source localization in the thoracic spine, due to its neural complexity and referred visceral pain patterns, has caused this area to be described as the great mystery of the vertebral column (Singer and Edmondston, 2000; Young *et al.,* 2008). Referred pain from visceral pathology can mimic musculoskeletal disorders and vice versa and should therefore be ruled out first before spinal manipulative therapy is considered by the chiropractor (Singer and Edmondston, 2000; Gatterman and Panzer, 1990; Erwin, 2005). Viscerosomatic reflex circles can for instance be the cause of the high association between angina pectoris and musculoskeletal pathology, especially in the upper thoracic spine at the levels of T1-T6 (Frobert *et al.,* 1999). Tissues in the neck, shoulder, pulmonary or even subdiaphragmatic structures may refer pain to the thoracic spine perceived as localised somatic pain, while the interscapular region again can refer pain to the chest and arms (Erwin, 2005). Research of the pain referral patterns in the thoracic spine has been relatively absent when compared to the cervical and lumbar spine (Young *et al.,* 2008). The thoracic spine poses an unique anatomical challenge when compared to the cervical and lumbar spine due to the presence of the rib cage and all its additional joints (Erwin, 2005). The costotransverse and costovertebral joints must also always be suspected as sources of referred thoracic pain, making this region even more problematic for the practitioner to diagnose the origin of pain (Young *et al.,* 2008). Mechanical TSP can clinically present as thoracic- and/or chest pain (around the rib cage), discomfort and may even refer pain to the shoulder, arm and flank areas as well as localised muscle stiffness and hypertonicity (Erwin, 2005). Also, mechanical TSP characteristically reproduces symptoms with movement of the involved segment while additional signs of true dyspnea might be indicative of underlying lung pathology (Erwin, 2005).

2.1.1 THORACIC SPINE PAIN AND CHIROPRACTIC

Chiropractic was founded in 1895 (Peterson and Hsu, 2005) when D. D. Palmer replaced a displaced fourth dorsal vertebra of Harvey Lilliard, who was deaf for seventeen years, which restored his hearing fully (Plaugher, 1993). Since then, chiropractic has grown to become the third most used primary health care profession in the world after medicine and dentistry (SPR Healthcare & Wellness Clinic, 2015).

Chiropractic forms part of the complementary and alternative medicine (CAM) body (Meeker and Mootz, 2005) that mainly specialises in spinal manipulative therapy (SMT) (Bronfort *et al.,* 2005). Chiropractic, as a profession, can provide continuity of care to patients with TSP by offering personal interviews, physical examinations, requesting and evaluating imaging, treating patients themselves or referring them for appropriate medical evaluation and management (Pedersen, 2005).

A local study determined the demographic profile of patients that presented to the DUT CDC with TSP. It was found that 54.8% of the thoracic pain patients were female, while 45.2% were male (Benjamin, 2007). A similar international study in France found that 60% of mechanical thoracic pain patients were female, while 40% were male (Dreiser *et al.,* 1997 as cited in Benjamin, 2007). The ages in the local study ranged from 11 to 73 years of age with the mean age being 33.3 years of age. The mean age was 32.3 (SD 13.1) years old, while the range was 0-85 years in a similar study conducted at the New Zealand College of Chiropractic teaching clinic. The females (51.9%) where slightly more than the males (48.1%) (Holt and Beck, 2005). A study done on radiograph utilization and demographics in an American Chiropractic College teaching clinic were as follows: average age, 46; age range, 11 to 89; and 48% female. The average age of patients send for thoracic spine radiographs to be 45.3 years (SD = 18.09). Furthermore, the thoracic spine were the third most common body region referred for radiographs after the lumbar and cervical spine (Lew and Snow, 2012).

2.2 THE AETIOLOGY AND DIAGNOSIS OF THORACIC SPINE PAIN

The causes of TSP are numerous, ranging from the more common less serious non-specific mechanical causes to less common more serious specific underlying pathology of which the latter are more common in the thoracic spine compared to the cervical or lumbar spine (Giles, 2000; Briggs *et al*., 2009). Thoracic spine pain can thus lead to unnecessary worry for the clinician when biomechanical joint dysfunction goes undiagnosed (Gatterman and Panzer, 1990). The differential diagnosis of TSP is presented in **Table 2.1**.

The more common causes of TSP are usually ‘spine-related’ or spondylogenic (van Kleef *et al.,* 2011) and include, muscle and connective tissue irritation, thoracic facet syndrome, costotransverse- and costovertebral articulation subluxation/joint dysfunction, disc syndromes and scoliosis (Erwin, 2005; Benjamin, 2007). Thoracic spine pain of mechanical origin usually occurs as a result of muscle strain, poor posture over time, trauma and/or sudden injuries e.g. sport or lifting injuries (Giles, 2000; Sellers, 2002; Benjamin, 2007). Postural deficiencies can result in thoracic hyperkyphosis and ultimately affect intervertebral and facet joints (Giles, 2000). In a local study, thoracic facet syndrome was the primary diagnosis in 74.7% of the population that presented to the DUT CDC, while myofasciitis was the second most diagnosed condition at 8.8% (Benjamin, 2007). Another study found the prevalence of thoracic facet joint pain in patients with chronic spine pain to be 42% (Manchikanti *et al.*, 2004).

The thoracic spine poses a unique anatomical challenge when compared to the cervical and lumbar spine due to the primary kyphotic curve and the presence of the rib cage and all its additional joints (Gatterman and Panzer, 1990; Erwin, 2005). The costotransverse and costovertebral joints must also always be suspected as sources of referred thoracic pain, making this region even more problematic for the practitioner to diagnose the origin of pain (Young *et al.,* 2008). Even the most sophisticated imaging procedures lack consensus on their diagnostic validity of mechanical TSP (Giles, 2000).

Degenerative joint disease (DJD) is a progressive, mechanical, non-inflammatory disease in which pathological changes occur in the articular cartilage and its related components. The exact aetiology of DJD is unknown and usually occurs in weight-bearing joints such as the spine. Degenerative joint disease of the thoracic spine is localised to three joint complexes: costal articulations (costovertebral and costotransverse joints), facetal articulations, and intervertebral discs (Bland, 2000; Yochum and Rowe, 2005). Spondylosis is a term applied to the degenerative changes of the spine (Yochum and Rowe, 2005). The degenerative changes in the discs and facet joints can result in neural compression of either the spinal cord or nerve roots. However, degenerative changes to the costovertebral and costotransverse joints are not associated with neurological changes (Bland, 2000). Radiographic features of thoracic spine degeneration are joint space narrowing, disc narrowing, endplate sclerosis and osteophytes (Yochum and Rowe, 2005).

Table 2.1: Differential diagnosis of thoracic spine pain*

Mechanical TSP	**Non-mechanical aetiologies**		
	Spinal disorders	**Visceral disorders**	**Others**
Thoracic spine strain or sprain	Neoplasms	Cardiovascular disease	Iatrogenic
Degenerative joint disease	Primary	Myocardial infarction	Post-thoracotomy syndrome
Spinal stenosis	Secondary	Angina pectoris	Psychogenic
Intervertebral disc lesions	Intramedullary	Coronary insufficiency	Depression
Costovertebral and costransverse syndrome	Extramedullary	Pericarditis	Anxiety
Facet joint syndrome	Infection	Pulmonary embolism	Malingering
T4 syndrome	Osteomyelitis	Bacterial endocarditis	Hysteria
Congenital anomalies	Tuberculosis	Heart valve disease	
Scoliosis	Inflammatory arthropathies	Dissecting aneurysm	
Kyphosis	Seropositive spondyloarthropathies	Pulmonary disease	
Scheuermann's disease	RA	Emobolus, Infarction	
Fracture	Seronegative pondyloarthropathies	Pneumothorax	
Trauma	Ankylosing spondylitis	Pneumonia	
Osteoporosis	Reiter's syndrome	Pleurisy	
Other	Psoriatic arthritis	Carcinoma	
Costochondritis	Enteropathic arthritis	Abdominal disease	
MFPD	DISH	Peptic ulcer	
Fibromyalgia	Metabolic	Hernia: hiatal, inguinal	
	Osteoporosis	Pancreatitis	
	Osteomalacia	Cholecystitis, Biliary colic	
	Hyperparathyroidism	Hepatitis	
	Cushing's disease	Hepatobiliary abscess	
	Eosinophilic granuloma	Pyelonephritis	
	Ochronosis	Ureteral colic	

*Source: Adapted from Hart (1985), Kenna and Murtagh (1989), Skubic and Kostuik (1991), Giles (2000) and Singer (2000).
DISH = diffuse idiopathic skeletal hyperostosis; MFPD = myofascial pain and dysfunction; T4 = fourth thoracic vertebra

Thoracic spinal canal stenosis occurs most commonly in the T10 to T12 region due to spinal degeneration in the absence of any systemic disease. Hypertrophic spondylosis, short pedicles, spondylolistesis and hypertrophy and/or calcification of the posterior longitudinal ligament and ligamentum flavum may lead to circumferential narrowing of the spinal canal resulting in possible cord compression. Symptoms may include back pain, lower extremity pain, claudication, cauda equina symptoms, upper and lower motor neuron lesions. CT (computed tomography) scans and MRI (magnetic resonance imaging) scans are the diagnostic tools of choice while plain film radiographs are of limited diagnostic value in identifying the lesion(s) (Gatterman and Panzer, 1990; Bland, 2000; McCall, 2000; Hui, 2011).

Thoracic disc herniation usually occurs in the lower third of the thoracic spine in the fourth to sixth decade of life with previous injury, degeneration and healed osteochondrosis (Scheuermann’s disease) being predisposing factors (Gatterman and Panzer, 1990; Skubic and Kostuik, 1991). The nucleus pulposus decreases in size due to desiccation and becomes fragmented while the surrounding annulus fibrosis thickens and develops multiple concentric tears that ultimately coalesce forming radial tear(s), which allow displacement of the nucleus pulposus through the tears in the annulus fibrosis. Acute or chronic nucleus pulposus protrusion, postero-central or postero-lateral, can result in neural compression of either the nerve roots or spinal cord (Bland, 2000).

Thoracic discodural and discoradicular lesions are common causes of referred pain in the thoracic and abdominal regions. A thoracic discodural lesion refers to a shifted component of a disc that impinges on the dura causing pain that has multi-segmental characteristics. These multi-segmental characteristics are usually caused by a postero-central thoracic disc protrusion and include extra-segmental pain that usually remains in the trunk. The pain is usually unilateral and can spread anteriorly and/or posteriorly over several segments while in rare instances it might also spread into the neck and buttocks. Central spinal pain radiating bilaterally to the sides is a possible but unusual phenomena in discodural lesions. A thoracic discoradicular lesion, caused by postero-lateral thoracic disc protrusion, impinges on the spinal nerve roots and their dural sleeve causing more specific segmental pain. For example, if the upper two thoracic nerve roots become impinged pain will be produced in the arm. The T1 nerve root will produce pain along the ulnar surface of the forearm, while the T2 nerve root will cause pain along the inner aspect of the arm from the elbow to the axilla as well as pain along the anterior aspect of the upper thorax around the clavicle and posteriorly along the spine of the scapula (Giles and Singer, 2000; Moore *et. al.,* 2010; Ombregt, 2013).

Discodural lesions in the cervical and lumbar spine usually present with a clear articular pattern where some movements hurt or are limited and others do not, always in an asymmetrical way. This however is not the case in the thoracic spine and patterns of pain are not that obvious making it very difficult to diagnose. There is usually only one of the six passive movements that are positive, namely rotation. Detectable posterolateral discoradicular lesions are a lot more common in the cervical and lumbar spine as opposed to the thoracic spine. Muscular weakness and disturbance of sensation are therefore very rarely seen in the thoracic spine as the location of the nerve root in the intervertebral foramen lies mainly behind the lower aspect of the vertebral body and less behind the disc (Ombregt, 2013). In advanced cases, thoracic disc herniations can result in varying degrees of spinal cord compression and myelopathy and can present as a loss of abdominal reflexes, abdominal weakness, wide-based gait, ankle clonus, extensor toe sign, intercostal neuralgia, sensory deficits, loss of sphincter control, sexual dysfunction and paraplegia (Gatterman and Panzer, 1990; Skubic and Kostuik, 1991; Erwin, 2005).

In the thoracic spine there is no tendency for spontaneous recovery of constant nerve root pain and it can persist for many years, while spontaneous recovery of nerve root pain in the cervical and lumbar spine occurs approximately after four months and twelve months, respectively. However, thoracic disc protrusions causing constant root pain can be easily and effectively cured. One to three sessions of manipulations can reduce disc protrusions – no matter how long they have been present, or whether they are hard or soft, or whether they are posterocentral or posterolateral (Ombregt, 2013).

A patient’s signs and symptoms must correlate with the abnormal anatomical changes observed on imaging to be considered discogenic pain. However, this is not always the case as the clinical presentation of thoracic discogenic pain can be quite varied. In some instances patients present to clinicians with thoracic spine pain without any abnormalities observed on imaging while other MRI studies demonstrated various thoracic spine abnormalities, such as disc herniations and spinal cord deformations, in asymptomatic individuals, making thoracic disc lesions extremely difficult to diagnose and treat (Erwin, 2005).

The symptoms of costovertebral pain syndromes are usually described as pain felt unilaterally between the vertebral column and scapula on the affected side (Ombregt, 2013). It is usually described as a sharp, stabbing pain made worst by deep inspiration, trunk rotation, coughing and/or sneezing. Continuous soreness at the costovertebral angle, radiating around to the lateral and/or anterior chest wall is a common complaint, similar to intercostal neuralgia. Localised tenderness and prominence of the rib head on palpation and/or absence of joint movement on motion palpation distinguishes it from intercostal neuralgia and thus gives the most definitive diagnosis (Gatterman and Panzer, 1990). A typical rib articulates posteriorly with the vertebral column at costotransverse joint via the tubercle of the rib. The head of each rib also articulates with the intervertebral disc of the same numerical number as the rib as well as the demifacets on the two adjacent vertebral bodies. The joints formed between the head of the ribs and the vertebral bodies are known as the costovertebral joints, while the costotransverse joints forms between the tubercle of the rib and the transverse process of the vertebral body (Moore *et al.,* 2010). In rare instances, costovertebral joints may be associated with atypical flank, abdominal and chest pain as a result of anomalies of costovertebral joint(s) compressing the sympathetic trunk and splanchnic nerves in the thorax (Erwin, 2005). Degeneration of the costovertebral and costotransverse joints are frequent sources of chronic spinal pain but are not associated with neurological involvement. However, these degenerative changes may lead to intercostal nerve compression and are difficult to differentiate from nerve root entrapment at the intervertebral foramen (Bland, 2000).

Facet joint syndrome is defined as pain or dysfunction that arises primarily at the facet joints. Facet joint dysfunction is a state of subluxation in which there is tension, pressure, stretching or irritation of the facet joint capsule which can occur as a result of trauma, degeneration or postural strain (Gatterman, 2005). Facet joint degeneration can sometimes result in neural compression of either thoracic nerve roots or the spinal cord and hence cause TSP (Bland, 2000). Facet joint pain can also occur in scoliosis, especially on the convex side, either above or below the apex

(Davies and Saifuddin, 2009). Even though thoracic facet syndrome is so common, diagnosing it remains difficult as patient history and clinical examination can only help to exclude some differential diagnoses. Plain film radiographs, CT scans and MRI scans are also of limited diagnostic value (Erwin, 2005). The chiropractic thoracic subluxation or joint dysfunction is a clinical syndrome of abnormal biomechanical function associated with symptoms of pain, discomfort and localised muscle spasms and stiffness. Facet joints are often considered as the primary pain source associated with spinal subluxations (Erwin, 2005). Thoracic facet joint pain is usually deep and localised, unilateral paravertebral pain up to the medial border of the scapula. The pain can be reproduced by palpation over the affected segments. Thoracic facet joint pain may also refer pain to the retrosternal, costosternal or costochondral areas upon palpation or sometimes spontaneously (Erwin, 2005; Ombregt, 2013).

The T4 syndrome is described as a clinical pattern that involves complaints of upper back stiffness and pain with associated upper extremity numbness and/or parasthesia with or without headaches and/or neck pain. The cause of the syndrome is unknown although sympathetic dysfunction related to upper thoracic (T2-T7) vertebral dysfunction is thought to cause the reflex phenomena in the upper extremities. These symptoms may be reproduced or eliminated by mobilizing an upper thoracic vertebra (usually T4). Women (4:1 ratio) between the age range of 30 to 50 years are more commonly affected. The symptoms usually occur at night or upon rising while postural strain such as prolonged sitting, reaching and pulling activities, shoveling and overhead activities may contribute to the syndrome. Radiographs are not considered as a diagnostic tool for this syndrome (Lawrence and Bakkum, 2000; Conroy and Schneiders, 2005; Souza, 2009).

Congenital anomalies of the thoracic spine include abnormalities of the vertebral body such as block vertebra, butterfly vertebra (sagitally cleft vertebra) and hemivertebra as well as abnormalities of the vertebral arch such as failure of fusion of spinous processes, absence of thoracic pedicle, rib and transverse process anomalies and an enlarged spinal canal (Gatterman and Panzer, 1990; Saada *et al.,* 2000; Yochum and Rowe, 2005). These anomalies may contribute to abnormalities in the spinal curvature such as scoliosis, thoracic kyphotic deformity and/or rib anomalies (Saada *et al.,* 2000). A patient may experience considerable amounts of discomfort and pain if a clinician attempts to manipulate these ‘misalignments’ (Gatterman and Panzer, 1990). Identification of these anomalies may thus aid the clinician in the choice of mechanical therapy and appropriate referral of the patient where necessary (Saada *et al.,* 2000).

Spinal curvature anomalies such as scoliosis, kyphosis and congenital anomalies are complex multifactorial conditions contributing to thoracic spine pain (Singer, 2000; Garcia-Ariz, 2010). The thoracic spine is the most common site for spinal deformity with idiopathic scoliosis as the most common cause (McCall, 2000). Scoliosis is defined as a lateral deviation in the normal straight vertical line of the spine and can be either classified as structural or functional scoliosis. Functional scoliosis is usually less dramatic and progressive than structural scoliosis. The main difference between functional and structural scoliosis is the disappearance of the lateral curvature of the spine during flexion or side-bending movements in functional scoliosis, while a rib hump appears in the structural scoliosis due to the fixed lateral curvature of the spine (Gatterman and Panzer, 1990). Scoliosis is a complex and poorly understood phenomena with surprisingly little known about the aetiology of this skeletal disorder (Singer, 2000; Erwin, 2005). Curvatures may range from a cosmetic deformity with no functional or clinical abnormality to structural deformities such as asymmetrical shoulders, hips and breasts, dorsolateral rib hump and short trunk with significant history of back pain (Erwin, 2005; Garcia-Ariz, 2010).

Interestingly, scoliotic patients were found to have an incidence of back pain similar to the rest of the general population. However, patients with back pain tended to have larger curves (Erwin, 2005). Plain film radiography is the diagnostic method of choice to diagnose scoliosis, characterise the type of spinal curvature(s), exclude underlying causes, determine the flexibility of the curvature(s), follow disease progression and monitor treatment. Standard evaluation of scoliosis consists of a standing frontal radiograph of the entire spine (Amzallag-Bellenger *et al.,* 2014). Radiographic changes evident at the apex of the curves with thoracic facet joint sclerosis have a strong correlation with patients with a history of back pain (Erwin, 2005). Once specific pathological causes such as diseases, injuries and traumas have been ruled out, scoliosis can be treated conservatively (Gatterman and Panzer, 1990). Thoracic scoliosis is mostly postural and can therefore often be voluntarily corrected by the patient (Ombregt, 2013).

A normal thoracic spine, when observed from the side, is convex posteriorly. An exaggeration of this curvature is possible in all age groups and is referred to as thoracic hyperkyphosis. Different degrees of hyperkyphosis exist and may even be combined with abnormal lateral curves, called kyphoscoliosis. Thoracic hyperkyphosis in children and adolescents could possibly indicate secondary epiphysitis, osteochondritis or Scheuermann’s disease, while in underdeveloped countries or patients with nutritional compromise may indicate rickets. Increased thoracic kyphosis in children and adults may also suggest bad posture as a consequence from upper crossed syndrome (Rothman and Thiel, 2005). The upper cross syndrome is defined as tightness of the pectoralis major, levator scapulae, and upper trapezius and weakness of the middle trapezius, rhomboids, serratus anterior, and deep neck flexors, especially the scalene muscles (Moore, 2004). Patients with ankylosing spondylitis usually present with thoracic hyperkyphosis and flattened lumbar lordosis, while an excessive low thoracic and high lumbar kyphosis can result from osteoporosis or Scheuermann’s disease (Ombregt, 2013). A localised, acutely angled kyphosis may occur as a result of a collapsed vertebral body caused by either trauma, osteoporosis, adolescent osteochondrosis, malignancy or infections such as osteomyelitis or tuberculosis (Rothman and Thiel, 2005; Ombregt, 2013).

A progressive increase in thoracic kyphosis is usually more evident in women after the sixth decade (Singer, 2000). The changes are usually associated with degenerative changes. The anterior part of the vertebral discs and bodies become more compressed resulting in loss of disc space and osteophytic changes. Plain film radiographs can be helpful in differentiating between these degenerative changes and similar changes that occur in patients with osteoporosis (Corrigan and Maitland, 1998). Radiographs of osteoporotic individuals usually show increased radiolucency, cortical thinning, accentuated primary trabecular pattern, changes in vertebral shape e.g. vertebra plana, wedge vertebra, biconcave deformities, endplate deformities and Schmorl’s nodes (Gatterman and Panzer, 1990; Yochum and Rowe, 2005e). Mild Scheuermann’s disease might go unnoticed until radiographic examination. In the early stages radiographic examination may show no abnormalities but as the condition progresses, irregularities along the vertebral endplates, Schmorl’s nodes and later characteristic wedging affecting several adjacent vertebrae are seen (Gatterman and Panzer, 1990). According to Yochum and Rowe (2005), Scheuermann's disease is radiologically defined as anterior wedging (more than 5°) of 3 or more contiguous segments, irregular endplates (Schmorl's nodes), loss of disc height and increased kyphosis (more than 40°) in the midthoracic area (75%) and/or thoracolumbar area (25%).

The symptoms of patients with thoracic hyperkyphosis can range from asymptomatic to severe aching pain. This pain is difficult to eradicate and to get under control may be present for many years, worse after activity and disturb sleep at night (Corrigan and Maitland, 1998). Patients with Scheuermann's disease experience pain typically at the end of the day. Spinous process palpation and percussion may also be tender with possible localised paraspinal muscle spasm and tight hamstring and pectoral muscles. Osteoporotic patients usually complain of ill-defined, aching back pain that can become sudden sharp pain due to compression fracture(s). These fractures can occur as a result of minimal trauma such as lifting and bending. The fractures are usually accompanied by painful muscle spasm (Gatterman and Panzer, 1990). Altered thoracic spine mechanics due to increased kyphosis can also affect normal respiratory physiology and cause long-term deformity (Singer, 2000).

The most common etiology of vertebral compression fractures is osteoporosis, followed by trauma, infection and neoplasms (Alexandru and So, 2012). Compression fractures are most common in the thoracolumbar spine, while the mechanism of thoracic vertebral fractures usually involves flexion and axial loads (Meyer, 1992 as cited in Giles and Singer, 2000; Alexandru and So, 2012) from motor vehicle accidents and falls (Daffner, 1990 as cited in Giles and Singer, 2000). Vertebral end-plate ruptures or Schmorl's nodes usually occur with rapid axial loading in flexion (Singer, 2000). Post-mortem studies revealed that most acute Schmorl's nodes were identified in spines of individuals aged between 11-30 years with the male to female ratio being 9:1, predominantly confined to the T8-L1 segments (Fahey *et al.,* 1998 as cited in Giles and Singer, 2000). Schmorl's node injuries are only radiological detectable once a difference of 40% in bone density exists (Singer, 2000). Vertebral compression fractures or fracture-dislocations are the most common findings in trauma cases (An *et al.,* 1994 as cited in Giles and Singer, 2000). Stress fractures must be considered in elite athletes and/or osteoporotic individuals when pain is aggravated by activity, but later even occur at rest, if the aggravating activity continues (Peterson and Hsu, 2005). Severe injuries can be serious due to potential spinal cord injury and subsequent neurological deficit (McCall, 2000). Thoracic spine fractures are associated with spinal cord injury in 50% of the cases (Anderson, 2010).

Costochondritis (Tietze’s syndrome) is described as syndrome of pain and swelling of the costal cartilage and usually involves the second rib. The patient is usually able to indicate the site of lesion accurately, while extensive radiation of pain may also occur (Skubic and Kostuik, 1991). The onset of costochondritis is often insidious, most commonly following a history of an upper respiratory viral infection, minor trauma or unaccustomed activity such as moving furniture, carrying awkward objects and painting. Pain is described as sharp, nagging, aching or pressure-like and may vary from a mild sensation to severe pain. The pain can be aggravated by deep inhalation, trunk movement and/or exertion, while decreased movement, quiet breathing and/or change in position may relieve the pain (Flowers, 2015). Palpation of the chest wall is considered important in the diagnosis of costochondritis as it may be mistaken for cardiac pain in individuals with thoracic pain complaints. Non-steroidal anti-inflammatory medication and steroid injections provided relief as a method of treatment (Skubic and Kostuik, 1991; Flowers, 2015).

One of the most common causes of thoracic spine pain is of myofascial origin (Friction, 1994; Erwin, 2005; Benjamin, 2007) characterised by localised muscle tenderness and pain (Friction, 1994). Trigger points in muscle bands, pain in a zone of reference, occasional associated symptoms and the presence of contributing factors are clinical characteristics of myofascial pain. Many of these characteristics are also found in fibromyalgia, tension-type headaches, myositis and muscle spasms. A trigger point is defined as deep localised tenderness within a taut band of skeletal muscle responsible for pain in a zone of reference that may resolve if treated appropriately (Friction, 1994; Travell and Simmons, 1999). These trigger points are thought to be local areas of inflammation, relative ischemia, or fibrosis within the taut muscle bands (Erwin, 2005). Trigger points usually develop in acute or chronic muscle strains due to local overload (Gatterman and Goe, 1990; Erwin, 2005). A muscle strain results in tissue damage which may include damage to the sarcoplasmic reticulum which impairs its ability to remove calcium from the injured site. The increased amount of calcium availability to the myofibrils results in sustained contraction of the sarcomere and eventually results in muscular fatigue and palpable taut bands associated with trigger points. This sustained contraction creates a region of uncontrolled metabolism that can result in additional mast-cell release of histamine and the depletion of local ATP (Adenosine Triphosphate). The sustained contraction may also result in local vasoconstriction which in turn results in reduced local blood flow to the area and local accumulation of metabolites, such as prostaglandins, which may irritate local nerve endings resulting in localised pain. The localised sustained contraction ultimately results in pain, stiffness, decreases range of motion and generalised disability (Gatterman and Goe, 1990). Psychological symptoms such as frustration, anxiety, depression and anger can cause acute cases to become chronic, while maladaptive behaviors such as postural decompensation, prolonged constrained posture, muscular deconditioning, poor sleep, poor dietary habits, tension-producing habits and medication dependencies may contribute to muscular fatigue and prolong muscle weakness, pain and stiffness (Friction, 1994; Travell and Simons, 1999; Erwin, 2005).

Most of the thoracic myofascial trigger points are found in the upper thoracic, paraspinal, accessory, and interscapular muscles. Most of the trigger points are found in the trapezius, rhomboids and levator scapulae muscles and are referred to as the antigravity muscles that support the pectoral girdle. These muscles have to withstand static loading as the individual works for prolonged periods of time with the arms in elevated positions (Gatterman and Panzer, 1990). The longissimus thoracis, iliocostalis thoracis and semispinalis thoracis muscles are most likely to develop trigger points in the mid-back area. Iliocostalis thoracis muscle trigger points at mid-thoracic level mainly refer pain upwards toward the shoulder and laterally to the chest wall, while iliocostalis thoracis muscle trigger points at the low thoracic level may refer pain upward across the scapula, around the abdomen and downward over the lumbar area. Longissimus thoracis muscle trigger points at the lower thoracic level refer pain to the buttock. The deeper semispinalis thoracis muscle may cause severe aching ‘bone’ pain that is persistent, worrisome and disabling (Travell and Simons, 1999).

Fibromyalgia is a common and debilitating cause of back pain, affecting 2%-5% of the population in developed countries, predominantly young to middle-aged females (Guymer and Littlejohn, 2013). Fibromyalgia is an idiopathic, chronic, multisystem, non-articular pain syndrome characterised by generalised and widespread soft tissue tender points, sleep disturbance, headaches, fatigue, morning stiffness, paresthesias and anxiety. The condition is diagnosed by the presence of widespread pain for at least three months with the presence of 11 tender points among 18 specific anatomical sites (Chakrabarty and Zoorob, 2007).

Bone neoplasms are classified according to their origin into either primary or secondary bone tumors. Primary bone tumors are further classified into either benign or malignant tumors, while secondary tumors are always malignant as a result of metastases (Peterson and Hsu, 2005). Primary lesions arise from local involvement of the spine such as bone, the spinal cord or its coverings, or contiguous spread from paraspinous soft tissues and lymphatics (Weinstein, 1991). The majority of malignant tumors of bone metastasise from epithelial origin in the breast, lung, prostate, kidney, thyroid and bowel (Yochum and Rowe, 2005; Algra *et al.,* 2013). Approximately 5-10% of all cancer patients will develop spinal metastatic disease of their tumors with up to 70% of them manifesting in the thoracic spine (Smith *et al.,* 2012). Approximately 30% of all malignant tumors are primary in nature, while 70% are of metastatic origin.

The most common primary malignant bone tumors are multiple myeloma, osteosarcoma, chondrosarcoma and Ewing sarcoma. The other, less common primary malignant bone tumors are Hodgkin and non-Hodgkin lymphoma, chordoma, fibrosarcoma, synovioma and adamantinoma. Most benign bone tumors are asymptomatic unless pathological fracture(s) occur, while malignant tumors almost always produce symptoms (Peterson and Hsu, 2005). Tumors of the spinal column usually remain asymptomatic for a short period of time until the symptoms develop. Pain seems to be the most common symptom in both benign and malignant tumors. It has an insidious and progressive onset that is localised and worst at night (Kostuik and Weinstein, 1991). Radicular symptoms usually present as a bilateral, segmental band or ‘girdle’ of pain in thoracic lesions (Gilbert *et al.,* 1978 as cited in Frymoyer *et al.,* 1991). Other symptoms include weakness, a palpable mass and /or bladder and bowel dysfunction due to spinal cord compression (Weinstein and McLain, 1987 as cited in Frymoyer *et al.,* 1991).

Alerting features of tumors in patients with acute TSP include: past history of malignancy, age > 50, failure to improve with treatment, unexplained weight loss, pain at multiple sites, pain at rest and night pain (Yelland *et al.,* 2004) (**Table 2.2**).

Approximately 70% of all intradural tumors are extramedullary with the rest being intramedullary. Intradural tumors have a slow progression of symptoms compared to extradural tumors. Thoracic extramedullary lesions tend to present more with radicular pain and asymmetric motor deficits than intramedullary tumors. In intramedullary lesions, the motor and sensory function are usually more severely affected at the level of the lesion than distally, similar to that seen in syringomyelia (Cassidy and Ducker, 1991).

Plain film radiography remains the initial investigative method in patients with suspected thoracic spine tumor(s). Soft tissue swelling, periosteal reactions, cortical destruction, a wide zone of transition and a moth-eaten or permeative pattern of bone destruction are all radiographic features of malignant tumors, while the radiographic features of benign tumors usually include a well-corticated sclerotic margin, geographic pattern of bone destruction and they rarely cause cortical disruption without trauma (Peterson and Hsu, 2005). Plain film radiographs of the spine may show widening of the interpedicular distance-, and erosion or thinning of the pedicles in intramedullary tumors, while extramedullary tumors cause widening of the intervertebral foramen, increased interpedicular distance and pedicle or/and bone erosion (Cassidy and Ducker, 1991). However due to limited diagnostic sensitivity, certain diseases such as osteomyelitis and metastasis of the spine have to cause a significant amount of damage (30%-50% loss of bone density and a lesion size of at least 1cm-5cm) to the spine before being radiologically evident (O'Connor *et al.,* 1999; Yochum and Rowe, 2005d).

Spinal infections accounts for only 10% of all osseous infections (Yochum and Rowe, 2005d). Only 2%-4% of all cases of spinal osteomyelitis are caused by suppurative infections (Goldman and Freiberger, 1979 as cited in Yochum and Rowe, 2005d). Thoracic pyogenic spinal infection includes vertebral osteomyelitis, epidural abscess and septic discitis. Vertebral osteomyelitis develops when infectious agents such as bacterial, viral, mycobacterial, fungal and/or parasitic organisms enter the bone and overcome the host's immune system (Vincent and

Benson, 1991; Peterson and Hsu, 2005). Osteomyelitis is therefore more common in immunocompromised individuals such as diabetics, alcoholics, people with malignancies, HIV (Human Immunodeficiency Virus). Other predisposing factors for spinal infection include: malnutrition, elderly, intravenous drug abuse, chronic steroid usage, malignancy, renal failure, septicemia, recent spinal surgery and intravascular devices (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Butler *et al.,* 2006; Michael *et al.,* 2009). These infections are usually classified in a functional way according to the causative agent (Vincent and Benson, 1991). *Staphylococcus aureus* is the most common isolated infectious agent in more than 90% of the cases, while other less common gram-negative infections result from *Escherichia coli, Pseudomonas, Salmonella, Klebsiela and Corynobacterium* (Yochum and Rowe, 2005). Infections usually invade the bone from a contiguous source, direct implantation, post-operative infection or via hematogenous spread of the infectious agent (Yochum and Rowe, 2005). The most common site for spinal infections is the lumbar spine, followed by the thoracic spine. These spinal infections are more common in males with the highest incidence in the fifth to sixth decade of life (Yochum and Rowe, 2005).

Non-suppurative/Granulomatous infections of the spine include tuberculosis of the spine (Pott's disease), fungal infections such as *Coccidioidomycosis, Blastomycosis, Cryptococcosis, Aspergillosis, Brucelosis* and *Actinomycosis* while rare parasitic spinal infections include *Echinococcosis*. In granulomatous infections, the invading organism triggers an immune response in the host which results in the formation of granulomas. The most common cause of granulomatous infection is tuberculosis, caused by the organism *Mycobacterium tuberculosis*. Granulomatous infections usually attack the skeleton, with the vertebral column commonly involved. Tuberculosis is the most common granulomatous infection that involves the spine, most commonly the lower thoracic and upper lumbar spine (Resnick and Niwayama, 1981 as cited in Yochum and Rowe, 2005d), and does so in more than 50% of cases (Vincent and Benson, 1991; Vinas, Stumpf and Rhodes, 2015).

The signs and symptoms of vertebral infections depend on the virulence of the organism, the extent of the disease, as well as the host resistance (Goldman and Freiberger, 1979 as cited in Yochum and Rowe, 2005d). It is most common during the first three decades of life and equally distributed between both sexes (Tuli, 2004). Back pain in the region of the involved joints is the most common complaint. The onset of the pain is usually insidious and constant. The pain may be with or without neurological involvement and may also be aggravated by motion. A sudden onset of lower limb paraplegia can occur in spinal tuberculosis and is referred to as Pott's paraplegia (Yochum and Rowe, 2005). Focal tenderness, localised muscle spasm and decreased range of motion are usually evident on physical examination. Fever occurs in only one-third of the patients with spinal infections (Garcia and Grantham, 1960 as cited in Yochum and Rowe, 2005d; Goldman and Freiberger, 1979 as cited in Yochum and Rowe, 2005d). Furthermore, abscesses or vertebral collapse can result in neurological compromise and requires surgical debridement and drainage (Vincent and Benson, 1991).

Plain film radiographs have a 90% sensitivity in the ability to detect infections at the later stages of the disease (Deyo and Diehl, 1986 as cited in Mootz *et al.,* 1999). However, the radiographic latent period of osteomyelitis in the spine is minimally 21 days and a significant amount of damage (30%-50% loss of bone density and a lesion size of at least 1cm-5cm) to the spine has to occur before being radiographically evident (O'Connor *et al.,* 1999; Yochum and Rowe, 2005). The earliest radiographical sign of spinal infection is disc space narrowing, followed by endplate irregularity and increased radiolucency. Eventually, vertebral destruction and collapse occurs with paraspinal soft tissue edema (Tuli, 2004; Yochum and Rowe, 2005). Infections can usually be distinguished from tumors on radiographs as they tend to cross joints while tumors do not (Peterson and Hsu, 2005).

Inflammatory arthropathies usually causes uniform loss of joint space, bony erosions, juxta-articular osteoporosis, periostitis of adjacent metaphysis, soft tissue swelling and edema that may manifest monoarticular or polyarticular. The manifestations are usually more symmetrical when polyarticular. Inflammatory arthritides can be either seronegative – or seropositive arthritides, depending on the presence of the rheumatoid factor (Yochum and Rowe, 2005; Hui, 2011).

Seropositive arthropathies are connective tissue disorders with the presence of rheumatoid factor in the serum and include rheumatoid arthritis, scleroderma, dermatomyositis and systemic lupus erythematosis (SLE) (Peterson and Hsu, 2005). Seropositive arthropathies are more common in females (3:1) at an age of 50 years and older (Hui, 2011). These disorders do not manifest in the thoracic spine region, except for rheumatoid arthritis in rare instances (Heywood and Meyers, 1986 as cited in Giles and Singer, 2000). Rheumatoid arthritis is a synovial inflammatory arthritis that targets mostly peripheral joints of both extremities, as well as larger joints and the cervical spine (Peterson and Hsu, 2005; Yochum and Rowe, 2005). These patients usually present with local pain, periarticular soft tissue swelling and stiffness from possible pathological facet joint granulations, subluxations and/or vertebral collapse. Vertebral endplate and facet joint erosions may be radiographically evident (Bland, 2000; Peterson and Hsu, 2005).

Seronegative spondyloarthropathies are arthritic disorders in which rheumatoid factor is distinctively absent and include ankylosing spondylitis, enteropathic arthritis, Reiter's syndrome, psoriatic arthritis and Behçet's syndrome (Katz and Liang, 1991; Yochum and Rowe, 2005; Hui, 2011). These arthropathies favor the axial skeleton and ligamentous attachment sites (Person and Hsu, 2005). Spinal involvement is especially common and severe in ankylosing spondylitis (Katz and Liang, 1991).

Ankylosing spondylitis is a chronic inflammatory disorder which distinctively affects the synovial joints of the axial skeleton and ligamentous attachment sites in predominantly younger adult males (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Weisman, 2011). Hereditary factors seem to be involved but the exact aetiology is unknown (Gatterman and Panzer, 1990). The disorder is characterised by the sequelae of articular bony ankylosis, ligament ossification and manifestations of enthesopathy (Yochum and Rowe, 2005). The onset of symptoms are usually insidious and included bilateral sacroiliitis, lumbar stiffness and thoracolumbar spinal pain. The symptoms are usually worse in the mornings and improve with exercise. Some patients experience intense pain at night which interrupts their sleep. Patients develop trunk muscle atrophy which may contribute to the development of a well-known and recognised feature of ankylosing spondylitis – their increased thoracic kyphosis (Khan, 1984 as cited in Katz and Liang, 1991; Resnick and Niwayama, 1995 as cited in Giles and Singer, 2000; Weinstein and Buckwalter, 2005). General radiographic features of ankylosing spondylitis are bilateral and symmetrical in nature and include bony and articular erosions, surrounding reactive sclerosis, followed by bony ankylosis (Weinstein and Buckwalter, 2005; Yochum and Rowe, 2005). A 'bamboo' spine is a characteristic radiographic appearance in patients with ankylosing spondylitis due to the ossification of the annulus fibrosis and marginal syndesmophytes (Gatterman and Panzer, 1990; Weinstein and Buckwalter, 2005; Yochum and Rowe, 2005).

Reiter's syndrome is a reactive arthritis that occurs secondary to dysenteric or venereal disease and manifests as a triad of urethritis, uveitis and polyarthritis. The syndrome has a preference for joints in the lower extremities while sacroiliac and thoracolumbar spinal joints are mainly affected in the axial skeleton (Peterson and Hsu, 2005).

Psoriatic arthritis is a destructive joint disease associated with only 5% of patients with cutaneous psoriasis (Peterson and Hsu, 2005; Weinstein and Buckwalter, 2005). Psoriatic spondylitis usually manifests in the lower thoracic and upper lumbar spine of approximately 60% of individuals with the skin disease (McEwen *et al.,* 1971 as cited in Yochum and Rowe, 2005b). Radiographic features of psoriatic arthritis are almost identical to those of Reiter's syndrome in the thoracolumbar area and consist of paravertebral ossifications (non-marginal syndesmophytes) in the connective tissues external to the anterior longitudinal ligament and annulus fibrosis (Sunduram and Patton, 1975 as cited in Yochum and Rowe, 2005b).

Enteropathic arthritis is a collective term to group all gastrointestinal diseases that produce articular abnormalities. Non-specific inflammatory diseases of the intestines include: Chrohn's disease, ulcerative colitis and Whipple's disease, while common infective enteritides include: salmonellosis, yersiniasis and shigellosis (Bahk, 2000; Zvaifler and Martel, 1960 as cited in Yochum and Rowe, 2005b). Radiographic features of the spine include facet and costovertebral joint erosion, sclerosis, loss of joint space and eventual ankylosis. A 'bamboo' spine similar to ankylosing spondylitis may occur in longstanding cases due to 'squaring' of vertebral bodies and bilateral, marginal syndesmophytes (Yochum and Rowe, 2005). Other common radiographic changes are osteoporosis and peri-articular soft-tissue swelling (Bahk, 2000).

Diffuse idiopathic skeletal hyperostosis (DISH) is characterised by calcification and ossification of predominantly the anterior longitudinal ligament, most commonly found at the middle and lower thoracic spine regions, and typically affects patients of the same age group as those with osteoarthritis (Gatterman and Panzer, 1990;

Peterson and Hsu, 2005). The condition ranges from asymptomatic to spinal stiffness, especially in the morning, thoracic spine pain and spinal tenderness (Utsinger, 1985 as cited in Giles and Singer, 2000). Radiological features include calcification and ossification along the anterolateral aspect of at least 4 contiguous vertebrae with the preservation of intervertebral disc height and absence of facet joint ankylosis, sacroiliac joint erosion or intra-articular osseous fusion (Resnick *et al.,* 1975 as cited in Yochum and Rowe, 2005b).

Metabolic disorders that affect the thoracic spine and may contribute to thoracic spine pain include osteoporosis, osteomalacia, hyperparathyroidism, Cushing's disease and corticosteroid osteonecrosis, eosinophilic granuloma and ochronosis (Bland, 2000; Singer, 2000; Peterson and Hsu, 2005; Yochum and Rowe, 2005).

Osteoporosis is the most common metabolic disease of bone (Peterson and Hsu, 2005) and is characterised by decreased bone mass and altered micro-architecture of bone which leads to increased bone fragility and rate of fractures in especially the spine, pelvis and long bones (Gatterman and Panzer, 1990; Peterson and Hsu, 2005; Yochum and Rowe, 2005). Osteoporosis is four times more common in females than males. However, differences in the ratio seems to equalise at 80 years of age (Peterson and Hsu, 2005; Yochum and Rowe, 2005). Symptoms in the thoracic spine are dependent on the bone mass and density, vertebral deformity and fractures. Other factors such as lifestyle, occupation, diet, smoking, vitamin D deficiency, disease and long-term steroid therapy should raise the suspicion of fractures as they may contribute to osteopenia (Singer, 2000; Peterson and Hsu, 2005) (**Table 2.2**). Stress fractures must be considered in elite athletes and/or osteoporotic individuals when pain is aggravated by activity, but later even occurs at rest, if the aggravating activity continues (Peterson and Hsu, 2005). Clinical features range from asymptomatic to neurological abnormalities in spinal compression and spinal stenosis (Yochum and Rowe, 2005). Acute thoracolumbar or pelvic pain and discomfort with insignificant trauma can be suggestive of osteoporotic fracture(s) (Peterson and Hsu, 2005).

Osteoporosis in the spine is frequently distinctive and pronounced. The major radiographic features of osteoporosis in the spine include: increased radiolucency, cortical thinning, accentuated primary trabecular pattern and changes in the vertebral body shape e.g. vertebra plana, wedge vertebra, biconcave deformities, endplate deformities and Schmorl's nodes which are most common in the mid-thoracic and thoracolumbar regions (Yochum and Rowe, 2005). However, plain film radiography is not generally utilised as a screening method because 40%-50% bone loss is required to detect an abnormality. Dual-energy X-ray absorptiometry (DEXA) is considered the 'gold standard' for screening osteoporosis (Moyad, 2003; Bussières *et al.,* 2008).

Osteomalacia literally means 'soft bones'. This disorder has multiple aetiologies and is characterised by deficient osteoid mineralization causing bone softening (Yochum and Rowe, 2005; Hussein *et al.,* 2010). Kyphoscoliosis and/or increased endplate concavities predominate as radiographic features in the thoracic spine of patients with osteomalacia. Other radiographic features of osteomalacia in the thoracic spine include a 'bell-shaped' thoracic cage with possible acute fracture deformities, coarsened trabeculae and cortical thinning. The patient may also present with muscle weakness, bone pain and deformities (Greenfield, 1980 as cited in Yochum and Rowe, 2005e; Hussein *et al.,* 2010).

Hyperparathyroidism is a condition in which the parathyroid glands secrete excess parathyroid hormone which result in overstimulated osteoclasts that remove bony matrix resulting in diffuse osteopenia (Peterson and Hsu, 2005; Yochum and Rowe, 2005). The spine is usually only affected in 5%-15% of patients receiving long-term hemodialysis. Approximately 30% of the patients are asymptomatic while 20% may experience cord compression symptoms that may be fatal (Stolpen, 1993 as cited in Yochum and Rowe, 2005e). Osteosclerosis in the sub-endplate zones of the vertebral bodies at multiple contigious levels produce the 'Rugger-jersey' spine which is a characteristic radiographic feature of hyperparathyroidism (Provenzale *et al.,* 2012). Other radiographic features may include endplate irregularities due to Schmorl's nodes, small subchondral resorptive changes and trabecular accentuation (Yochum and Rowe, 2005; Provenzale *et al.,* 2012).

Excessive production of glucocorticoid steroids by the adrenal cortex results in Cushing's disease. Cushing's disease and corticosteroid osteonecrosis results in osteopenia, biconcave deformities of vertebral bodies (fish-mouth vertebrae), avascular necrosis, compression fractures wedged anteriorly, anteriorly and posteriorly or centrally, destructive arthropathy and/or soft tissue atrophy (Murray, 1976 as cited in Yochum and Rowe, 2005e; Naidich *et. al.,* 2011). Vertebral collapse occurs mostly due to avascular necrosis with occasional nitrogen gas collections within the vertebral body and is known as a 'intravertebral vacuum cleft' sign (Maldaque, Noel and Malghem, 1978 as cited in Yochum and Rowe, 2005e; Golimbu *et al.,* 1986 as cited in Yochum and Rowe, 2005e). Approximately 50% of these vertebral compression fractures occur in the thoracolumbar spine and usually results in 25%-75% loss of vertebral body height (Kumpan *et al.,* 1986 as cited in Yochum and Rowe, 2005e) and accentuation of the thoracic spine (Naidich *et al.,* 2011). Other associated radiographic findings include adjacent degenerative disc disease and vertebral ankylosis (Murray, 1976 as cited in Yochum and Rowe, 2005e). The lower thoracic and upper lumbar vertebrae undergo repeated microfractures of the endplate and sub-endplate zones which manifest radiographically as abundant callus, especially in the sub-endplate zone, resulting in a hazy band of sclerosis and is referred to as a 'marginal condensation' sign (Yochum and Rowe, 2005; Naidich *et al.,* 2011).

Eosinophilic granuloma is a disease in which there is a considerable amount of proliferating histiocytes (mainly Langerhans's histiocytes) within a granuloma that provokes a significant immune response dominated by eosinophils (Osband, 1987 as cited in Yochum and Rowe, 2005e). Eosinophilic granuloma affects the spine 6% of the time, with more than 50% involving the thoracic spine (Wilner, 1982 as cited in Yochum and Rowe, 2005e; David *et al.,* 1989 as cited in Yochum and Rowe, 2005e). Vertebral involvement can result in focal pain, paravertebral swelling and complicating myelopathy secondary to cord and/or nerve root compression following vertebral collapse (Kulkarni, 2009). Eosinophilic lesions are usually solitary but may occasionally involve multiple levels (Yochum and Rowe, 2005). The most prominent radiographic feature of eosinophilic granuloma is the 'silver dollar vertebra' in which both the anterior and posterior vertebral body surfaces collapse, resulting in significant loss of vertebral body height as thin as 2 mm. It usually results in a short-segment kyphosis when the thoracic spine is involved (Ippolito *et al.,* 1984 as cited in Yochum and Rowe, 2005e).

Ochronosis stems from defective homogentisic acid oxidase (Peterson and Hsu, 2005; Pope *et al.,* 2014) resulting in hereditary degenerative arthritis of large joints and the spine (Yochum and Rowe, 2005). The spine is affected in 95% of the cases, especially the thoracic and lumbar regions, resulting in increasing thoracic kyphosis and progressive flattening of the lumbar lordosis (O'Brien *et al.,* 1963; Yochum and Rowe, 2005; Pope *et al.,* 2014). Patients with ochronosis usually suffer from progressive spinal pain and stiffness, especially by the fourth decade of life (Pope *et al.,* 2014). Radiographic features of ochronosis are most characteristic in the spine, especially in the thoracic and lumbar spine and include severe disc narrowing, 'waferlike' calcifications parallel to the vertebral body endplates at multiple levels, 'vacuum' phenomenon, small osteophytes, ligamentous ossification, progressive kyphosis and eventual osseous ankylosis. (Pomeranz *et al.,* 1941 as cited in Yochum and Rowe, 2005e; Pagan-Carlo and Payzant, 1958 as cited in Yochum and Rowe, 2005e; Peterson and Hsu, 2005; Pope *et al.,* 2014).

Other causes of TSP may include iatrogenic, post thoracotomy syndrome, and psychogenic conditions (Skubic and Kostuik, 1991; Giles, 2000). Post thoracotomy pain syndrome occurs in approximately 5% of patients after a thoracotomy. Painful or disturbing sensations are usually experienced around the incisions or a dermatomal pattern may be experienced around the chest due to intercostal nerve irritation. Most cases resolve spontaneously with time while others undergo intercostal nerve blocks or surgical intercostal rhizotomy (Skubic and Kostuik, 1991).

Psychogenic aetiological factors of spinal pain are not well understood and may be primary (conversion disorder), secondary (depression, poor coping strategies), contributory (myofascial dysfunction) or absent (Keim and Kirkaldy-Willis, 1987 as cited in Giles and Singer, 2000). 'Yellow flags' is a term given to psychological, social and environmental risk factors resulting in disability and failure to return to work as a consequence of musculoskeletal symptoms (Kendall *et al.,* 1997; Nicholas *et al.,* 2011). Examples of 'yellow flags' include: poor expectations of treatment outcomes, belief that pain and injury is uncontrollable and likely to worsen, emotional disturbances such as worry, anxiety, fear and poor pain coping strategies (Nicholas *et al.,* 2011). These 'yellow flags' are commonly seen in practice, especially in patients suffering from chronic back pain. It is therefore important for clinicians to recognise these psychosocial factors as they may have a direct influence on the management and outcome of patients with TSP (Pederson, 2005).

Visceral pathology may refer pain to the thoracic spine. These pain syndromes include, but are not limited to, sources from the cardiovascular, respiratory and gastrointestinal systems (Singer, 2000).

In rare instances cardiac, pulmonary or abdominal structures may refer pain to the thoracic spinal region, requiring the clinician to maintain a high level of suspicion for visceral disease (McClune *et al.,* 2000; Erwin, 2005). These viscerogenic causes include disorders of the cardiovascular, pulmonary and abdominal system (**Table 2.1**). Even though these instances are rare, the thoracic spine as an area should be viewed as more significant for underlying pathologies than any other area of the spine (Erwin, 2005). It is important to acknowledge that the pain location may not correspond with the origin of the pathology. The nature or behaviour of pain (dull, sharp, intermittent or constant) can be used as a guide in formulating a provisional diagnosis (Singer, 2000). Failure to diagnose these ominous pathologies could result in potential fatal consequences (Erwin, 2005).

Thoracic spine pain of mechanical origin is most commonly encountered and therefore warrant special mention. Approximately 10%-20% of TSP patients suffer from non-mechanical TSP, which may be due to serious pathology, while the remaining 80%-90% have mechanical TSP (Giles, 2000). Mechanical TSP is considered a 'diagnostic dilemma' as the specific anatomical diagnosis for mechanical TSP is difficult to make and no specific laboratory or diagnostic imaging tests exists that can confirm the diagnosis of mechanical TSP (Singer and Edmondston, 2000; Erwin, 2005). However, clinical diagnoses can be based on information derived from the case history, physical examination and radiological examination (Singer and Edmondston, 2000). The numerous causes of TSP stresses the importance of a thorough and detailed medical history and physical examination in formulating a provisional diagnosis or differential diagnoses. As mentioned earlier, the majority of TSP causes are mechanical of origin and therefore self-limited. However, unrecognised pathology may lead to serious complications through delays in initiating referral for appropriated management. Further diagnostic investigations such as plain film radiographs, CT scans, MRI scans and/or laboratory tests may thus be necessary to exclude any red flags and/or to verify or rebut the suspected clinical diagnosis.

2.2.1 FACTORS ASSOCIATED WITH THE DIAGNOSIS OF THORACIC SPINE PAIN

Much less is known about the mechanisms of TSP and it's pain referral patterns than the cervical and lumbar spine regions and joints (Erwin, 2005; Young *et al.,* 2008). The thoracic spine is considered a complex and challenging region to determine the exact aetiology of the patient's back pain (Erwin, 2005).

Thoracic spine pain syndromes must be viewed in the context of (1) the less well defined, but more prevalent, conditions of TSP of mechanic origin, and (2) those of more serious, clearly defined conditions of pathological origin (Giles, 2000).

The more common, less serious, mechanical causes of TSP are usually self-limiting (Michael *et al.,* 2009) and likely to respond dramatically to manual treatment such as mobilization and/or manipulation (Giles, 2000). However, according to Michael *et al.,* (2009), TSP should always be considered as a 'red-flag' because patients with TSP are proportionately far more likely to have serious underlying spinal pathology than those with cervical and lumbar spine pain. Red flags are features of potential serious underlying pathology and are recognised through subjective and objective assessments (Henschke *et al.,* 2013).

A thorough and detailed medical history and physical examination remain supreme in formulating a provisional diagnosis in patients with TSP (Bland, 2000; Giles, 2000, Singer and Edmondston, 2000; Erwin, 2005; Michael *et al.,* 2009). Diagnosing the exact aetiologies of mechanical TSP are extremely difficult (Findlay and Eisenstein, 2000) as the manifestations of disease in the thoracic spine fluctuate and relate to pain and loss of function (Bland, 2000). Even the most sophisticated diagnostic imaging procedures lack consensus on their diagnostic validity of mechanical TSP (Giles, 2000). Understanding the physiology and anatomy of the thoracic spine is therefore vital in assisting the clinician in making an accurate diagnosis (Bland, 2000).

The presence of red flags may indicate underlying disorders such as fractures, malignancy, infections, inflammatory arthritides, neurological disturbance, or other serious conditions (Michael *et al.,* 2009) (**Table 2.2**). Red flags qualify as indicators for further appropriate investigations such as plain film radiography or advanced imaging procedures and/or specialist referral (Pederson, 2005; Bussiéres *et al.,* 2008) before a diagnosis of benign mechanical TSP can be made (Michael *et al.,* 2009). It is vital to identify red flags as misdiagnosis may result in serious complications due to the delays in initiating referral for appropriate treatment (Giles, 2000). Specific care should be taken in patients with the presence of red flags as early diagnosis of these underlying pathologies may prevent unnecessary invasive surgery or alter the long term outcome and survival of patients with TSP (Michael *et al.,* 2009)

Table 2.2: Red flags associated with thoracic spine pain*

DISORDER	HISTORY FINGS	PHYSICAL FINDINGS
General	Age of onset < 20 and > 50 [4;5] Recent history of violent trauma [5] Constant, progressive, non-mechanical pain (no relief or worsened with bed rest) [4;5] Persistent, localised thoracic pain (> 4 weeks) [4] Past history of malignant tumor [5] Prolonged use of corticosteroids [5] Drug abuse, immunosuppression, HIV [5] Systemically unwell [5] Unexplained weight loss [4;5] Widespread neurological symptoms (including cauda equina syndrome) [4;5] Fever [4;5] Progressive or painful structural deformity [4;5] No response to care after 4 weeks [4] Significant activity restriction > 4 weeks [4]	Scoliosis [5] Hyperkyphosis [5] Café au lait spots [5]
Fracture	Minor trauma (Age > 50 years, history of osteoporosis, taking corticosteroids) [1;2] Major trauma [1;2]	Deep tenderness on spinous percussion [1;2;5]
Infection	Fever (> 38.3°C) for > 3 weeks [2;4] Night sweats [2] Risk factors for infection (immunosuppression, IV drug abuse, penetrating wound, underlying disease process) [2;4] Elevated ESR > 20mm/h [4] History of spine surgery [4]	Structural deformity (Pott's diease) [5] Deep tenderness on spinous percussion [4] Neurological deficit [1;5] Lymphadenopathy [1;4;5]
Malignancy	Past history of malignancy [1;2;4] Age < 20 and > 50 [1;2;3;4]	Deep tenderness on spinous percussion [5] Neurological deficit [1;5]

	Unexplained weight loss (> 10lb over 4 weeks) [1;2;3;4] Failure to improve with treatment (> 4 weeks) [2;4] Pain at multiple sites [3] Pain at rest [3] Night pain [1;3]	Lymphadenopathy [1;4;5] Signs of Horner's syndrome [1]
Inflammatory arthritides	Family history of inflammatory arthritides [5] Early morning stiffness (> 1hour) [4;5] Eye symptoms [4;5] Urethritis [4;5] Dermititis [4;5] Gastroenteritis [4;5] Gradual onset < age 40 [4] Pain duration > 3 months [4] Peripheral joint involvement [4] Persistent motion restriction [4]	Deep tenderness on spinous percussion [4;5] Spondylitis [5] Systemic manifestations [4;5] Painful, hot, swollen, stiff joints [3] Decreased chest expansion in Ankylosing Spondylitis [5]
Thoracic IVD prolapse	Sensory changes [5] Limb weakness [5] Leg pain [5]	Sensory and motor deficit [5] Weakness of lower abdominal muscles [5] Absent lower abdominal reflexes [5] Increased lower limb muscle tone [5] Increased knee and ankle reflexes [5]

*Souce: adapted from [1] McClune *et al.,* (2000); [2] Yelland *et al.,* (2004); [3] Peterson and Hsu, (2005); [4] Bussiéres *et al.,* (2008); [5] Michael *et al.,* (2009)

< = less than; > = more than; ESR = erythrocyte sedimentation rate; HIV = Human Immunodeficiency Virus; IV = intravenous ; IVD = intervertebral disc; lb = pounds; mm/h = millimeter/hour; °C = degree Celsius

The importance of a thorough and exhaustive case history and physical examination cannot be overemphasised in not only detecting red flags, but also at arriving at an accurate clinical diagnosis (Giles, 2000). The seriousness of the condition should then be determined by the clinician and referred for the appropriate investigations and management (Singer and Edmondston, 2000; Bussiéres *et al.,* 2008). Plain film radiography is often the first line investigative method of choice (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Michael *et al.,* 2009). However, advanced imaging procedures and specialist referrals are recommended in the presence of a potential serious pathology as suggested by the history, physical examination and/or radiographs, even if the plain film radiographs are unremarkable (Bussiéres *et al.,* 2008). A logical and systematic assessment is thus useful in assisting a clinician with the diagnosis and helps to avoid missing any serious underlying pathology (Michael *et al.,* 2009).

Significant trauma in high velocity injuries such as motor vehicle accidents or falls can result in fractures (Daffner, 1990 as cited in Giles and Singer, 2000; Michael *et al.,* 2009) (**Table 2.2**). Minor or insignificant trauma in older individuals, especially females over the age of 50 years, can result in acute thoracic spine pain and discomfort suggestive of osteoporotic vertebral compressive fractures (Melton, 1995 as cited in Giles and Singer, 2000; Peterson and Hsu, 2005). Dynamic loads such as lifting activities may result in complete vertebral collapse under the compressive forces (Singer, 2000).

Low grade thoracic spine pain with insidious onset of pyrexia (> 38.3°C for > 3 weeks), night sweats, loss of appetite, loss of weight and local tenderness are usual features of spinal infections (Tuli, 2004; Michael *et al.,* 2009) (**Table 2.2**). A history of persistent pain not relieved by rest, local tenderness and deformity from a localised angular kyphosis (gibbus) may be evident. Occasionally, partial or complete neurological deficit may be present initially or develop during treatment (McCall, 2000; Michael *et al.,* 2009) (**Table 2.2**).

The thoracic spine is the most common region of metastases in the spine (Tokuhashi *et al.,* 2008; Michael *et al.,* 2009), therefore suspicion for metastatic bone disease should be raised in patients with a history of previous malignancy, unexplained weight loss (> 10lb over 4 weeks), night pain, lymphadenopathy and cachexia as these are constitutional symptoms found in cancer patients (McClune *et al.,* 2000; Yelland *et al.,* 2004; Peterson and Hsu, 2005; Bussiéres *et al.,* 2008; Michael *et al.,* 2009) (**Table 2.2**). A clinician should be mindful in patients younger than 20 years of age and in patients older than 50 years of age since these are red flags for malignancy (Greenspan, 1993 as cited in Haldeman, 2005). Neurological deficit in the form of radiculopathy or myelopathy can be the result of growing tumors on the surrounding nerve structures and always constitute red flags (Peterson and Hsu, 2005) (**Table 2.2**).

The peak onset of inflammatory arthropathies occur between the age of 20 and 40 years with males having a predominance over females (Hui, 2011). The most common signs and symptoms of inflammatory arthritis include a gradual onset of morning stiffness (> 30 min), pain, swelling, tenderness in joints, especially sacroiliac and spinal joints, with periarticular redness of skin (Yochum and Rowe, 2005; Bussiéres *et al.,* 2008; Michael *et al.,* 2009; Hui, 2011) (**Table 2.2**).

Red flags of thoracic degenerative disc disease and neurological abnormalities include leg numbness, coldness or pain and progressive heaviness or weakness in legs. Other neurological involvement include weakness and absent reflexes of lower abdominal muscles, exaggerated knee and ankle reflexes and extensor plantar reflexes (Michael *et al.,* 2009) (**Table 2.2**).

2.2.2 THE RELATIONSHIP BETWEEN THE HISTORY AND EXAMINATION FINDINGS AND THE DIAGNOSIS OF THORACIC SPINE PAIN

A careful patient history and suitable physical examination are vital in narrowing down the numerous differential diagnoses of thoracic spine disorders (Bland, 2000; Giles, 2000, Singer and Edmondston, 2000; Erwin, 2005; Michael *et al.,* 2009). However, it remains extremely difficult to make a precise diagnosis after specific causes of TSP like infections, inflammation or tumors have been ruled out (Stolker and Groen, 2000). A precise diagnosis may be difficult as the manifestations of the disease that arise in the thoracic spine are usually ever-changing and variable (Bland, 2000), thus making it exceptionally difficult to establish the specific tissue or structure that is the source of the patient’s symptoms (Singer and Edmondston, 2000). Furthermore, these physical signs and symptoms are often non-specific and fail to correlate with radiological findings, while the pain patterns described in the history may not be specifically related to the origin of pain (Stolker and Groen, 2000).

According to these findings it is thus difficult to link specific patient history and physical examination findings with certain disorders. Furthermore, no conclusive statements can be made with regards to the natural history and physical signs and symptoms of certain disorders due to the lack of large studies being done (Bland, 2000; Singer, 2000).

The relationship between TSP and thoracic spine abnormalities is controversial as some patients with tremendous back pain showed no radiographic findings, while other asymptomatic patients showed positive radiographic findings (Lutz *et al.,* 2003). The great majority of patients with radiological signs of thoracic spondylosis remain asymptomatic (Bland, 2000). Also, as many as 73% of asymptomatic patients have thoracic spine disc abnormalities on MRI (Wood *et al.,* 1997 as cited in Haldeman, 2005). Furthermore, older women with severe thoracic hyperkyphosis secondary to osteoporosis may suffer from less severe TSP than women with less marked structural abnormalities (Ettinger *et al.,* 1994 as cited in Singer and Edmondston, 2000). The relationship between spinal posture and the development of pain syndromes is now being challenged (Singer and Edmondston, 2000). However, according to Findlay and Eisenstein, (2000), severe pain may exist in hyperkyphotic, osteoporotic individuals, especially in those with collapsed vertebral bodies. Contrary to these findings some patients may present with TSP that have completely normal findings on imaging (Erwin, 2005). Thoracic spondylosis, osteoporosis and thoracic hyperkyphosis are rarely associated with TSP, whereas degenerative disc disease, bony thoracic canal stenosis and Scheuermann's disease are thought to cause TSP (Bland, 2000; Louw, 1990; Singer and Edmondston, 2000). However, according to Wood *et al.,* (1997) as cited in Haldeman, (2005), the majority of patients with degenerative disc disease are asymptomatic. Also, according to Saada *et al.,* (2000), a large number of patients Scheuermann's disease remain asymptomatic. Thoracic spine pain in scoliotic patients seems to be roughly the same as for the normal population (Edgar, 1987 as cited in Haldeman, 2005). However, patients with larger scoliotic curves tends to have more pain. Radiographic changes such as facet sclerosis at the apex of scoliosis seems to correlate with a history of back pain (Erwin, 2005). Osteoarthritis of the costotransverse and costovertebral joints is a frequent source of non-specific back pain, therefore contributing to the relationship between spondylosis and TSP (Bland, 2000). However, according to Erwin, (2005), the clinical findings of costovertebral joint syndromes continue to be poorly recognised and understood and conclusive statements cannot be made due to the lack of large studies being done.

2.3 THE ROLE PLAIN FILM RADIOGRAPHS IN DIAGNOSING THORACIC SPINE PAIN

2.3.1 UTILISATION OF PLAIN FILM RADIOGRAPHS IN CLINICAL PRACTICE

The presence of red flags (**Table 2.2**) and failure to respond to treatment qualify as indicators for further investigations (Pederson, 2005; Yochum and Rowe, 2005; Lew and Snow, 2012). Plain film radiographs are usually considered as a first line investigative method to identify potential serious underlying causes of TSP (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Michael *et al.,* 2009). These findings may require specific alterations in the treatment protocols that can be beneficial especially for chiropractors, due to the nature of their treatment which often involves a high-velocity low-amplitude thrust into a joint complex that may potentially cause injury to a diseased area if not picked up before treatment. Chiropractors may thus be more likely to request plain film radiographs than their medical counterparts. Plain film radiography has been assisting chiropractors in their diagnostic work-up since it was founded in 1895. Chiropractors also originally focused on postural and biomechanical abnormalities on radiographs to determine the location of vertebral 'malpositions' they felt needed treatment. Nowadays plain film radiographs should only be requested when ethically indicated based upon the history and physical examination findings and the presence of red flags (Peterson and Hsu, 2005).

Skeletal radiographs are relatively inexpensive, easy to access, easy to interpret and have many applications. They are universally considered as the initial investigative method of potential skeletal abnormalities. They assist in making a definitive diagnosis or help determine a short list of differential diagnoses. They provide important additional information as to what further imaging methods are indicated or contraindicated. They are considered as the baseline investigation method for monitoring disease processes over time. Functional stress radiographs can identify biomechanical abnormalities (Yochum and Rowe, 2005). Plain film radiographs can help chiropractors identify contraindications to spinal manipulation (Peterson and Hsu, 2005).

Various studies in the recent years have started to show the dangers associated with ionising radiation, such as the increasing risk of developing malignancies with an increased number of radiographic exposures (Andrieu *et al.,* 2006; Butt *et al.,* 2007; Pijpe *et al.,* 2012). The harmful effects from the use of diagnostic radiographs has led to the development of the justification principal, by the International Commission on Radiology, where the benefits of the plain film radiographs must exceed the risks of taking such a radiograph (Faulkner, 2004). Evidence-based guidelines and rules have also been developed to help health care practitioners recognise indicators and non-indicators for plain film radiographs (**Table 2.3**) and are also applicable to cases of TSP (Yochum and Rowe, 2005; Butt *et al*., 2007). Chiropractors have been accused of failing to adhere to these guidelines and over utilising plain film radiographs for non-specific back pain (Ammendolia *et al.,* 2008; Bussiéres *et al.,* 2014). This may be supported by the fact that they request routine radiograph as part of the diagnostic workup (Peterson and Hsu, 2005). Many chiropractors also request plain film radiographs to screen for contraindications to spinal manipulation which may contribute to overutilization of plain film radiographs worldwide (Ammendolia *et al.,* 2008).

A survey of chiropractic schools worldwide found most schools to adhere to the evidence-based guidelines for plain film radiography. European schools appeared to have a higher adherence to radiography guidelines (Ammendolia *et al.,* 2008). The development and distribution of diagnostic imaging guidelines among private physicians was associated with an immediate reduction in plain film radiograph claims by chiropractors in the United States (Bussiéres *et al.,* 2014). **Table 2.3** depicts the indications and non-indications for plain film radiography of the thoracic spine.

Table 2.3: Indications and non-indications of plain film radiography for the thoracic spine*

Indications:
❖ Adult patient with complicated (‘red flag’) TSP and indicators of contraindication to SMT (**Table 2.2**)
❖ Re-evaluation of adult patient in the absence of treatment response or worsening after 4 wk
❖ Suspected compression fracture
❖ Adult patient with painful or progressive scoliosis
❖ Trauma, unexplained weight loss, night pain, neuromotor deficit, inflammatory arthritis, history of malignancy, fever unknown origin (> 37.7°C), abnormal blood findings, deformity (scoliosis), failure to respond to therapy and medicolegal implications.
❖ Older than 50 years of age, drug/alcohol abuse, corticosteroid use, unavailable/lost/previously inadequate studies, research, systemic disease, recent immigration, therapeutic risk assessment and therapeutic response.
Non-indications:
❖ Adult patient with uncomplicated acute (< 4 week duration) TSP
❖ Adult patient with uncomplicated subacute (4-12 week duration) TSP
❖ Adult patient with uncomplicated persistent (> 12 week duration) TSP
❖ Musculoskeletal chest wall pain
❖ Adult patient with non-painful and non-progressive scoliosis
❖ Education of patients, routine screening, routine biomechanical assessment, habit, discharge status assessment, pre-employment status, untrained personnel, financial gain, high levels of recent radiation exposure and pregnancy.

***Source:** adapted from Yochum and Rowe, (2005) and Bussiéres *et al.,* (2008)

TSP = thoracic spine pain; SMT = spinal manipulative therapy; < = less than; > = more than; °C = degree Celsius

These guidelines recommend the use of plain film radiographs in the presence of clinical indicators (red flags) suggestive of potential serious underlying disease (Ammendolia *et al.,* 2008; Michael *et al.,* 2009) (**Table 2.2).** Red flags serve as the basis for evidence-based guidelines and help the clinician determine the need for plain film radiographs (Peterson and Hsu, 2005). Routine radiographs are not indicated in uncomplicated acute TSP (< 4 week duration), subacute (4-12 week duration) TSP or chronic (> 12 week duration) TSP as it does not provide useful information. However, the absence of expected treatment response or worsening of symptoms after 4 weeks requires reassessment of the patient and referral for thoracic spine radiographs. Radiographs are not indicated in patients with musculoskeletal chest wall pain, while emergency referral without imaging is recommended in adult patients with life-threatening, non-musculoskeletal causes of chest wall pain such as cardiovascular, pulmonary or gastrointestinal disorders. Radiographs are indicated in patients with a suspected compression fracture, while radiographs for suspected osteoporosis are unreliable as 30%-50% loss of bone density is necessary for it to be radiologically evident. Radiographs are not routinely indicated in adult patients with non-painful and non-progressive scoliosis, while thoracic spine and additional full spine radiographs, follow-up evaluation and repeat radiographs are indicated in adult patients with painful, progressive scoliosis (Bussières *et al.,* 2008).

Investigations such as spinal radiographs can make important observations possible that may verify the clinical diagnosis, change the management of the patient and allow patient outcomes to improve (Beck *et al.,* 2004; Butt *et al*., 2007). According to The Royal College of Radiologists (1998) as cited in Haldeman (2005), plain film radiographs should only be requested if it is clinically indicated and its result, whether it be normal or abnormal, is likely to influence the management of the patient. According to Beck *et al.* (2004), any radiographic anomalies are considered unimportant unless they have clinical relevance. To have clinical relevance, the findings must provide information additional beyond the history taking and physical examination, as well as leading to significant changes in patient management and benefits (Beck *et al.*, 2004).

Plain film radiographs may identify radiological abnormalities, such as spinal degeneration, that correlate poorly with the patient's back pain. The abnormalities are therefore of limited value in assessing the severity of the majority of back complaints (Waddell *et al.,* 1991). Most of these abnormalities are incidental findings on radiographs. These abnormalities are mostly seen in asymptomatic patients and are therefore referred to as incidental findings as they were not expected to be observed (Smoker, 1994 as cited in Haldeman, 2005; Lumbreras *et al.,* 2010). The biggest dilemma is to determine whether the presenting symptoms can be attributed to these abnormalities (Peterson and Hsu, 2005) as these occasional incidental findings may require alterations in the treatment protocols (Beck *et al.,* 2004). A study by Lumbreras *et al.* (2010) found incidental findings to be more prevalent among older patients, with major co-morbidities. These incidental findings were predominantly found in the pulmonary, musculoskeletal and gastrointestinal systems.

A study conducted by Beck *et al.* (2004) found that 68% of patients that present to chiropractic care had significant radiographic anomalies. The most common incidental findings were degenerative joint disease (23.8%), fractures (6.6%), osteoporosis (5%), atherosclerosis (2.2%), scoliosis of less than 20° (1.3%) and Scheuermann's disease (1.1%). In another study, diagnostic imaging discovered incidental findings in 15% of the cases of which 16.2% were related to musculoskeletal lesions (Lumbreras *et. al.,* 2010). The musculoskeletal lesions included vertebral body malformation, hemangioma, degenerative changes, healed fracture, osteitis condensans and spondylosis.

Current guidelines outline the minimum diagnostic series of diagnostic radiography and include an antero-posterior (AP) and lateral view for the thoracic spine (Peterson and Hsu, 2005). This minimal diagnostic series has been developed to limit a patient's exposure to ionising radiation (Butt *et al.,* 2007). Most regions of the musculoskeletal system require at least two views at 90° to each other to constitute a minimal diagnostic series. (Yochum and Rowe, 2005; Butt *et al.,* 2007; Brown, 2013). A swimmer's lateral view can be considered as a supplementary view in patients with symptoms located in the cervicothoracic junction (Peterson and Hsu, 2005).

The vertebral bodies and disc spaces are well demonstrated on the lateral view, while the facet joints and pedicles are usually difficult to visualise due to the overlying ribs and superimposition of the joints. The facet joints are aligned in the coronal plane and are therefore not visible on the AP view. The paravertebral shadow can be seen on the AP view. The paravertebral shadow is a well-defined soft tissue line parallel to the spine, slightly wider on the left compared to the right (McCall, 2000).

2.3.2 ADVANTAGES OF PLAIN FILM RADIOGRAPHS IN DIAGNOSING THORACIC SPINE PAIN

The main advantages of plain film radiography is that it is readily available, noninvasive and the least expensive imaging modality available. Plain film radiography is available to a wide range of health care professionals that may aid them in the diagnosis and management of patients in a time efficient fashion. The radiographic assessment is a well-regulated process and generally considered fairly safe. Plain film radiographs reveal anatomical detail in a format that is easily understandable. Plain film radiographs enables one to assess contiguous structures over a considerable length. Plain film radiography is universally considered as the initial investigative method of choice to detect congenital anomalies, a wide range of pathological changes in bones, joints and cartilage and to monitor disease processes over time. (Yochum and Rowe, 2005; Brown, 2013). Plain film radiographs have a 90% sensitivity in the ability to detect neoplasms, infections, fractures and degenerative and inflammatory diseases at their later stages of development in high-risk populations (Deyo and Diehl, 1986 as cited in Mootz *et al.,* 1999). These findings can be beneficial especially for chiropractors as it helps to identify contraindications to spinal manipulation (Peterson and Hsu, 2005).

2.3.3 LIMITATIONS OF PLAIN FILM RADIOGRAPHS IN DIAGNOSING THORACIC SPINE PAIN

Even though radiographic assessments are generally considered fairly safe in comparison to other imaging methods (Brown, 2013), various studies in recent years have started to show the dangers associated with ionising radiation, such as the increasing risk of developing malignancies with the increased numbers of radiographic exposures (Andrieu *et al.,* 2006; Butt *et al.,* 2007; Pijpe *et al.,* 2012). One of the major drawbacks of conventional radiology is the lack of soft tissue discrimination (Yochum and Rowe, 2005). Intervertebral disc herniations and non-osseous causes of thoracic spinal stenosis are thus not identified with plain film radiographs unless they contain significant calcification (McCall, 2000). Also, due to limited diagnostic sensitivity, certain diseases such as osteomyelitis and metastasis of the spine have to cause significant amount of damage (30-50% loss of bone density and a lesion size of at least 1-5cm) to the spine before being radiologically evident (O'Connor *et al.,* 1999; Yochum and Rowe, 2005). Disease processes that manifest clinically may take time to become radiographically evident. This is referred to as the radiographic latent period. The radiographic latent period of osteomyelitis in the spine is minimally 21 days while tumors of the spine take minimally 4-6 weeks before manifestation becomes evident on plain film radiographs (Yochum and Rowe, 2005). Plain film radiographs may thus miss tumors and infections in their early stages of development (Yochum and Rowe, 2005; Bussiéres *et al.,* 2008). Further drawbacks of conventional radiology are the variability and effect of exposure differences, and technical artifacts (Yochum and Rowe, 2005).

2.4 THE RELATIONSHIP BETWEEN THE CLINICAL AND RADIOGRAPHIC FINDINGS OF THORACIC SPINE PAIN

Thoracic spine radiographs remain widely used as a first-line investigative method and are often requested in patients with TSP (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Michael *et al.,* 2009). However, they are considered to be of limited diagnostic value (Erwin, 2005) as numerous radiographic methods have produced limited radiographic findings that correlate with the clinical symptoms of non-specific thoracic spine pain (Lutz *et al.,* 2003; Erwin, 2005; Manchikanti *et al.,* 2009).

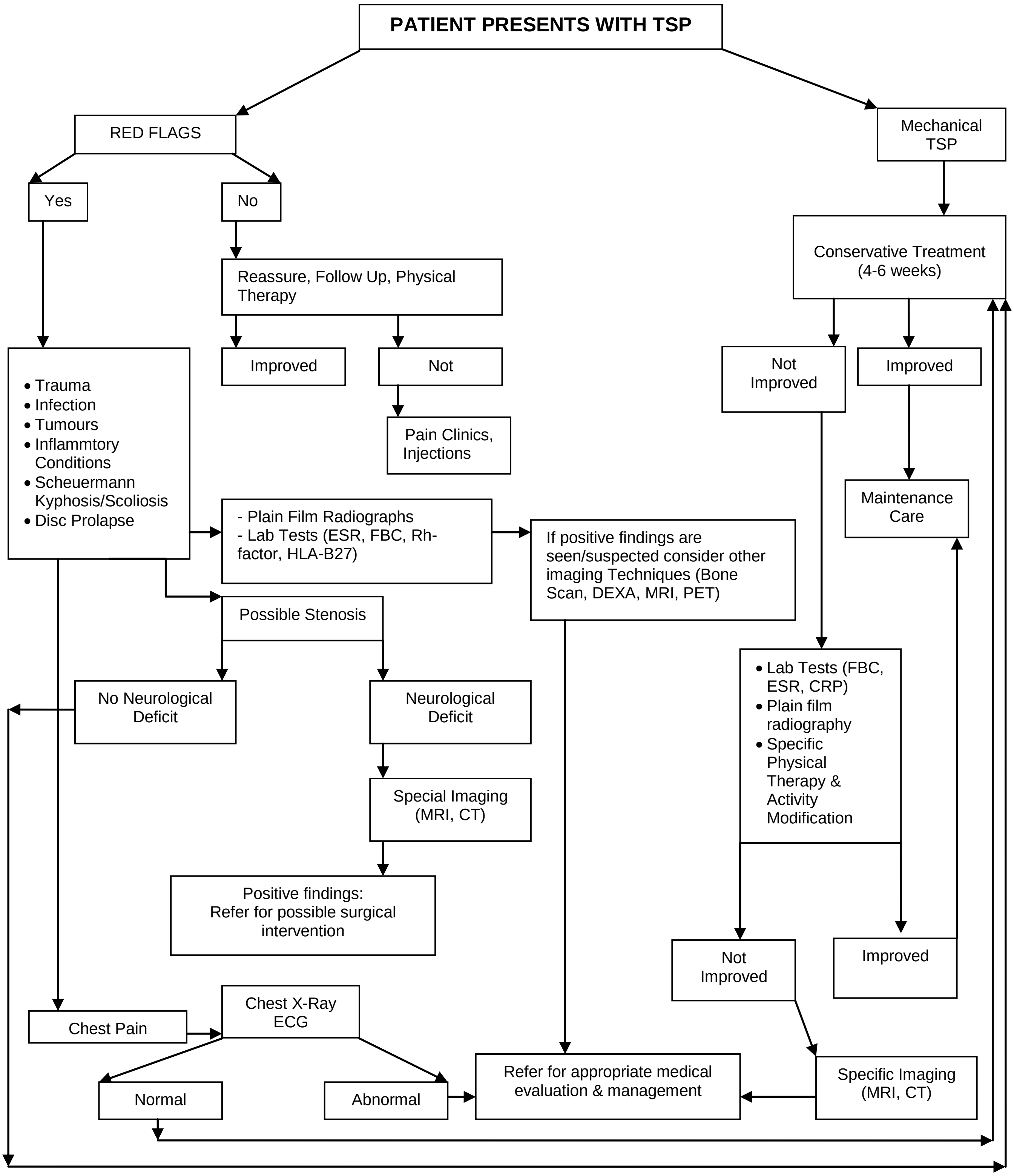
Many spinal abnormalities can be identified with plain film radiographs in asymptomatic individuals. These findings include spondylosis, facet joint abnormalities, Schmorl's nodes, some congenital anomalies and mild scoliosis and are more common in older individuals (van Tulder *et al.,* 1997; Jarvik and Deyo, 2002). According to Waddell *et al.* (1991) plain film radiographs of the spine can provide important information about fractures and congenital anomalies, while findings of degeneration are considered of limited diagnostic value due to the lack of correlation between the radiographic changes and clinical symptoms. The relationship between disc degeneration, facet joint osteoarthritis, thoracic kyphosis and TSP remain unclear (McCall, 2000). However, radiographic changes such as facet joint sclerosis at the apex of scoliosis and osteoarthritis of the costotransverse and costovertebral joints are a frequent source of non-specific TSP, therefore contributing to the relationship of spondylosis and TSP (Bland, 2000). The relationship between TSP and thoracic spine abnormalities is thus controversial as some patients with tremendous back pain showed no radiographic findings, while other asymptomatic patients showed positive radiographic findings (Lutz *et al.,* 2003).

Although conventional radiography is considered as a standard baseline investigative method for the evaluation of the musculoskeletal system, it may often miss certain spinal pathologies, especially those of soft tissue origin (Erwin, 2005; Brown, 2013). Also, as mentioned earlier, some patients may be symptomatic without any radiographic abnormalities, while others may be asymptomatic with significant radiographic abnormalities (Lutz, *et al.,* 2003). It is thus important that radiographs should not be interpreted in isolation. They need to be interpreted in a clinical context as additional imaging methods may be required to provide more specific information (Brown, 2013).

2.5 AN OVERVIEW OF THE MANAGEMENT OF THORACIC SPINE PAIN

The management of TSP depends on the cause of the condition, therefore the key to successful management lies in early and accurate clinical diagnosis (Findlay and Eisenstein, 2000; Stolker and Groen, 2000). Also, different health care professions will address and manage the condition differently. A medical doctor will make use of non-invasive treatment such as drug therapy, including prescribing paracetamol, non-steroidal inflammatory drugs (NSAIDs) or opioids (Stalker and Groen, 2000). Neurosurgeons or orthopaedic surgeons will rely on invasive treatment such as surgical interventions and percutaneous procedures. These invasive treatments are only to be considered after appropriate conservative treatment has failed or in the case of impending damage to the spinal cord in severe spinal stenosis (Stalker and Groen, 2000). Chiropractic is part of the complementary and alternative medicine

(CAM) approach (Meeker and Mootz, 2005) that mainly specialises in spinal manipulative therapy (Bronfort *et al.,* 2005). A general algorithm for the management of TSP adapted from Michael *et al.,* (2009) and Souza (2009) is suggested in **Figure 2.1**. This algorithm illustrates the different ways of managing patients with TSP according to their suspected aetiology.



Key: TSP= thoracic spine pain; ESR=erythrocyte sedimentation rate; CRP= C-Reactive protein; FBC= full blood count; MRI= magnetic resonance imaging; CT= computed tomography; PET= positron emission tomography; DEXA= dual-energy x-ray absorptiometry; ECG = electrocardiogram

Figure 2.1 Suggested algorithm for the treatment of thoracic spine pain
Source: Adapted from Michael *et al.,* (2009) and Souza, (2009).

Clinicians can start to formulate treatment regimens according to the specific diagnosis of TSP after a patient has been cleared from any serious and/or life-threatening diagnoses (Erwin, 2005). Patients with potential serious causes of TSP (**Table 2.2)** should be referred for appropriate investigations and management (Bussiéres *et al.,* 2008; Michael *et al.,* 2009). These investigations include diagnostic laboratory tests and imaging methods. Laboratory tests include blood tests such as full blood count (FBC), inflammatory markers such as erythrocyte sedimentation rate (ESR) and C-Reactive Protein (CRP), rheumatoid factor (Rh-factor) and HLA-B27 suggestive of inflammatory spondyloarthropathies (**Figure 2.1**). The imaging methods include plain film radiography, computed tomography (CT), positron emission tomography (PET), ultrasound (US), isotope bone scans and magnetic resonance imaging (MRI) (Michael *et al.,* 2009) (**Figure 2.1**).The patient will then be referred for the appropriate medical, invasive or conservative treatment, depending on the results of the investigative tests (Stalker and Groen, 2000).

Most patients will undergo a period of four to six weeks of conservative treatment after being cleared from potential serious causes of TSP (Jarvik and Deyo, 2002). Patients with uncomplicated compression fractures, uncomplicated Scheuermann's disease, thoracic facet syndrome, postural syndrome, T4 syndrome, mild to moderate idiopathic scoliosis that is not rapidly progressing and other mechanical causes of TSP should be managed conservatively (Souza, 2009). Conservative treatment includes: education, exercise, soft tissue therapy, acupuncture, bed-rest, drug therapy (analgesics, NSAIDs, opioids), physiotherapy (heat/cold, traction, laser, therapeutic ultrasound, short wave, interferential current [IFC], massage, transcutaneous electrical nerve stimulation [TENS]), mobilization, manipulation and work disability prevention interventions (Stolker and Groen, 2000; Yelland *et al.,* 2003; Shabat *et al.,* 2006; Airaksinen *et al.,* 2006; Souza, 2009). This treatment is usually provided by practitioners of the complementary and alternative medicine (CAM) body, such as chiropractors (Meeker and Mootz, 2005).

The treatment of mechanical TSP is complex due to the numerous variables involved such as stress, posture, nutritional inadequacies, and functional factors and no clear treatment protocols exist (Schiller, 2001). There is also limited evidence for the effectiveness of interventions for TSP in literature. The evidence for therapies specifically for acute TSP is also limited. More research is thus required in this area.

According to literature, no distinction can be made between cases of TSP and low back pain (LBP) in terms of the evidence for the efficacy of spinal therapies (Yelland *et. al.,* 2003). Spinal manipulative therapy (SMT) has become the most widely used treatment method for uncomplicated mechanical thoracic spine pain and dysfunction as a conservative treatment modality (Schiller, 2001).

The treatment of acute non-specific, mechanical back pain is usually symptomatic. The main objectives are to reduce pain and resume activities of daily living as soon as possible. A short-course (two to three days) of NSAIDs, opioids and muscle relaxants are usually prescribed for severe acute pain. A short duration (two to three days) of bed rest is advised for severe acute pain with rapid resumption of normal activity thereafter. Exercise is not recommended in the acute, painful phase. A follow-up consultation within one to two weeks is recommended. It is also important for the clinician to explain the diagnosis and plan of management to the patient as this may have a positive effect on patient satisfaction and compliance. The patient should also be educated on possible red flag symptoms that should not be ignored and require urgent attention (Deyo, 1991; Edlow, 2015).

The management of patients with chronic thoracic spine pain is challenging as a definite diagnosis can seldom be made. These patients usually undergo a variety of diagnostic tests, unsuccessful therapeutic procedures or referrals to various specialists. The treatment of patients should be cause-related. However, patients can be treated symptomatically if the cause cannot be found after extensive investigations or if cause-related treatment is not available (Stolker and Groen, 2000).

Postural abnormalities may contribute to muscular fatigue, weakness, pain and stiffness (Friction, 1994; Travell and Simons, 1999; Erwin, 2005). Chronic, non-specific thoracic spine pain is usually treated by a short course of spinal manipulation/mobilization (4 to 6 weeks) and exercise therapy (Schiller, 2001; Erwin, 2005; Airaksinen *et al.,* 2006; Souza, 2009). These exercises include stretching routines to help regain/maintain flexibility, simple isometric strengthening/reconditioning and progressive exercises to strengthen the small internal stabilizing muscles of the vertebrae in addition to the broader regional muscles, modification of work and recreational activity patterns (Erwin, 2005; Souza, 2009). Specific patient centered treatment in patients with thoracic hyperkyphosis should focus on stretching of deep cervical extensors, pectoral, lumbar erector spinae, iliopsoas and hamstring muscles coupled with the strengthening of deep cervical flexors, midscapular muscles, abdominals and gluteal muscles (Souza, 2009). Cognitive-behavioural treatment, multidisciplinary biopsychosocial rehabilitation and certain pharmacological procedures (noradrenergic-serotonergic antidepressants, benzodiazepines muscle relaxants, NSAIDs and opioids) are also recommended for patients with chronic back pain (Airaksinen *et al.,* 2006).

Plain film radiography and/or blood tests (ESR) are usually considered in patients not responding to six weeks of conservative management or in patients presenting with symptoms suggestive of systemic disease (Jarvik and Deyo, 2002; Souza, 2009) (**Figure 2.1**). The findings of the plain film radiographs can help the clinician decide to consider further advanced imaging. Also, for patients with symptoms of spinal stenosis that do not improve after six weeks or patient's symptoms that are persistent or progressive and unbearable, further advanced imaging is appropriate. MRI is usually the imaging of choice (Jarvik and Deyo, 2002) (**Figure 2.1**).

Patients with primary tumors or metastasis, infection, unstable fracture, severe or rapidly progressive scoliosis or kyphosis and complications due to corticosteroid use should be referred for appropriate medical evaluation and management or co-management (Souza, 2009) (**Figure 2.1**).

Invasive therapy, such as surgical and percutaneous procedures, are only to be considered after proper conservative management have failed or in the case of impending spinal cord damage in severe spinal stenosis (Stolker and Groen, 2000). According to Skubic and Kostuik (1991), the main objective of thoracic spine surgery is to correct scoliosis or to protect the spinal cord in the presence of fractures or severe spinal stenosis with impending neurological deficit. Further indications for spinal surgery are pain and/or paralysis due to the collapse of the spine, pain and/or paralysis due to tumor invasion of the spinal cord and radio-resistant malignancies. Patients with poor general health, high sensitivity to hormone therapy or radiotherapy with less than 6 months life expectancy, patients that demonstrate poor will-to-live and patients that did not give consent to surgery should not be considered for surgery (Michael *et al.,* 2009).

The most common percutaneous procedures include test blocks and therapeutic blocks which may be done by injection of trigger points, epidural injection of steroids or neurlolytic blocks (Stolker and Groen, 2000). Common decompressive surgical procedures include laminectomy, facetectomy and costotransversectomy with or without fusion for thoracic spinal stenosis, disc herniation, trauma, tumour and infection. However, laminoplasty is gaining increasing popularity as a decompression surgery as it preserves posterior stability and provides a greater bed for bone grafting (Healy *et al.,* 2014). Endoscopic transforaminal thoracic discectomy and foraminotomy is a safe, effective treatment option and offers a few advantages compared to the traditional surgical discetomy. However, conditions such as sequestrated thoracic disc herniation and large central herniations still require traditional open spine surgeries (Nie and Liu, 2013).

2.5.1 CHIROPRACTIC MANAGEMENT OF THORACIC SPINE PAIN

It is imperative that a thorough medical history and physical examination is conducted and that the health care practitioner understand the nature of a patient's compliant(s). This will enable the practitioner to make an informed decision as to whether or not a patient is a candidate for conservative management or if referral to specialists is indicated (Lawrence and Bakkum, 2000).

Chiropractors usually reach a diagnosis by taking a full clinical history, performing a physical and regional examination and ordering or performing specific investigations when indicated such as plain film radiographs and/or blood work (Pederson, 2005). The presence of red flags qualify as indicators for further investigations (Pederson, 2005), while conservative treatment is usually considered in the absence of red flags (Erwin, 2005). Chiropractors should refer patients for special imaging, laboratory testing or medical evaluation if conservative management (4 to 6 weeks) fails to produce favorable results (Schiller, 2001; Souza, 2009).

Chiropractic is part of the CAM approach (Meeker and Mootz, 2005) that mainly specialises in spinal manipulative therapy (Bronfort *et al.,* 2005). Spinal manipulative therapy (SMT) has become the most widely used treatment method for uncomplicated mechanical thoracic spine pain and dysfunction as a conservative treatment modality (Schiller, 2001).

A study conducted by Giles and Muller (2003) compared chiropractic spinal manipulation, acupuncture and medication in chronic spinal pain of more than 13 weeks. After nine weeks of treatment, the highest proportion of early recovery was found for manipulation (27,3%), followed by acupuncture (9,4%) and medication (5%). The above mentioned study thus shows that chiropractic spinal manipulation provided the best overall short-term results for chronic spinal pain syndromes. Schiller (2001) studied the effectiveness of spinal manipulative therapy in the treatment of mechanical thoracic spine pain. The patients received six treatments over a period of two to three weeks with a one month follow-up appointment to assess the relative long-term benefits of the treatment. Statistically significant results were noted for the percentage of pain experienced (Numerical Pain Rating Scale) and for left and right lateral flexion of the thoracic spine during intergroup comparison after the final treatment.

Spinal manipulative therapy acts on a manipulable lesion, also known as a functional spinal lesion or subluxation, by reducing the internal mechanical stresses that generates symptoms. A manipulative lesion is usually a comorbid condition in a host of clinical conditions that may benefit from SMT. These conditions include costovertebral joint disorders, degenerative disc disease, disc bulge/protrusion/herniation, facet syndrome, joint dysfunction/subluxation, spinal stenosis and spinal sprain/strain. These conditions are thus indications for SMT (Lawrence and Bakkum, 2000; Triano, 2001). Spinal manipulative therapy should not be considered a totally harmless procedure although serious complications of SMT are extremely rare (Haldeman and Philips, 1991). Relative contraindications to SMT may warrant a more careful administration or modification of the manipulation technique. Relative contraindications to SMT include demineralization of bone (osteopenia, osteoporosis), herniated nucleus palposus, articular hypermobility, spondylolisthesis with progressive slippage, postsurgical joints, acute soft tissue injuries, benign bone tumors, clinical manifestations of vertebrobasilar insufficiency, aneurysm, anticoagulant therapy and blood dyscrasias. It is vital for the practitioner to seriously consider the risk in relation to the expected benefit in patients with relative contraindications prior to SMT. Specific absolute contraindications to SMT include cauda equina syndrome, acute inflammatory arthropathies, acute fractures and dislocations, signs of ligamentous rupture or instability, any form of primary or secondary malignant process involving the spinal cord or vertebral structures, bone or/and joint infections, presence of a large aortic aneurysm, acute myelopathy and progressive neurological deficits (Haldeman and Philips, 1991; Assendelft *et al.,* 1996; Kohlbeck, 2005).

Chiropractors make use of other treatment options as well which include ice, heat, stretching routines, strengthening programs, education on lifting techniques, sleeping and posture, myofascial release techniques consisting of active/passive release therapy, deep cross-fiber friction massage and therapeutic massage, acupuncture, dry needling, physical electrical modalities such as transcutaneous electrical nerve stimulation (TENS), interferential current (IFC) and ultrasound (US), traction, nutritional and orthotics advice (Haldeman, 1991; Erwin, 2005; Souza, 2009).

Various treatment options are available to the chiropractic students, ensuring optimal evidence-based health care for patients presenting to the CDC at DUT. Manual therapy which includes thoracic spine manipulation or mobilisation is considered as the primary modality utilised, while other supplementary therapy procedures such as soft tissue therapy and electrotherapy are also available to augment chiropractic adjustive care. Soft tissue therapy includes massage, ischaemic compression of myofascial trigger points, active and passive release therapy, acupuncture and dry needling. Electrotherapy includes ultrasound, IFC, TENS and laser. Other treatment modalities include heat therapy, cryotherapy, traction (McManis, linear and Leander), stretching and strengthening exercises. The use of these supplementary modalities help facilitate the healing process of various conditions (Chiropractic Clinic Manual, 2013). Ischemic compression therapy, TENS, IFC, myofacial release therapy and ultrasound are considered as non-invasive techniques, while dry needling is considered an invasive technique in the management of myofascial trigger points in skeletal muscle(s) (Lavelle *et al.,* 2007). During ischemic compression the physician applies pressure to a trigger point in a muscle to cause ischemia at the point of pressure until there is relief in tension within the muscle (Travell and Simmons, 1999). Dry needling involves numerous advances of a needle into the trigger point area in a muscle with the aim to elicit a localised twitch response at the hyperirritable point in the muscle that results in mechanical disruption of the trigger point contraction knots (Travell and Simmons, 1999; Lavelle *et al.,* 2007). This treatment may also activate satellite cells that migrate to the damaged area(s) within the muscle. The satellite cells are involved in the process of muscle regeneration as they repair and replace damaged myofibrils (Dommerholt *et al.,* 2006). Acupuncture is a specific technique in which fine needles are inserted into specific points along the acupuncture meridians on the body to achieve therapeutic purposes. The main focus of acupuncture is to balance the flow of energy within living beings prevent illness or manage disease symptoms including pain (Chon and Lee, 2013). Myofascial release therapy restore optimal length, decrease pain and improve function by applying a low load, long duration stretch to the myofascial complex (Ajimsha *et al.,* 2012). Active release therapy is a technique used to break down adhesions formed in myofascial tissues by applying deep digital tension over the tenderness and asking the patient to actively move the tissue from the shortened to a lengthened position (Trivedi *et al.,* 2014). TENS and IFC are noninvasive applications of electrical stimulation, at varying frequencies, intensities and pulse durations of stimulations, to the skin for pain control (Sluka and Walsh, 2003; Vidyarthi *et al.,* 2014). This technique is commonly utilised in the management of acute and chronic pain management by placing the electrodes along areas of referred pain or at trigger point sites (Graff-Radford *et al.,* 1989; Lavelle *et al.,* 2007). Ultrasound involves the use of high-frequency acoustic energy that transmit vibration energy at molecular level to treat acute and chronic disorders of the musculoskeletal system (Gam *et al.,* 1998; Esenyel *et al.,* 2000; Lavelle *et al.,* 2007). The therapeutic effects of ultrasound include a reduction in muscle pain and spasm, decrease in joint stiffness, increase extensibility of tendons and joint capsules and increase blood flow to the area to help resolve a chronic inflammatory process (Pillay, 2003). Laser therapy involves the penetration of wavelengths to the region of myofascial trigger points with the aim of mediating inflammatory processes, enhancing tissue repair and promoting analgesia in cases of acute or chronic pain (Uemoto *et al.,* 2013).

According to a systematic review of literature on the effectiveness of non-invasive treatments for active myofascial trigger point pain, laser therapy may be effective as a short-term intervention for reducing pain intensity in the back. TENS appears to have an immediate effect on the reduction of pain intensity in the back although insufficient evidence exist on the effectiveness of TENS immediately after treatment. Limited evidence exist on the use of IFC for myofascial trigger point pain in the back, while ultrasound is no more effective than placebo or no treatment for myofascial trigger point pain in the back and neck (Rickards, 2006). Another systematic review of the literature on chiropractic management of myofascial trigger points and myofascial pain syndrome produced similar findings. Evidence strongly support the use of manipulation, ischemic compression and laser therapy for immediate pain relief at myofascial trigger points, but only limited evidence exist for long-term pain relief at myofascial trigger points. Moderate evidence supports the use of TENS and acupuncture in the treatment of myofascial trigger points and myofascial pain syndrome, while there is only limited evidence to support the effectiveness of IFC. The evidence that supports the use of ultrasound in the management of myofascial trigger points and myofascial pain dysfunction is weak (Vernon and Schneider, 2009).

According to the Durban University of Technology's (DUT) chiropractic clinical manual (2013), radiographs will be considered if the clinician and chiropractic student feel they will significantly contribute to the diagnosis and management plan of the presenting complaint. The decision to undergo radiographs will be based on the information obtained through a thorough case history, physical examination and the results of laboratory data. Radiographs should therefore primarily be used for the purposes of confirming or rejecting a clinical impression. Ionising radiation is thus minimised at the DUT CDC as routine radiographs for general screening purposes are not ethically indicated.

2.6 CONCLUSION

Thoracic spine pain is a common condition experienced across the lifespan of various individuals and can be just as disabling as cervical and lumbar spine pain. The causes of thoracic spine pain are numerous, ranging from the more common, non-specific mechanical causes to the less common, more serious specific underlying causes of which the latter are more common in the thoracic spine compared to the cervical or lumbar spine. Over the years, researchers have been relatively unsuccessful in linking specific patient history and physical examination findings with certain disorders. The presence of red flags may be indicative of serious underlying causes of thoracic spine pain and qualify as indicators for further investigations. Plain film radiographs are universally considered as the first line investigation method to identify potential serious underlying causes and has been assisting chiropractors in their diagnostic work-up since it was founded in 1895. These findings can be beneficial especially for chiropractors, due to the nature of their treatment which often involves a high-velocity low-amplitude thrust into a joint complex that may potentially cause injury to a diseased area if not picked up prior to treatment. Chiropractors may thus be more likely to request plain film radiographs than their medical counterparts. However, nowadays according to evidence-based guidelines, plain film radiographs should only be requested when red flags are detected or in patients not responding to six weeks of conservative management. Guidelines have also been developed to help primary health care practitioners recognise indicators for plain film radiographs. Many chiropractors fail to adhere to these guidelines leading to overutilization of radiographs worldwide. Literature is currently limited on the role thoracic spine radiographs and their influence on the management of patients with TSP.

The aim of this study was to determine whether a relationship exists between the clinical and radiological diagnoses of thoracic spine pain and whether thoracic spine radiographs affect the diagnosis and management of patients who present to the DUT CDC with TSP.

CHAPTER 3 : MATERIALS AND METHODS

3.1 STUDY DESIGN

A retrospective, quantitative, descriptive, empirical clinical cohort study design was explored. All data were collected from the thoracic spine radiographs and corresponding clinical records of patients who presented with thoracic spine pain at the Chiropractic Day Clinic (CDC) at the Durban University of Technology (DUT) from 1 January 1997 to 31 December 2014. Approval to conduct the study and ethical clearance was obtained from the Faculty of Health Sciences Research Committee at DUT. (Ethics clearance certificate number: 037/15 [**Appendix F**])

3.2 PATIENT CONFIDENTIALITY

All patients, who presented to the DUT CDC after 1 January 2001, signed a consent form (**Appendix D**), prior to initial consultation, allowing their clinical and/or radiological information to be utilised in the future for research purposes given that their identities would not be revealed in any way whatsoever. Permission to gain access to the clinical files and corresponding plain film radiographs that were recorded prior to 2001 was granted by the Executive Dean of Health Science (**Appendix E**). This was necessary as clinical records prior to 2001 did not explicitly request permission from the patients for their data to be utilised for research purposes. An alpha-numerical coding system (**Appendix A**) ensured confidentiality of the patients' personal information throughout the research process. The electronic data were password protected and clinical files were locked up throughout the research process with access granted to only the researcher, co-supervisor and supervisor.

3.3 SAMPLING METHOD AND SAMPLE SIZE

In this study, all information collected was recorded on data sheets (**Appendix B**) using purposive sampling. The sample consisted of the clinical records of all the patients who presented to the DUT CDC with thoracic spine pain (TSP) and were sent for thoracic spine radiographs during their management from 1 January 1997 to 31 December 2014. A total 56 thoracic spine radiographs were extracted from the DUT CDC archives. All the clinical records and radiographs that did not meet the inclusion and exclusion criteria were excluded from the study. The final sample size consisted of 30 thoracic spine radiographs and corresponding clinical records that met the criteria of the study.

3.4 INCLUSION AND EXCLUSION CRITERIA

3.4.1 INCLUSION CRITERIA

- A minimum of two radiographic views (AP and lateral) are required for each clinical record and must be accompanied by a radiological report.
- Radiographs must be taken during the course of treatment between 1 January 1997 to 31 December 2014 at the DUT CDC.
- Each clinical record must contain a complete SOAPE (Subjective, Objective, Assessment, Plan and Education) note with the initial diagnosis and management plan.

3.5 EXCLUSION CRITERIA

- Clinical records of patients presenting to the DUT CDC with radiographs that were not requested by the interns.
- Radiographs lacking a radiological report and radiological request form.
- Incomplete clinical records (lacking patient history, physical examination, thoracic spine regional and/or SOAPE-note).

3.6 RESEARCH PROCEDURE

The researcher approached the Chiropractic Head of Department and Directors of the DUT CDC to obtain permission to access all thoracic spine radiographs and corresponding clinical records **(Appendix C)**. All the available thoracic spine radiographs from the DUT CDC archives were then collected and set aside. Each patient’s name and date of birth and file number was then recorded on a confidentiality sheet **(Appendix A)** using an alpha-numerical coding system ensuring confidentiality throughout the research process. The recorded information was then used to locate corresponding patient files and file numbers using the DUT CDC computer archive system. All data sheets were kept in a file and locked in a cupboard at the DUT CDC throughout the research process. These data sheets will be kept at the DUT CDC for a period of five years after which they will be incinerated or shredded.

The final sample size was determined by evaluating which radiographs and clinical records met the inclusion and exclusion criteria. All those that did not meet these criteria were excluded from the study.

Each thoracic spine radiograph was analysed by the researcher and evaluated without any knowledge of the patients' main complaint in order to avoid bias. The ABCS (Alignment, Bone, Cartilage and Soft tissue) System was used to evaluate the radiographs and all the findings were recorded on the data sheets **(Appendix B).** The radiographic findings were then compared to the radiographic findings of the radiologist. This was followed by the evaluation of the clinical record and recording of the following data as shown in **Table 3.1**.

Table 3.1: Recorded data and source

Recorded data	**Source**
Code, age and gender	**Appendix A**; Case history form
Date of initial consultation	Case history form; SOAPE note
Clinical diagnosis at initial consultation	SOAPE note
Treatment at initial consultation (prior to radiographs)	SOAPE note
Reason for radiographic referral	SOAPE note and/or radiology request form
Number of treatments before radiographic referral	SOAPE note
Date of radiographs	Radiology report and/or identification marker on x-ray film
Researcher's radiographic diagnosis	Radiological findings of the researcher
Radiologist's diagnosis	Radiology report
Radiographic incidental findings	Radiology report and/or radiological findings of the researcher
Clinical diagnosis after radiographs	SOAPE note
Change/no change in treatment after radiographs	SOAPE note

3.7 STATISTICAL ANALYSIS

IBM SPSS version 22.0 (SPSS Inc, Chicago, Illinois, USA) and the McNemar's chi square test for binary paired proportions were supposed to be utilised in the analysis of the data. However, it was not possible to assess any statistical association between the clinical diagnosis and radiological diagnosis in a paired comparison, as the categories were too many and too different. Statistical testing using a paired *t*-test was not considered to evaluate association between the clinical diagnosis and radiological diagnoses, as they were not the same. Therefore, a descriptive assessment of the radiological diagnoses for each clinical diagnosis was performed by cross tabulating the relevant variables. For objectives which were purely descriptive, the outcomes were reported using frequency counts, means, standard deviations and percentages since all outcomes were categorical variables (Esterhuizen, 2015).

CHAPTER 4 : RESULTS

4.1 AGE AND GENDER

Thirty clinical records and their corresponding thoracic spine radiographs were analysed in this study. The mean (± SD) age of the patients whose clinical files and thoracic spine radiograph records were examined was 43.6 (± 19.1) years, while the range was from 14 - 79 years.

The data of 12 (40%) male and 18 (60%) female subjects were obtained in this study as shown in **Figure 4.1**.

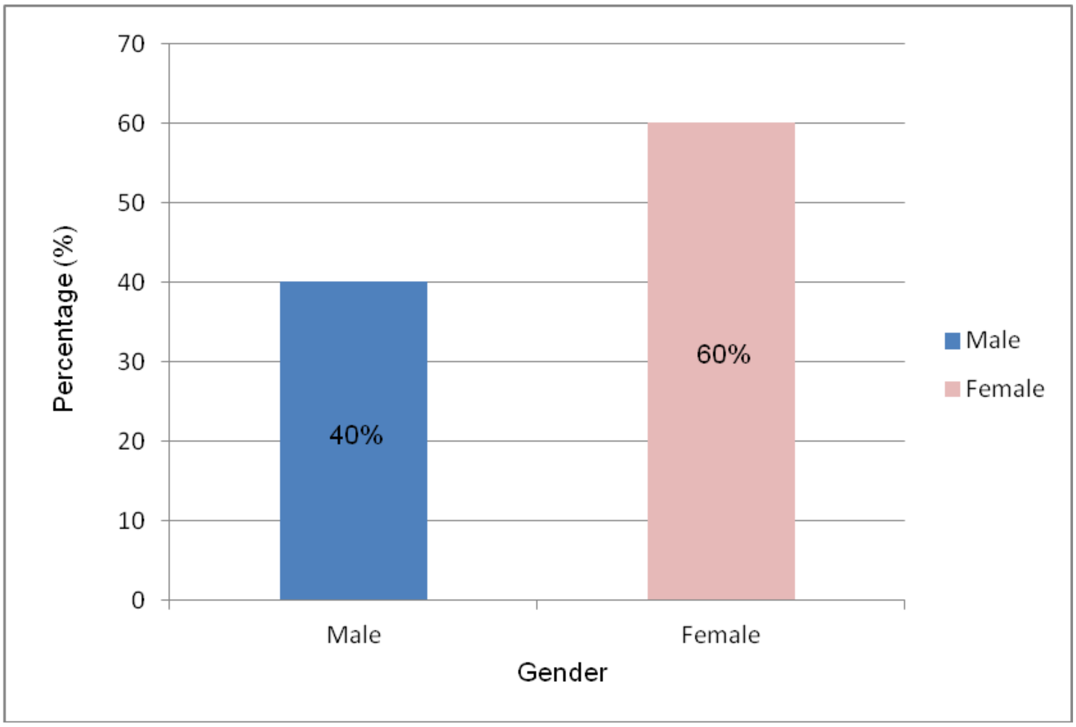


Figure 4.1: Gender distribution of patients whose radiographic and clinical records were inspected

4.2 THE RELATIONSHIP BETWEEN THE CLINICAL AND THE RADIOLOGICAL DIAGNOSES OF PATIENTS THAT PRESENTED WITH THORACIC SPINE PAIN

The attempts at correlating the pre-radiographic primary clinical diagnoses with the primary and secondary radiological diagnoses were unsuccessful as the clinical diagnoses and radiological diagnoses were not the same. Therefore, a paired test was not carried out. A cross tabulation was carried out between the pre-radiographic primary clinical diagnosis and the primary (**Table 4.1**) and secondary (**Table 4.2**) radiological diagnosis but there were too many categories. This meant that too many cells had zero values and prevented a chi squared statistical test, or any other statistical test, to correlate the variables from being performed. Instead the relationship between the pre-radiographic primary clinical diagnosis and either the primary or secondary radiologic diagnosis is shown in **Tables 4.1** and **4.2** (Esterhuizen, 2015).

The pre-radiographic primary clinical diagnosis refers to the diagnosis made by the attending student at the time of the first consultation after a thorough case history, physical and regional examination were completed. The primary radiological diagnosis refers to the main diagnosis of the patient based on radiographic findings by the radiologist, while the secondary radiologic diagnosis refers to the additional findings that were also identified on the patient’s radiographs.

The totals of the pre-radiographic clinical diagnoses and the totals of the primary, secondary and combined primary and secondary radiologic diagnoses are shown in **Tables 4.1**, **4.2** and **4.3** respectively. The totals in the vertical columns of **Tables 4.1**, **4.2** and **4.3** refers to the total number of records to whom that particular pre-radiographic primary clinical diagnosis applies. The totals in the horizontal columns of **Tables 4.1**, **4.2** and **4.3** reflect the total number of radiographic diagnoses. The totals in **Table 4.3** are based on total number of cases and not the total number of diagnoses. Therefore the column and row totals do not equal the sum of the individual diagnoses as some records had more than one diagnosis.

Thoracic facet syndrome was by far the most frequent pre-radiographic primary clinical diagnosis at 50% (n = 15), followed by thoracic myofasciitis and no primary diagnosis both at 16.7% (n = 5) (**Tables 4.1, 4.2 and 4.3**). Both scoliosis and old trauma were equally observed as the most common primary radiological diagnoses at 33.3% (n = 10) in patients who were clinically diagnosed with thoracic facet syndrome (**Table 4.1**). No secondary radiological diagnoses were made in 60% (n = 18) of the records, while thoracic spondylosis was diagnosed in 16.7% (n = 5) of the records as a secondary radiologic diagnosis (**Table 4.2**). Scoliosis and thoracic spondylosis were most commonly observed in records with mechanical thoracic spine pain (TSP) especially thoracic facet syndrome and thoracic myofasciitits (**Table 4.3**).

Table 4.1: Pre-radiographic primary clinical diagnosis versus primary radiological diagnosis

		Primary Radiological Diagnosis					
		Old Trauma	Osteoporosis	Scoliosis	Spondylosis	Normal	**Total**
Pre- Radiographic Primary Clinical Diagnosis	Thoracic facet syndrome	7	0	6	1	1	**15**
	No primary diagnosis	0	2	2	1	0	**5**
	Thoracic myofasciitis	1	0	1	3	0	**5**
	Costotransverse syndrome	1	0	0	0	0	**1**
	Scoliosis	0	0	1	0	0	**1**
	Thoracic spondylosis	0	0	0	1	0	**1**
	Rheumatoid arthritis	0	1	0	0	0	**1**
	Compression fracture	1	0	0	0	0	**1**
	Total	**10**	**3**	**10**	**6**	**1**	**30**

Table 4.2: Pre-radiographic primary clinical diagnosis versus secondary radiological diagnosis

		Secondary radiological diagnosis					
		Osteoporosis	Scoliosis	Spondylosis	No secondary radiographic diagnosis	Normal	**Total**
Pre-Radiographic Primary Clinical Diagnosis	Thoracic facet syndrome	0	1	1	12	1	**15**
	No primary diagnosis	0	2	2	1	0	**5**
	Thoracic myofasciitis	1	1	1	2	0	**5**
	Costotransverse syndrome	0	0	1	0	0	**1**
	Scoliosis	0	0	0	1	0	**1**
	Thoracic spondylosis	0	1	0	0	0	**1**
	Rheumatoid arthritis	0	0	1	0	0	**1**
	Compression fracture	1	0	0	0	0	**1**
	Total	**2**	**5**	**6**	**16**	**1**	**30**

Table 4.3: Pre-radiographic primary clinical diagnosis versus a combination of primary and secondary radiological diagnoses

		Combined Primary and Secondary Radiological Diagnoses						
		Old Trauma	Osteoporosis	Scoliosis	Spondylosis	No secondary radiographic diagnosis	Normal	**Total**
Pre- Radiographic Primary Clinical Diagnosis	Thoracic facet syndrome	7	0	7	2	12	1	**15**
	No primary diagnosis	0	3	2	2	3	0	**5**
	Thoracic myofasciitis	1	1	2	4	2	0	**5**
	Costotransverse syndrome	1	0	0	1	0	0	**1**
	Scoliosis	0	0	1	0	1	0	**1**
	Thoracic spondylosis	0	0	1	1	0	0	**1**
	Rheumatoid arthritis	0	1	0	1	0	0	**1**
	Compression fracture	1	1	0	0	0	0	**1**
	Total	**10**	**6**	**13**	**11**	**18**	**1**	**30**

4.3 THE CONSULTATION WHEN RADIOGRAPHS WERE REQUESTED AND THE REASONS THEREFORE

The consultation and reason(s) for radiographic referral by the attending student is summarized in **Table 4.4**. The radiographs were requested based on the clinical information obtained from the case history, physical and regional examinations. The total count in **Table 4.4** and **Table 4.5** may be more than the frequency (amount of records), since more than one reason for radiographic referral may have been recorded on the radiographic referral letter. **Table 4.5** demonstrates the rankings of the most common reasons for radiographic referral.

The majority of the thoracic spine radiographs were requested at the initial consultation. The frequency of radiographic requests decreased as the number of consultations increased. Overall, the most common reasons for radiographic referrals (n = 88) were severe, progressive TSP at 19.3% (n = 17), trauma at 15.9% (n = 14) and persistent, localised TSP for more than four weeks at 12.5% (n = 11) (**Table 4.5**).

The most common reasons for radiographic referrals during the initial consultation (n = 63) were severe, progressive TSP at 19% (n = 12) followed by trauma at 15.9% (n = 10) and persistent, localised TSP for more than four weeks at 11.1% (n = 7) (**Table 4.4**). Interestingly, the five most common reasons for radiographic referral at the initial consultation were the same for the overall radiographic referrals in patients with TSP. These included: severe, progressive TSP, trauma, persistent, localised TSP for more than four weeks, TSP (age less than 10 or greater than 50 years) and spinous process tenderness. The main reasons for radiographic referrals at the second consultation (n = 15) was trauma at 26.7% (n = 4) and both severe, progressive TSP and persistent, localised TSP for more than four weeks at 20% (n = 3).

Only one radiograph was requested to evaluate why the patient was not responding to treatment. Interestingly this was done after the 18^{th} consultation. One patient was referred for radiographs at the third consultation without any reason or suspected diagnoses written on the radiographic request form.

Table 4.4: A summary of the consultations at which radiographs were requested and the reasons therefore

Consultation number	Frequency	Percentage	Reason for radiographic referral	Count (n)
1	21	70.0%	❖ Severe, progressive TSP	12
			❖ Trauma	10
			❖ Persistent, localised TSP > 4 weeks	7
			❖ TSP (age less than 10 or greater than 50 years)	6
			❖ Spinous process tenderness	4
			❖ DMR compromise	3
			❖ TSP associated with headache(s)	3
			❖ Possible osteoporosis	3
			❖ Night pain	2
			❖ Possible DJD	2
			❖ Past history of rheumatoid arthritis	2
			❖ Chest pain (musculoskeletal)	2
			❖ Family history/ past history of malignancy	2
			❖ Diagnose / assess degree of scoliosis	2
			❖ Possible TB	1
			❖ Unexplained skin lesions/masses	1
			❖ Past history of gout	1
2	5	16.7%	❖ Trauma	4
			❖ Severe, progressive TSP	3
			❖ Persistent, localised TSP > 4 weeks	3
			❖ Diagnose / assess degree of scoliosis	2
			❖ Spinous process tenderness	2
			❖ TSP (age less than 10 or greater than 50 years)	1
5	2	6.7%	❖ TSP (age less than 10 or greater than 50 years)	1
			❖ Spinous process tenderness	1
			❖ Severe, progressive TSP	1
			❖ Night pain	1
			❖ Possible DJD	1
			❖ Chest pain (musculoskeletal)	1
18	1	3.3%	❖ Failure to improve with treatment	1

			❖ Severe, progressive TSP	1
			❖ Persistent, localised TSP > 4 weeks	1
3	1	3.3%	❖ No suitable reason given	1
Total	**30**	**100%**		**88**

TSP = thoracic spine pain ; > = greater than; DMR = dermatome, myotome, reflexes; DJD = degenerative joint disease; TB = tuberculosis

Table 4.5: Ranking of common reasons for radiographic referral in patients with thoracic spine pain

Ranking	Reason for radiographic referral	Count (n)	Percentage
1	❖ Severe, progressive TSP	17	19.3%
2	❖ Trauma	14	15.9%
3	❖ Persistent, localised TSP > 4 weeks	11	12.5%
4	❖ TSP (age less than 10 or greater than 50 years)	8	9.1%
5	❖ Spinous process tenderness	7	8%
6	❖ Diagnose / assess degree of scoliosis	4	4.5%
7	❖ Chest pain (musculoskeletal) ❖ TSP associated with headache(s) ❖ DMR compromise ❖ Possible DJD ❖ Possible osteoporosis ❖ Night pain	3	3.4%
8	❖ Past history of rheumatoid arthritis ❖ Family history / past history of malignancy	2	2.3%
9	❖ No reason given ❖ Past history of gout ❖ Possible TB ❖ Unexplained skin lesions/masses ❖ Failure to improve with treatment	1	1.1%

TSP = thoracic spine pain ; > = greater than; DMR = dermatome, myotome, reflexes; DJD = degenerative joint disease; TB = tuberculosis

4.4 SUSPECTED CLINICAL DIAGNOSES AND MANAGEMENTPRIOR TO REFERRAL FOR RADIOGRAPHIC EXAMINATION

Table 4.6 portrays a summary of all the management options provided by the attending student for each of the pre-radiographic clinical diagnosis. The combined totals of the management options in the horizontal row will be greater than the total patients in the vertical column, as patients may have undergone multiple treatment sessions with multiple treatment modalities prior to radiographic referral (**Table 4.6**). **Figure 4.2** depicts the proportion of SMT to other treatment modalities prior to radiographic examination.

Soft tissue therapies involved modalities such as ‘grip and rip’ and massage of the thoracic spine musculature. Electro modalities that were used in patients with TSP include ultrasound (US), interferential current (IFC) and transcutaneous electrical nerve stimulation (TENS). Stretches of thoracic spine musculature included static stretches and proprioceptive neuromuscular facilitation stretches (PNF). Spinal manipulative therapy (SMT) and thoracic spine mobilisation constitute manual therapy. Other treatment options included dry needling and acupuncture. Patients that did not receive any form of treatment prior to the radiographs were included in the “no treatment” category (**Table 4.6; Figure 4.2**).

Prior to the examination of the radiographs, the treatment modalities most frequently utilised were electro modalities at 33.3% (n = 10), soft tissue therapy at 30% (n = 9), both spinal manipulative therapy (SMT) and stretches at 26.7% (n = 8) and dry needling at 23.3% (n = 7) (**Figure 4.2**). Interestingly, 20% of patients with thoracic spine pain were referred for radiographs without receiving any form of treatment. Of these patients, three patients suffered traumatic experiences, one patient had a 15 year history of rheumatoid arthritis, one patient suffered from chest pain and one patient was referred for suspected vertebral fracture/cancer/TB.

Table 4.6: Suspected clinical diagnosis and management prior to radiographic evaluation

Pre-radiographic primary clinical diagnosis	Pre-radiographic management: SMT	Dry Needling	Stretches	Electro Modalities	Soft Tissue Therapy	Acupuncture	Cryotherapy	Ischemic Compression	Active/Passive Release Therapy	Joint Mobilisation	No Treatment	Total patients
Thoracic facet syndrome	5	2	4	4	5	0	1	2	2	1	3	15
No primary diagnosis	0	1	1	1	0	1	0	0	0	0	2	5
Thoracic myofasciitis	1	2	1	1	1	0	0	1	0	0	1	5
Costotransverse syndrome	1	0	1	1	1	0	0	0	0	0	0	1
Scoliosis	1	1	1	1	0	0	0	0	0	0	0	1
Thoracic spondylosis	0	0	0	1	1	0	0	0	0	1	0	1
Rheumatoid arthritis	0	1	0	0	0	0	0	0	0	0	0	1
Compression fracture	0	0	0	1	1	0	0	0	0	0	0	1
Total	8	7	8	10	9	1	1	3	2	2	6	30

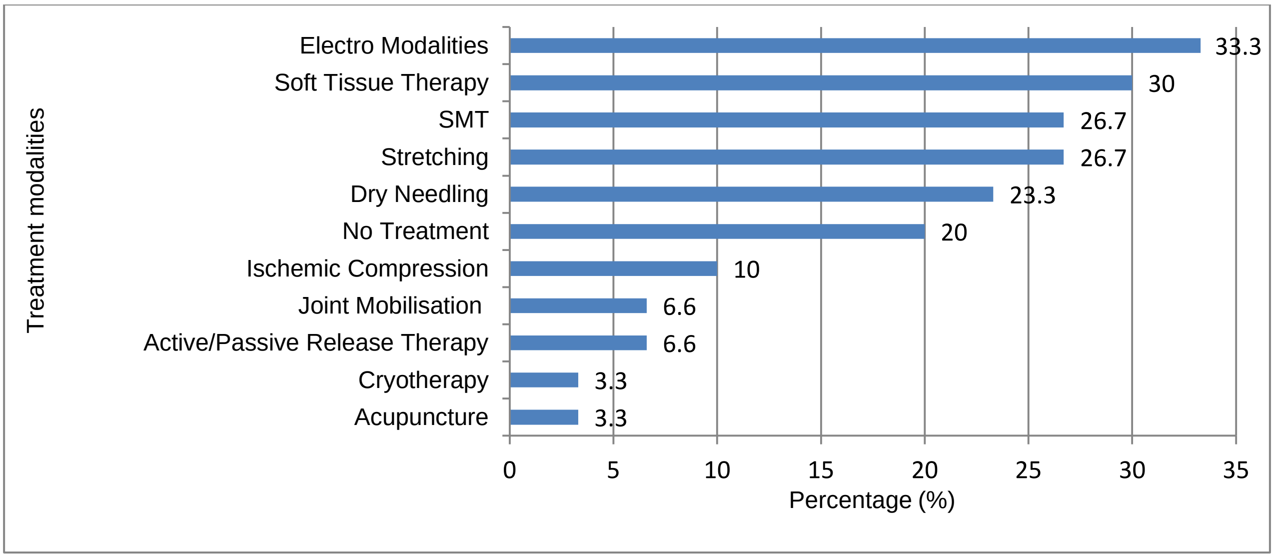


Figure 4.2: Management prior to radiographic evaluation

4.5 CHANGES IN THE CLINICAL DIAGNOSES AND MANAGEMENT AFTER RADIOGRAPHIC EVALUATION

Of the 30 clinical records in this study, a total of 9 records (30%) had a change in diagnosis while 21 records (70%) had no change in diagnosis following thoracic spine radiologic evaluation (**Figure 4.3**). Thoracic facet syndrome was by far the most common clinical diagnosis at 50% prior to, and 56.7% after radiographic evaluation (**Table 4.7**).

A total of 20 (66.6%) of the clinical records in the study had a change in management after thoracic spine radiographs were obtained and evaluated (**Figure 4.4**). The majority of the treatment modalities were utilised more often following radiographs (**Table 4.5**). Following radiographic evaluation, the treatment modalities most frequently utilised were spinal manipulative therapy (SMT) at 56.7%, electro modalities at 46.7% and soft tissue therapy at 43.3% (**Table 4.5**). Spinal manipulative therapy was the most common treatment modality added in 30% of the cases, followed by soft tissue therapy and electro modalities at 23.3% and 20% respectively (**Figure 4.5**). Interestingly, no treatment modalities were added or removed in 30% of the patients sent for plain film radiographs (**Figure 4.5**). Interestingly, SMT became the most popular treatment modality utilised following radiographic evaluation as it was only the third most utilised treatment option prior to radiographic referral. Furthermore, the use of SMT in patients has more than doubled (56.7%) as a treatment modality after radiographs were obtained than before radiographs were taken (26.7%) (**Figures 4.2 and 4.5**).

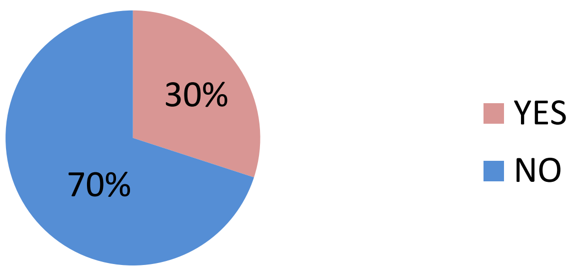


Figure 4.3: Was there a change in the clinical diagnoses following radiographic evaluation

Table 4.7: Details of change of diagnosis

Pre-radiographic primary clinical diagnoses	Primary radiologic diagnoses	Post-radiographic primary clinical diagnoses	Count
No primary diagnosis	Osteoporosis	Osteoporosis	2
	Scoliosis	Thoracic facet syndrome	1
		Osteoporosis	1
	Spondylosis	Thoracic facet syndrome	1
Thoracic facet syndrome	Old Trauma	Thoracic facet syndrome	6
		Compression fracture	1
	Scoliosis	Thoracic facet syndrome	6
	Spondylosis	Thoracic facet syndrome	1
	Normal	Thoracic facet syndrome	1
Thoracic myofasciitis	Old Trauma	Thoracic myofasciitis	1
	Scoliosis	Scoliosis	1
	Spondylosis	Thoracic facet syndrome	1
		Thoracic myofasciitis	1
		Scoliosis	1
Costotransverse syndrome	Old Trauma	Costotransverse syndrome	1
Scoliosis	Scoliosis	Scoliosis	1
Thoracic spondylosis	Spondylosis	Thoracic spondylosis	1
Rheumatoid arthritis	Osteoporosis	Rheumatoid arthritis	1
Compression fracture	Old Trauma	Compression fracture	1
Total			**30**

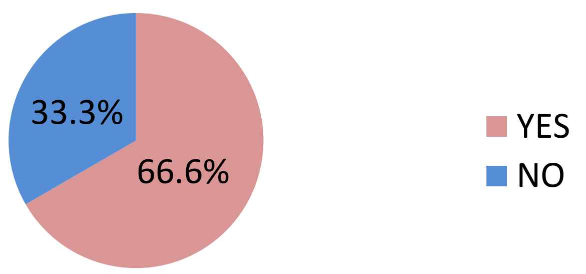


Figure 4.4: Was there a change in the management of pre-radiographic clinical diagnoses following radiographic evaluation

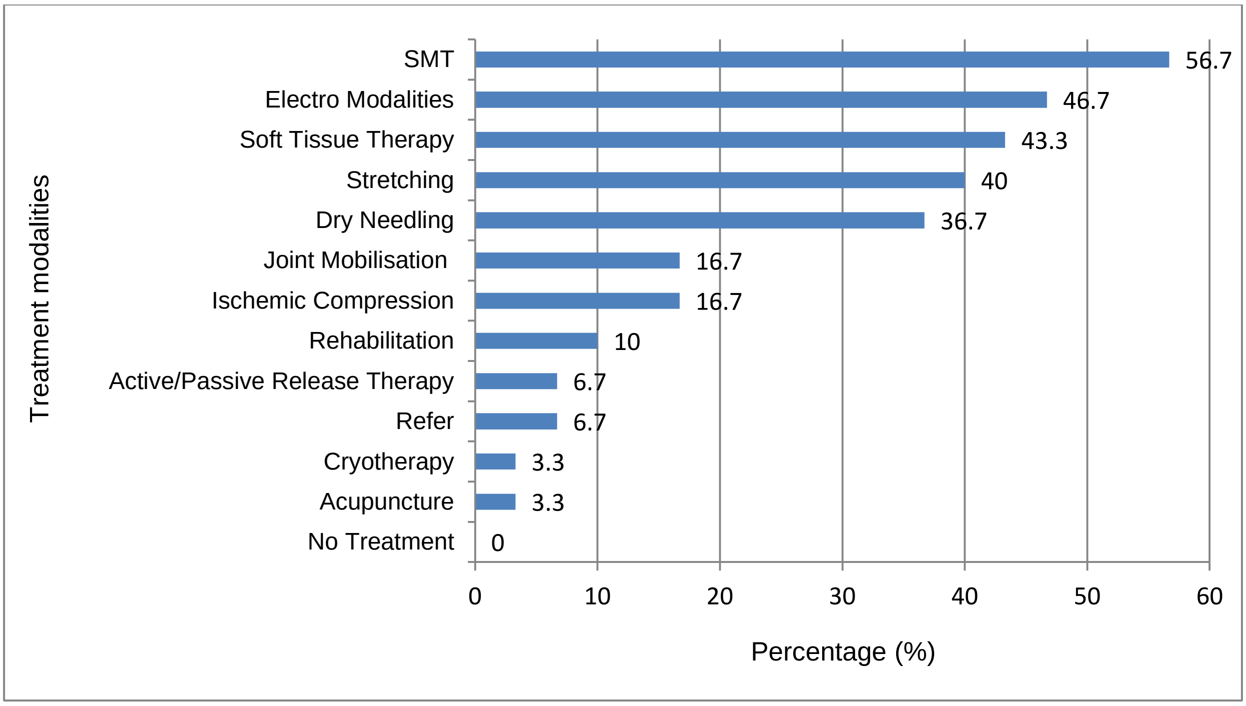


Figure 4.5: Management after thoracic spine radiographs were obtained

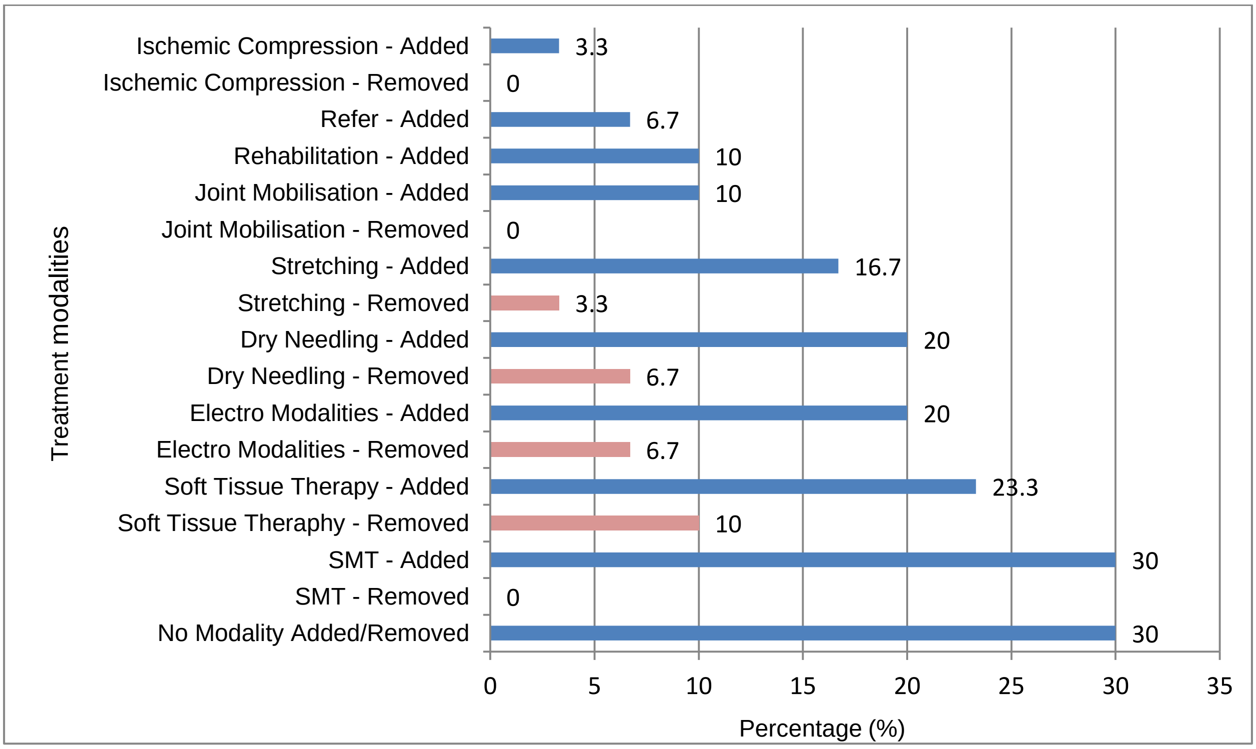


Figure 4.6: Change in management following radiographic evaluation

4.6 INCIDENTAL RADIOGRAPHIC FINDINGS

The incidental findings and its related pre-radiographic clinical diagnoses and post radiographic clinical diagnoses are displayed in **Table 4.8**. There were 23 (76.7%) incidental findings observed in 30 thoracic spine radiographs. In some instances more than one incidental finding was observed in a single patient. The most common incidental findings were thoracic vertebral compression fractures (30%) and scoliosis (23.3%) as shown in **Table 4.8**. More than half of the incidental findings (52.2%) were observed in clinical records with a diagnosis of thoracic facet syndrome, while 26.1% of incidental findings were observed in records with 'no primary clinical diagnosis' and 13% in thoracic myofasciitis (**Table 4.8**)..

Table 4.9 shows if there was a change in treatment in the clinical records of those patients with TSP following the observation of incidental finding(s) on radiographic evaluation. **Table 4.9** shows a change of treatment in 69.6% of the clinical records of which incidental findings were observed.

Table 4.8: Incidental findings and related pre-radiographic clinical diagnoses and post-radiographic clinical diagnoses

Incidental findings	Count (%)	Pre-radiographic clinical diagnosis (with percentage)	Post-radiographic clinical diagnosis (with percentage)
Schmorl's node	4 (13.3%)	Thoracic facet syndrome (100%)	Thoracic facet syndrome (100%)
Atherosclerosis of thoracic aorta	3 (10%)	No primary diagnosis (66.6%)	Thoracic facet syndrome (33.3%)
			Osteoporosis (33.3%)
		Rheumatoid arthritis (33.3%)	Rheumatoid arthritis (33.3%)
Scoliosis	7 (23.3%)	Thoracic facet syndrome (57.1%)	Thoracic facet syndrome (42.9%)
			Compression fracture (14.3%)
		Thoracic myofasciitis (28.6%)	Thoracic facet syndrome (14.3%)
			Scoliosis (14.3%)
		Thoracic spondylosis (14.3%)	Thoracic spondylosis (14.3%)
Compression fracture	9 (30%)	No primary diagnosis (44.4%)	Thoracic facet syndrome (22.2%)
			Osteoporosis (22.2%)
		Thoracic facet syndrome (44.4%)	Thoracic facet syndrome (33.3%)
			Compression fracture (11.1%%)
		Thoracic myofasciitis (11.1%)	Thoracic myofasciitis (11.1%)
Total	**23 (76.7%)**		

Table 4.9: Incidental findings and its effect on the related post-radiographic management

				Count	Count %
Incidental finding (Count)	Schmorl's node (4)	Was there a change in treatment	yes	3	75%
			no	1	25%
	Atherosclerosis of thoracic aorta (3)	Was there a change in treatment	yes	1	33.3%
			no	2	66.7%
	Scoliosis (7)	Was there a change in treatment	yes	5	71.4%
			no	2	28.6%
	Compression fracture (9)	Was there a change in treatment	yes	7	77.8%
			no	2	22.2%

CHAPTER 5 : DISCUSSION OF RESULTS

5.1 AGE AND GENDER

The mean age (± SD) of the patients in this study was 43.6 (± 19.1) years, while the range was from 14 - 79 years. This figure is similar to the average age of patients, 45.3 years (SD = 18,09), referred for thoracic spine radiographs at an American Chiropractic College (Lew and Snow, 2012). The age range is also comparable to the age range, 11 - 89 years, of the patients referred for radiographs at the American Chiropractic College. The female to male ratio in this study (**Figure 4.1**) was 3:2 in keeping with the findings of Dreiser *et al.* (1997, as cited in Benjamin, 2007).

5.2 THE RELATIONSHIP BETWEEN THE CLINICAL AND THE RADIOLOGICAL DIAGNOSES OF PATIENTS WITH THORACIC SPINE PAIN

No statistical tests could be performed to compare the diagnoses or test associations in the study as the categories were too many and too different. The large number of differing diagnoses led to unsuccessful attempts in correlating clinical and radiological diagnoses of TSP. Various reasons may be provided for the failure to establish any relationship between the two diagnoses. These may include: incorrect initial clinical diagnosis, incorrect or missed radiologic diagnosis, failure to incorporate radiographic findings in the eventual diagnosis, uncertainty of the student as to whether to stay with the initial clinical diagnosis or to change to the radiologic diagnosis. Although a clinician or student should maintain a higher level of suspicion for red flags in patients with TSP compared to the rest of the spine, the results of the study shows over-reliance of the students on radiographs to reach a diagnosis. This may indicate the inexperience and/or lack of confidence of the students to formulate an appropriate clinical diagnosis. Some students may also feel the need to clear a patient from any contraindication(s) prior to manipulation and therefore refer patients for radiographs as a consequence.

Thoracic facet joint syndrome was by far the most common clinical diagnosis in this study (**Table 4.1**) at 50%. This figure is similar to another study that found the prevalence of thoracic facet joint pain in patients with chronic spine pain to be as high as 42% (Manchikanti *et al.,* 2004). A local retrospective cross sectional survey of thoracic cases found thoracic facet syndrome as the primary diagnosis in 74.7% of the population that presented to the DUT CDC. This may indicate an over reliance on the diagnosis by students at the DUT CDC. It may also be a diagnosis of convenience as thoracic facet syndrome may be caused by a wide variety of conditions such as trauma, degeneration and postural strain (Gutterman, 2005). Scoliosis, spondylosis and common radiographic findings of old trauma were the most common radiological diagnoses in this study (**Table 4.3**). The most common radiographic findings of old trauma were compression fractures and Schmorl's nodes.

Thoracic facet syndrome can occur as result of scoliosis (Davies and Saifuddin, 2009), trauma and degeneration (Gutterman, 2005) to the spine. Scoliosis can result in facet joint pain, especially on the convex side, either above or below the apex (Davies and Saifuddin, 2009). Furthermore, facet joint sclerosis at the apex of the curve have a strong correlation with patients with TSP (Erwin, 2005). Trauma, from motor vehicle accidents and falls, commonly results in flexion and axial loads on the vertebral column (Daffner, 1990 as cited in Giles and Singer, 2000; Meyer, 1992 as cited in Giles and Singer, 2000) resulting in tension, pressure, stretching or irritation of the facet joint capsule which ultimately result in thoracic facet syndrome (Gatterman, 2005). This may explain the relationship between those patients who were diagnosed with thoracic facet syndrome (n = 15) who had radiographic findings of scoliosis (n = 7), old trauma (n = 7) and spondylosis (n = 2) (**Table 4.3**).

Five patients (16.7%) were sent for thoracic spine radiographs without being clinically diagnosed (**Table 4.3**). These patients had their diagnosis left 'blank' or "diagnosis pending radiographic results" in their files. The following reasons for radiograph referral were given on the radiograph request form: two of the patients suffered trauma (fall and motor vehicle accident (MVA)), DJD was suspected in one patient, one possible pathology, one possible cancer/TB/infection. Following imaging, these patients were found to have radiographic evidence of osteoporosis, spondylosis and scoliosis (**Table 4.3**). None of these diagnoses are classified as specific pathological conditions, however all five patients had the presence of red flags which warrants further investigative methods such as plain film radiography. The red flags included trauma, TSP in patient with age > 50 years, neurological (DMR) compromise, pain worse at night and family history of malignancy (**Table 2.2**).

Thoracic myofasciitis was another common clinical diagnosis at 16.7% of all the clinical diagnoses of the thoracic spine (**Table 4.3**). The reasons for radiographic referral in these patients included: trauma in two patients, one possible cancer, one persistent, localised TSP > 4 weeks and assessment of spinal curvatures in one patient. The most frequent radiological diagnosis in these individuals was spondylosis (**Table 4.3**). Degenerative changes in the thoracic spine are usually associated with a progressive increase in thoracic kyphosis (Corrigan and Maitland, 1998; Singer, 2000). This change in posture may contribute to muscular fatigue and prolong muscle weakness, pain and stiffness (Friction, 1994; Travell and Simons, 1999; Erwin, 2005). This may explain the relationship between those patients who were diagnosed with thoracic myofasciitis and showed radiographic findings of spondylosis (**Table 4.3**).

Two cases of suspected malignancy and one case of suspected TB were referred for radiographs after the initial consultation. Two of the patients were referred for radiographs without being clinically diagnosed, while the other patient was clinically diagnosed with thoracic myofasciitis. However, no significant radiographic findings were observed in these cases. This may occur due to the radiographic latent period of the diseases or manifestations of the diseases at other anatomical locations other than the spine. The patient suspected of TB did not receive any treatment prior to radiographic evaluation. However, following radiographic evaluation, the patient did receive treatment in the form of thoracic spine mobilization and exercises. Referral of these patients to medical practitioners for an assessment would have been a more appropriate way of management in these cases (Bussiéres *et al.,* 2008). One patient suspected of malignancy was referred for blood tests (FBC and urea and electrolytes (U&E) test), but it is not recorded in the patient files whether or not the patient was referred to a medical practitioner. Both patients suspected of malignancy received treatment in the form of electro modalities following radiographic evaluation. It is thus of immense importance to record these specific referrals in the patient files as medicolegal disputes may arise in the future.

5.3 THE CONSULTATION WHEN A THORACIC SPINE RADIOGRAPH WAS REQUESTED AND THE REASONS THEREFORE

Evidence-based medicine states that radiographs should not be requested in the acute stages of TSP, except in the presence of red flags, as it does not provide useful information (Bussières *et al.,* 2008). However, radiographs should be requested if the patient fails to respond to appropriate treatment over a period of four weeks (Peterson and Hsu, 2005; Bussières *et al.,* 2008). As mentioned earlier, indicators and guidelines have been developed to assist health care practitioners in identifying reason(s) to refer for plain film radiographs (Yocum and Rowe, 2005; Bussières *et al.* 2008). According to the Chiropractic Clinic Manual (2013), the primary role of diagnostic plain film radiographs is to confirm or reject any clinical impression after a thorough patient history and physical examination to identify red flags.

It is important to note that acute TSP will most likely be managed differently by different health care professions. Medical treatment will most likely consist of non-invasive treatment such as drug therapy (Stalker and Groen, 2000), while chiropractic treatment mainly consists of spinal manipulative therapy (Bronfort *et al.,* 2005). Chiropractors may be more likely to request plain film radiographs than their medical counterparts as it can help identify contraindications to spinal manipulation (Peterson and Hsu, 2005). It is therefore particularly interesting to see that the majority of thoracic spine radiographs (70%) were requested after the initial consultation (**Table 4.4**). Following radiographic evaluation, SMT were added as a treatment modality in 33.3% of these cases. This finding therefore suggest that the students were more comfortable utilization SMT as a treatment modality after patients have been cleared from contraindications to spinal manipulation. As mentioned earlier, the total count (n) of reasons for radiographic referral in **Table 4.4** and **Table 4.5** may be more than the frequency (amount of records), since more than one reason for a radiographic referral may have been recorded on the radiographic referral letter. A total of 28.6% (n = 18) of the reasons provided for radiographic referrals during the initial consultation (n = 63) (**Table 4.4**) are not considered as indicators for plain film radiography for the thoracic spine (**Table 2.3**). These reasons included: spinous process tenderness (n = 4), TSP associated with headache(s) (n = 3), possible osteoporosis (n = 3), night pain (n = 2), chest pain (musculoskeletal) (n = 2), unexplained skin lesion (n = 1) and past history of gout (n = 1) (**Table 4.4**). With this being said, the majority of the reasons (71.4%, n = 45) for radiographic referrals at the initial consultation are considered indicators for plain film radiography of the thoracic spine (**Table 2.3**). The most common reasons for radiographic referral during the initial consultation (n = 63) were severe, progressive TSP at 19% (n = 12), trauma at 15.9% (n = 10) and persistent, localised TSP for more than four weeks at 11.1% (n = 7) (**Table 4.4**). These reasons for radiographic referrals are considered as red flags in patients with TSP (**Table 2.2**) and are therefore consistent with the internationally accepted evidence-based guidelines that were developed to help a clinician determine the need for plain film radiographs. Overall, these three reasons for radiographic referrals were also ranked as the most common reasons for radiographic referral in the study (n = 88) with severe, progressive TSP at 19.3% (n = 17), trauma at 15.9% (n = 14) and persistent, localised TSP for more than four weeks at 12.5% (n = 11) (**Table 4.5**).

Other common reasons for radiographic referrals include TSP (patients with age less than 10 years or greater than 50 years) at 9.1% (n = 8) and spinous process tenderness at 8% (n = 7) (**Table 4.5**).

Four patients were sent for plain film radiographs to diagnose and/or assess the degree of scoliosis (**Table 4.5**). The one patient was clinically diagnosed with scoliosis and associated myofasciitis. However, according to the history of the patient, the patient had never been sent for plain film radiographs to diagnose or assess the degree of scoliosis. According to the Chiropractic Clinic Manual (2013), radiographic analysis could be used to support or reject findings noted during the relevant history and physical examination. The clinical diagnosis was confirmed and remained the same following radiographic evaluation. Another patient was diagnosed with scoliosis earlier in life, according to the history of the patient. However, no findings was made to support this statement during the physical examination at the initial consultation at the DUT CDC. Furthermore, the patient did not have any other evidence of scoliosis in the form of plain film radiographs. This patient was clinically diagnosed with thoracic facet syndrome and associated myofasciitis. This diagnosis remained the same following radiographic evaluation. Two other patients were also send for plain film radiographs in whom scoliosis were suspected. These two patients were clinically diagnosed with myofasciitis. However, both diagnoses were changed to scoliosis following radiographic evaluation. Plain film radiography is the diagnostic method of choice to diagnose scoliosis and requires a standing frontal radiograph of the entire spine (Amzallag-Bellenger *et al.,* 2014). Full spine radiographs were only requested in one of these four cases. Therefore, three of these radiographic requests were contrary to the literature for standard assessment of scoliosis as they did not include radiographs of the entire spine. The patient who was referred for full spine radiographs was initially diagnosed with thoracic myofasciitis, while the radiographs revealed findings of scoliosis. The patient's diagnosis was changed to scoliosis, following radiographic evaluation, which led to changes in the treatment plan. These changes included the addition of rehabilitative core exercises and the removal of dry needling.

Two of the major drawbacks of conventional radiology is the lack of soft tissue discrimination and limited diagnostic sensitivity, especially in certain diseases such as infections and tumors of the spine where 30%-50% loss of bone density is necessary before being radiologically evident (O'Connor *et al.,* 1999; Yohum and Rowe, 2005). Plain film radiography was considered as the baseline investigative method, at the initial consultation, for possible TB or tumors of the spine (**Table 4.5**) as suggested by literature (Peterson and Hsu, 2005; Yochum and Rowe, 2005; Michael *et al.,* 2009). However, referral to a medical practitioner might have been a more appropriate way of managing these patients as plain film radiographs may miss early signs of tumors and infections due to the radiographic latent period (Yohum and Rowe, 2005; Bussières *et al.,* 2008).

One patient was referred for radiographs at treatment eighteen, three years after the initial consultation as the patient was responding inadequately to the treatment (**Table 4.4**). This, however, is contrary to the evidence-based guidelines which suggest plain film radiography and/or blood tests (ESR) in patients not responding in four (Bussières *et al.,* 2008) to six weeks of conservative managements (Jarvik and Deyo, 2002; Souza, 2009). The delay in radiographic referral may be attributed to the fact that different students attended to the patient over the three year period. This delay might also be attributed to the failure of students to make a correct clinical diagnosis, use appropriate or correct treatment modalities or examine the patient's files thoroughly. The patient was initially diagnosed with thoracic facet syndrome without any red flags being identified. Spinal manipulative therapy and electro modalities were the treatment modalities of choice which was consistent with the recommendations of Souza (2009) with regards to conservative management of thoracic facet syndrome. The failure of the patient to respond to adequate treatment was a valid reason for radiographic referral (Jarvik and Deyo, 2002; Souza, 2009). The radiographs revealed findings of scoliosis. This radiographic finding did not lead to a change in the diagnosis. However, stretching, ischemic compression, thoracic spine mobilization and other electro modalities were added to the management plan of the patient which are consistent with literature (Erwin, 2005). Literature remains inconclusive as to the most effective treatment for patients with scoliosis as the results of research are currently contradictory (Erwin, 2005).

One patient was referred for radiographs without any suitable reason or presence of red flags (**Table 4.4**). The reason for radiographic request merely stated 'pathology' which is not considered as an indicator for plain film radiography (Yochum and Rowe, 2005; Bussiéres *et al.,* 2008). This patient was clinically diagnosed with a thoracic facet syndrome prior to radiographs. The Radiographic Guidelines and Procedures (Chiropractic Clinic Manual, 2013) of the CDC state that radiographs should be used to confirm or reject a clinical impression based on a thorough history and physical examination. It is therefore interesting to see that a patient with a non-specific mechanical diagnosis, without any red flags was referred for radiographs after the third treatment without any suitable reason. There was no change to the clinical diagnosis after the radiographs were taken. However, following radiographs, SMT was added as a treatment modality while dry needling was removed.

Possible osteoporosis, TSP associated with headache(s) and possible DJD are not considered red flags (**Table 2.2**) or indicators for skeletal radiography (**Table 2.3**) in patients with TSP. These requests for radiographs were therefore contrary to the evidence-based guidelines. A patient with suspected osteoporosis should rather be referred for a DEXA scan as it is considered the 'gold standard' for osteoporosis screening, while 40%-50% of bone loss has to occur before features of osteoporosis become evident on plain film radiographs (Moyad, 2003; Bussières *et al.,* 2008). The patient with possible DJD was referred for radiographs after five consultations within three weeks. Radiographs are only ethically indicated once four to six weeks of conservative treatment has failed (Jarvik and Deyo, 2002; Souza, 2009). These patients as well as the patient that was sent for radiographs without a suitable reason are thus considered as unsuitable referrals for radiographic evaluation. At the DUT CDC, supervising clinicians guide students in formulating accurate clinical diagnoses and counsel the students on the appropriate use of diagnostic tests such as plain film radiography. The clinician on duty can only advise on findings reported by the student thus if these clinical findings are incorrect there is no way for the clinician to know any different (Clinic Manual, 2013).

Overall, the majority of the reasons (71.6%, n = 63) were considered relevant indicators for plain film radiographic referral in patients that presented with TSP at the DUT CDC. Other reasons that were not considered relevant indicators for plain film radiographic referral were present in 28.4% of the cases and were suggestive of mechanical diagnosis. The students therefore adhered relatively well to the evidence-based guidelines for plain film radiography and sent for plain film radiographs as a base line investigation. This finding is comparable to a survey conducted on chiropractic schools worldwide which established that most schools adhere to the evidence-based guidelines for plain film radiography (Ammendolia *et al.,* 2008). The early detection of red flags are crucial as misdiagnosis may result in serious complications due to the delays in initiating referral for appropriate treatment and acquiring injuries due to the unrecognised pathology.

5.4 THE SUSPECTED CLINICAL DIAGNOSES AND MANAGEMENT PRIOR TO REFERRAL FOR THORACIC SPINE RADIOGRAPHS

The majority of patients were diagnosed with non-specific, mechanical causes of TSP such as thoracic facet syndrome and thoracic myofasciitis. This finding is consistent with those in literature stating that TSP of mechanical origin are most commonly encountered and consequently deserves special mention (Giles, 2000).

Five patients were referred for radiographs at their initial consultation without being diagnosed clinically (**Table 4.1**). Three of the five patients suffered from trauma, while osteoporosis and TB were suspected in the other two patients. All five patients were diagnosed with mechanical causes of TSP following radiographic evaluation. It is interesting to see that three of the five patients received treatment in the form of dry needling, stretches, electro modalities and acupuncture without being diagnosed clinically (**Table 4.6**). Spinal manipulative therapy was not considered in these patients prior to radiographic referral and was only added as a treatment modality in two of the patients following radiographic evaluation. According to literature a clinician can only start to formulate treatment regimes once a diagnosis has been made and a patient has been cleared from any serious and/or life-threatening diagnoses (Erwin, 2005). The treatment of these patients are therefore contrary to literature and is therefore not ethical. However, according to the DUT Clinic Manual (2013) a conditional will be signed, and dated, to allow the student to treat a patient in acute pain before the necessary paperwork or radiographs have been completed. According to Stoker and Groen (2000), patients may be treated symptomatically if the cause cannot be found after extensive investigations or if the cause-related treatment is unavailable. It is thus clear in the above mentioned findings that there is inconsistency regarding treatment protocols in patients with TSP.

A wide variety of treatment modalities were employed in the treatment of the patients prior to radiographs (**Table 4.6**). The use of electro modalities and soft tissue therapy were the highest, followed by stretches and SMT. Six patients did not receive any form of treatment as three patients suffered traumatic experiences, one patient had a 15 year history of rheumatoid arthritis, one patient suffered from chest pain and one patient was referred for suspected vertebral fracture/cancer/TB. Interestingly, four of the six patients were clinically diagnosed with non-specific, mechanical causes of TSP while the other two patients were not diagnosed clinically.

In summary, the great majority of patients were diagnosed with non-specific, mechanical causes of TSP. Five patients were not clinically diagnosed prior to radiographic evaluation. The majority of the patients received some form of conservative therapy, while 20% of the patients did not receive any form of treatment.

5.5 CHANGES IN THE CLINICAL DIAGNOSIS AND MANAGEMENT AFTER RADIOGRAPHS

Only 30% of the patients in this study had a change in diagnosis following radiographic examination, while the other 70% of the diagnoses remained the same (**Figure 4.3**). However, a total of 66.6% of the patients in the study had changes made to their management protocol following radiographic evaluation (**Figure 4.4**). SMT become the most popular treatment modality after radiographic evaluation at 56.7% compared to 26.7% prior to radiographic imaging. The fact that the popularity of SMT has more than doubled following radiographic evaluation suggest that students felt more comfortable using SMT in patients presenting with TSP after evaluating the radiographs at the DUT CDC. This finding supports the fact that radiographic evaluation can be beneficial especially for chiropractors who primarily treat patients with SMT which involves a high-velocity low-amplitude thrust into a joint (Peterson and Hsu, 2005).

The pre-radiographic clinical diagnoses are similar to the post-radiographic clinical diagnoses in **Table 4.7**. Radiographs seem to have little effect on the more common, less serious non-specific clinical diagnoses as their diagnoses remained either the same or merely changed to another non-specific mechanical cause of TSP (**Table 4.7**). 96.7% of the post-radiographic primary clinical diagnoses were non-specific, mechanical of origin, while only 3.3% were considered as red flag conditions (**Table 4.7**). This is comparable with literature that suggests that 80%-90% of spinal pain cases are non-specific of origin while 10%-20% are pathological (Giles, 2000).

As mentioned earlier, five patients were referred for radiographs without being clinically diagnosed by the student, with three patients having suffered from trauma, while the other two was suspected of osteoporosis and TB respectively. The radiographs confirmed features of osteoporosis in the patient who was suspected of osteoporosis and was therefore ultimately clinically diagnosed with osteoporosis. Radiographs revealed compression fractures in all three patients who suffered from trauma. However, two were clinically diagnosed with thoracic facet syndrome, while the other patient was diagnosed with osteoporosis. Radiographs also revealed a compression fracture in the patient suspected of TB. Following this, the clinical diagnosis was changed to that of osteoporosis (**Table 4.7**). Spinal manipulative therapy was only added as a treatment modality in the two patients diagnosed with thoracic facet syndrome after radiographs were taken.

Two patients that were clinically diagnosed with thoracic facet syndrome and thoracic myofasciitis respectively were referred for radiographs during their initial consultation as they were suspected of having cancer. The radiographs of the one patient revealed increased thoracic kyphosis, Schmorl's nodes, endplate irregularities and anterior compression of three consecutive vertebrae which lead to a radiographic diagnosis of 'old trauma'. However, the clinical diagnosis of thoracic facet syndrome remained unchanged as there was no evidence of trauma in the history and physical examination. Another possible, more accurate radiologic diagnosis that should have been considered by the radiologist was Scheuermann's disease as the patient was also only 26 years of age. The radiographs of the other patient, showed features of degeneration of the spine which led to a radiologic diagnosis of spondylosis. However, the clinical diagnosis of thoracic myofasciitis remained unchanged following radiographs. As mentioned earlier, referral to a medical practitioner might have been a more appropriate way of managing these patients as plain film radiographs may miss early signs of tumors due to the radiographic latent period.

Two patients were referred for radiographs at their initial consultation due to a history of rheumatoid arthritis. Interestingly, only one patient was diagnosed clinically with rheumatoid arthritis, while the other patient was clinically diagnosed with thoracic myofasciitis. A more accurate clinical diagnosis could have been rheumatoid arthritis with associated thoracic myofasciitis. The radiographs of this patient revealed a compression fracture which led to a radiologic diagnosis of 'old trauma'. However, the initial clinical diagnosis of thoracic myofasciitis remained unchanged, even though the radiographic diagnosis was supported by trauma in the patient's history. As mentioned earlier, rheumatoid arthritis is a synovial inflammatory joint disease that mainly targets peripheral joints of the extremities, larger joints, the cervical spine and to a lesser extend the thoracic spine (Peterson and Hsu, 2005; Yochum and Rowe, 2005b). The radiographs of the other patient revealed features of osteoporosis and atherosclerosis of the thoracic aorta which lead to a radiologic diagnosis of osteoporosis. Radiographic features such as vertebral endplate sclerosis was also noted in this patients that seems to be consistent with literature which states that vertebral endplate and facet joint erosions may be radiographically evident in patients with rheumatoid arthritis in the spinal region (Bland, 2000; Peterson and Hsu, 2005; Yochum and Rowe, 2005b). No change was made to the initial clinical diagnosis of rheumatoid arthritis, although the patient was radiologically diagnosed with osteoporosis. It might therefore be possible that the student was relying on the previous diagnosis of rheumatoid arthritis.

Radiographic evaluation revealed features of conditions that were not clinically suspected such as thoracic scoliosis (23.3%), osteoporosis (23.3%) and thoracic spondylosis (13.3%). Although these conditions are considered as mechanical causes of TSP (**Table 2.1**) they were not necessarily recorded as a clinical diagnosis, as the initial clinical diagnosis mostly remained unchanged or merely changed to another non-specific mechanical cause of TSP (**Table 4.7**). As mentioned earlier, the gold-standard of diagnosing osteoporosis and scoliosis is a DEXA scan and full spine radiographs respectively.

A change in the management protocol was observed in 66.6% of patients following radiographic evaluation (**Figure 4.4**). There was also an increase in the utilization of the majority of the treatment modalities following radiographs (**Table 4.5**). The use of SMT became the principal treatment modality for patients with TSP as its utilization percentage increased from 26.7% of cases prior to radiographic evaluation to 56.7% of cases following radiographic evaluation. This finding is in keeping with the Chiropractic Clinic Manual (2013) which states that manual therapy which includes thoracic spine manipulation or mobilisation is considered as the primary modality utilised, while other supplementary therapy procedures such as soft tissue therapy and electrotherapy are also available to supplement chiropractic adjustive care.

5.6 INCIDENTAL RADIOGRAPHIC FINDINGS

Incidental findings were observed in the radiographs of 21 (70%) patients in this study, which is comparable to the study conducted by Beck *et al.* (2004) in which 68% of patients that presented for chiropractic care were found to have radiographic anomalies. Two incidental findings were observed in two of the 21 patients in the study, while only one incidental finding was observed in the remaining 19 patients. A total of 23 (76.7%) incidental findings were thus observed in the 30 thoracic spine radiographs in this study (**Table 4.8**).

The most common incidental findings in the study were healed thoracic vertebral compression fractures (30%) and scoliosis (23.3%) which are both higher than that reported by Beck *et al.* (2004) with fractures (6.6%) and scoliosis (1.3%). An explanation for this might be the fact that the radiographs of the entire spinal region were analysed for radiographic anomalies in the study of Beck *et al.* (2004), while this study was only evaluating the thoracic spine. Furthermore, compression fractures are most common in the thoracolumbar spine (Meyer, 1992 as cited in Giles and Singer, 2000; Alexandru and So, 2012), while the thoracic spine is also the most common region of spinal deformity with idiopathic scoliosis as the most common cause (McCall, 2000). In this study, atherosclerosis was observed in 10% of patients which is comparable to the 13.5% of patients that were reported by Beck *et al.* (2004) with soft tissue abnormalities.

In this study, vertebral compression fractures were mostly found in patients who were clinically diagnosed with either 'no primary diagnosis' or thoracic facet syndrome (**Table 4.8**). The majority of compression fractures were observed in patients that suffered from trauma which included falls and motor vehicle accidents. This information seems to be supported by literature which states that the most common mechanism of thoracic vertebral fractures involves flexion and axial loads (Meyer, 1992) from motor vehicle accidents and falls (Daffner, 1990). Trauma can cause tension, pressure, stretching or irritation of the facet joint capsule and ultimately result in facet joint syndrome (Gutterman, 2005). Scoliosis was mostly found in patients who were clinically diagnosed with thoracic facet syndrome and to a lesser extent in patients who were clinically diagnosed with thoracic myofasciitis (**Table 4.8**). According to Davies and Saifuddin, (2009) scoliosis can cause facet joint pain, especially on the convex side, either above or below the apex. Postural decompensation in the coronal plane results in scoliosis which may contribute to muscular fatigue and prolong muscle weakness, pain, stiffness and thus ultimately thoracic myofasciitis (Friction, 1994; Travell and Simons, 1999; Erwin, 2005). Schmorl's nodes were observed in patients who were all clinically diagnosed with thoracic facet syndrome (**Table 4.8**). The majority of Schmorl's nodes were observed in patients who suffered from trauma. The literature supports this information by stating that vertebral end-plate ruptures, or Schmorl's nodes, usually occur with rapid axial loading when the spine is in a flexed forward position (Singer, 2000). As mentioned earlier, trauma may cause tension, pressure, stretching or irritation of the facet joint capsule that ultimately results in facet joint syndrome (Gutterman, 2005).

Occasional incidental findings may require alterations in the treatment protocols (Beck *et al.,* 2004). For instance moderate-severe vertebral compression fracture(s) in osteoporotic or traumatic individuals is a relative to absolute contraindication to SMT (Haldeman and Philip, 1991; Haldeman *et al.,* 1993; Assendelft *et al.,* 1996; Kohlbeck, 2005). Also, patients with osteoporotic fractures may require further alterations in the treatment protocols such as additional nutritional and exercise advice. A change in treatment was observed in 69.6% of the patients with incidental findings that were referred for thoracic spine radiographs (**Table 4.9**).

CHAPTER 6 : CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The majority of patients (70%) were referred for thoracic spine radiographs after their initial consultation. The amount of patients referred for plain film radiographs decreased progressively as the consultation number increased. Overall, the majority of the reasons (71.6%, n = 63) were considered relevant indicators for plain film radiographic referral in patients that presented with TSP at the DUT CDC. The students therefore adhered relatively well to the evidence-based guidelines for plain film radiography which is comparable to a survey done on chiropractic schools worldwide which established that most schools adhere to the evidence-based guidelines for plain film radiography (Ammendolia *et al.,* 2008). The majority of the pre-radiographic clinical diagnoses were non-specific mechanical causes of TSP with the most common being thoracic facet syndrome in 50% of the cases and thoracic myofasciitis in 16.7% of the cases. These diagnoses seems to be diagnoses of convenience for the students as the presence of red flags and radiographic evaluation seems to have little effect on the non-specific clinical diagnoses. Although thoracic spine radiographs were not influential in changing the clinical diagnosis in 21 (70%) of the cases, it did however change the clinical diagnosis in 9 (30%) of the cases. Thoracic spine plain film radiographs have little impact on the non-specific mechanical diagnoses of patients that present with TSP at the DUT CDC as their diagnoses remained either the same or merely changed to another non-specific mechanical cause of TSP.

The evaluation of thoracic spine radiographs lead to a change in the management of 20 (66.6%) of the patients that presented with TSP at the DUT CDC. Electro modalities at 33.3% and soft tissue therapy at 30% were the most commonly utilised treatment modalities prior to radiographic evaluation. SMT was added as a treatment modality in 30% of the cases and became the most popular treatment modality following radiographic evaluation at 56.7% compared to 26.7% prior to radiographic imaging. The fact that the popularity of SMT more than doubled following radiographic evaluation suggest that students felt more comfortable using SMT in patients presenting with TSP after evaluating the radiographs at the DUT CDC. Interestingly, 20% of patients with TSP were referred for radiographs without receiving any form of treatment. SMT was added in 66.7% of these patients following radiographic evaluation. These findings support the fact that radiographic evaluation can be beneficial, especially for chiropractors, to clear patients from contraindications to SMT as they primarily treat patients with SMT which involve a high-velocity low-amplitude thrust into a joint (Peterson and Hsu, 2005). Spinal manipulative therapy (SMT) has become the most widely used treatment method for uncomplicated mechanical thoracic spine pain and dysfunction as a conservative treatment modality. Chiropractic students at the DUT CDC are encouraged to make use of manual therapy such as SMT or mobilization as a primary treatment modality. However, this raises a question of ethics in withholding such treatment from patients that have not been referred for radiographs as a precaution. It is therefore vital for the students and clinicians to adequately examine a patient so that they can be confident that the benefits of the radiographic exposure outweighs the risk with regards to the management of patients at the DUT CDC. The most common incidental finding was compression fractures in 30% of the cases. Incidental radiographic findings such as Schmorl's nodes, compression fractures and scoliosis lead to a change in treatment in 75%, 77.8% and 71.4% of patients respectively (**Table 4.9**). The structural and biomechanical radiographic information of scoliosis is useful and vital in determining patient diagnosis and management. Furthermore, incidental radiographic findings such as Schmorl's nodes and compression fractures and their alterations in the treatment protocols can be beneficial especially for chiropractors, due to the nature of their treatment which often involves a high-velocity low-amplitude thrust into the joint that may potentially cause injury to a diseased area if not picked up before treatment.

6.2 RECOMMENDATIONS

The following recommendations are proposed to the DUT CDC arising from the results of this study:

- ❖ The clinicians should encourage the students to consider and explore all the possible clinical diagnoses based on the patient history, physical examination and radiographs rather than over-relying on the common, mechanical clinical diagnoses such as thoracic facet syndrome and thoracic myofasciitis. Students should also be encouraged to formulate differential diagnoses as suspected clinical diagnosis and not merely leave the diagnosis blank on the SOAPE note in the patient's file.

- ❖ Students and clinicians should familiarise themselves with the accepted guidelines for ordering radiographs and adhere to them at the DUT CDC. Radiographic request forms should have a valid reason for ordering radiographs and never be left blank. Plain film radiographs should only be requested at the initial consultation if the student and clinician have a strong suspicion for any serious underling conditions e.g. presence of red flags (Pederson, 2005; Michael *et al.,* 2009).

- ❖ Patients that present with red flags in their history and/or physical examination should be referred to appropriate medical practitioners to ensure the most suitable investigations and management for the particular patient (Singer and Edmondston, 2000). No treatment should be considered for these individuals at the DUT CDC until they have been cleared from underlying pathology.

- ❖ Clinicians and students should be aware of radiographic latent periods in the early stages of certain clinical entities such as infections, cancer and fractures. These patients should therefore be evaluated on a regular basis for the appearance of any possible red flags or be referred to medical practitioners for a second opinion.

- Patients with clinical findings of osteoporosis should be referred for a DEXA scan as it is considered the ‘gold standard’ for screening osteoporosis (Moyad, 2003).

- Students need be informed that full spine radiographs need to be requested to diagnose and/or assess the degree and severity of scoliosis as only one of four cases were referred for full spine radiographs to assess the degree and severity of scoliosis.

- Changes to a clinical diagnosis, through either physical or radiological examination findings, needs to be properly documented by the student in the SOAPE note of the patient’s file in compliance with medicolegal requirements. The addition of incidental findings as concomitant diagnosis should also be considered.

- Students should be encouraged to formulate their treatment protocols based on evidenced-based guidelines.

- Exposure of the students to different fields of expertise would most likely improve their diagnostic skills and help develop their means of treatment in patients with thoracic spine pain.

Recommendations for future studies include:

- A similar study should be performed at the Chiropractic Day Clinic at the University of Johannesburg to determine whether these findings are unique to the DUT CDC or if they are comparable to those of another chiropractic teaching clinic.

- This study could also be conducted at a private chiropractic practice to compare the results of a chiropractic teaching clinic to those of a private chiropractic practice.

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APPENDIXES

Appendix A: Patient Confidentiality Coding Sheet

Patient name	Date of birth	File number	Code

Appendix B: Data Sheet

Patient Information from patient file

Code		
Age		
Gender	Male	Female

Patient's Initial Clinical Consultation from patient file

Date							
Clinical Diagnosis							
Treatment	SMT	Dry Needling	Stretching	Electro-Modalities	Soft Tissue Therapy	Refer	Other (specify)
Reason for Radiographic Referral							
Number of treatments before referral for radiographs							

Radiologist Report/ Radiograph

Date radiograph Performed		
Researchers Diagnosis		
Radiologist Diagnosis		
Incidental Findings	Yes	
	No	

After Radiographs were performed

Change in the Clinical Diagnosis	Yes											
	No											
Change in Treatment And was a modality added or removed	Yes	SMT		Dry Needling		Stretching		Electro-Modalities		Soft Tissue Therapy		Refer or Other modality (specify)
	No	added	Removed	added	Removed	added	Removed	added	Removed	added	Removed	

Source: Adapted from McPhail 2011

Appendix C: Permission form to access clinical records

RE: Permission to go through the patient files at the DUT chiropractic day clinic

The information needed from the patient files:

- The number of patients that presented to the clinic with neck pain(Stefan) and upper back pain (Henri) (period yet to be determined since we need to determine the availability of those files)
- Clinical diagnosis and management of the patients with neck (Stefan) and upper back pain (Henri) by the intern/clinician prior to x-ray referral
- To view motivation by intern/ clinician to send patient for those x-rays
- The x-rays of relevant neck and thoracic spine regions that was performed
- Diagnosis of the radiologist of relevant x-rays
- Soap notes
- The incidental findings that was reported
- The clinical diagnosis and management after x-rays was noted

Reason for the need of this information

We need the information since we are in process of completing our PG-1 document and we are interested to do a retrospective study on:

"The role of cervical x-rays (Stefan) and thoracic x-rays (Henri) on the diagnosis and management of patients that presented with neck pain and upper back pain respectively"

We need to be sure that the necessary information are available in the patient files before we submit our PG-1 since if it's not then will jeopardize our research at a later stage in the research process.

Declaration

We, **Stefan Eloff** (21009716) and **Henri Myburgh** (21020470) hereby declare that we will keep the information in the patient files confidential and we will only use the information that is relevant to our investigation.

[redacted]

Stefan Eloff

Henri Myburgh

Head of department

Dr. A. Docrat

Clinic Directors:

Dr. D. Varatharajullu

Dr. C. Korporaal

Appendix D: Indemnity Form

Medical Aid schemes pay in varying degrees for coverage of Chiropractic Services. This coverage is therefore medical aid dependant and we request that you check with your medical aid in this respect. **The DUT Chiropractic Day Clinic is contracted out of medical aid**, which means that we run on a **strictly cash only basis**, whereby you are requested to pay cash in advance of services rendered. You will be sent a monthly statement which you must submit to your medical aid for them to refund you directly. This statement will be sent out at the **end of each month.**

Charges are **not** applicable to **research patients**

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

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

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

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

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

By signing this form I agree that

a) I understand and take full financial responsibility for consultations.
b) I understand that I cannot request records for medico legal reasons.
c) I understand that should I be on medical aid, that my diagnosis and treatment information will be shared for the purposes of medical aid reimbursing me according to that which I am contractually bound in terms of my medical cover (and that only a written request or instruction from myself will be accepted in terms of discontinuing this practice by my health care provider – the Chiropractic Day Clinic).
d) Should I need to be referred that my medical information (pertinent to my condition) will be shared with the doctor / specialist to whom I have been referred.
e) I understand that with my attendance at the Chiropractic Day Clinic, that my medical information will be discussed between the student responsible for my care and the supervising clinician who is responsible for overall oversight of my care.

Date:		**Patient Signature:**	
Parent/legal guardian signature: (in the case of patient's who are under the age of 12 years and those requiring assistance between the ages of 12-18 years)			
Relationship of guardian to the minor:			
Date:		**Student Signature:**	
Date:		**Clinician Signature:**	

By signing this section of the form I agree that (to be completed after you have been assessed and prior to your treatment / referral):

a) The student has discussed with me to my satisfaction, and I fully understand, my / my minor child's diagnosed condition(s) that I have.
b) The student has discussed with me to my satisfaction, and I fully understand all treatment and/or non treatment options and their relative successes and/or failures as applicable to the diagnosed condition(s).
c) I am making an informed decision with regard to, and will submit to / consent to my minor child being submitted to, the treatment protocol as explained.

Based on the above I therefore give consent for the treatment of my named complaint by signing the form hereunder:

Date:		**Patient Signature:**	
Parent/legal guardian signature: (in the case of patient's who are under the age of 12 years and those requiring assistance between the ages of 12-18 years)			
Relationship of guardian to the minor:			
Date:		**Student Signature:**	
Date:		**Clinician Signature:**	

Appendix E: Letter of approval of Executive Dean

Dear Prof Puckree,

I, Henri Myburgh am currently busy with a retrospective research project: **The impact of thoracic spine radiographs in the diagnosis and management of patients who presented with thoracic spine pain at the Chiropractic Day Clinic at the Durban University of Technology.**

All patients sign consent forms prior to their initial visit giving permission that their clinical information may be used for research purposes. However, it was discovered that the consent forms in the older patient files, pre dating the year 2001, in the Chiropractic Day Clinic (CDC) at the Durban University of Technology (DUT) simply stated that they as the patients know and understand that the CDC is a teaching clinic and that they give permission to be treated and observed by chiropractic students. These forms thus lack consent from the patients that their clinical information may be used for research purposes. The researcher (Henri Myburgh) needs this clinical information in these patient files to complete the research and therefore requests your approval as gatekeeper, thus allowing this research to proceed.

The clinical information used in the research will be kept confidential by the following means:

- Permission was granted from the Chiropractic Head of Department and Directors of the DUT CDC to access all thoracic spine radiographs and corresponding clinical records.

- All the relevant clinical files will be locked and kept save and will only be available for the researcher, supervisor and co-supervisor.

- An alpha numerical code will be given to each patient's personal details.

- Data collection will be done in a research room in the DUT CDC.

Researcher:

Henri Myburgh

Supervisor:

Dr. G Harpham

Head of Department Chiropractic:

Dr. A Docrat

Executive Dean: Faculty of Health Sciences:

Prof. L Puckree

[redacted]

Appendix F: IREC approval

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

6 May 2015

IREC Reference Number: **REC 42/15**

Mr H J Myburgh
115 Waterkant Road
8 Ocean Gardens
Durban North
Durban
4051

Dear Mr Myburgh

The impact of thoracic spine radiographs in the diagnosis and management of thoracic spine pain at the Chiropractic Day Clinic at the Durban University of Technology

I am pleased to inform you that Full Approval has been granted to your proposal REC 42/15.

The Proposal has been allocated the following Ethical Clearance number **IREC 037/15**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2015 -05- 06
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA