Hyperextension Injury of the Cervical Spine with Central Cord Syndrome

CRISPIN THOMPSON

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M Med Neurosurgery

Faculty of Health Sciences

UNIVERSITY OF CAPE TOWN

Supervisor

David Welsh

Division of Neurosurgery

Faculty of Health Sciences

University of Cape Town

Declaration

I, Crispin Thompson, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been is being, or is to be, submitted for another degree in this or any other university.

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Date: 16 April 2013

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List of Abbreviations

AIS	ASIA Impairment Scale
ASCI	Acute Spinal Cord Injury
ASIA	American Spinal Injury Association
CT	Computerised Tomography
DRC	Departmental Research Committee
FIM	Functional Independence Measure
GSH	Groote Schuur Hospital
ICU	Intensive Care Unit
MMed	Masters Degree of Medicine
MRI	Magnetic Resonance Imaging
TCCS	Traumatic Central Cord Syndrome
UCT	University of Cape Town
ZPP	Zone of Partial Preservation

Glossary of Terms

Tetraplegia	impairment of function, motor and/or sensory, in the cervical segments of the spinal cord, as a result of neural injury, affecting the upper limbs, trunk, lower limbs and pelvic organs (preferred to quadriplegia)
Paraplegia	impairment of function, motor and/or sensory, in the thoracic, lumbar or sacral segment of the spinal cord, or cauda equina, as a result of neural injury, affecting the trunk, lower limbs and pelvic organs (depending on the level of the injury)
Dermatome	an area of skin innervated by the sensory nerve root contributing to a single spinal cord segment
Myotome	a unit of muscle fibres innervated by the motor nerve root arising from a single spinal cord segment

Part A: Study Protocol

Hyperextension Injury of the Cervical Spine with Central Cord Syndrome

Principal Investigator: Dr Crispin Thompson

Supervisors: Dr David Welsh

Introduction

Traumatic Central Cord Syndrome (TCCS) is the most commonly encountered type of incomplete spinal cord injury [1,2], accounting for nearly 45-70% of incomplete and 10-25% of all clinical syndromes following traumatic spinal cord injury [2,3,4]. TCCS typically occurs in patients with a narrow spinal canal and follows an acute hyperextension injury of the cervical spine [5]. The upper limbs are usually more severely affected than the lower limbs. Patients with a central cord type injury may present initially with a severe motor-sensory spinal cord injury, but have a much better prognosis for neurological improvement than other types of injury. Recovery of motor function is a fairly predictable feature of central cord syndrome, however it does not always lead to a good functional outcome. Surgical decompression and stabilisation of the injured cervical spine is an established strategy for managing TCCS, however not all patients require surgery in the acute stages or at all.

Rationale for the Study

The optimal management strategy for Traumatic Central Cord Syndrome is not clearly defined within current surgical literature. The salient clinical features have been described for some time already [6], however no clear prognostic indicators have been identified to assist in making management decisions. Several previous studies have suggested that early surgical intervention improves patient outcome [7-15], however there is little consensus regarding patient selection and timing for surgery. The hope of this study is to identify useful clinical guidelines that assist in decision making and positively influence patient outcome.

Hypothesis

Patients that present to hospital following an acute spinal cord injury consistent with a traumatic central cord syndrome may benefit from a structured and clinically guided treatment strategy.

Methods

1. Study design

A retrospective folder review was performed of patients who presented to the ASCI unit at Groote Schuur Hospital over the five-year period from January 2004 to December 2008.

2. Subject identification or selection

A systematic review of the regional acute spinal cord injury (ASCI) register was performed and a list of patient names was generated based on information available in

the patients' discharge summaries. All patients who presented to Groote Schuur Hospital (GSH) with a history consistent with having sustained a hyperextension type injury of the cervical spine and with a neurological deficit suggesting a central cord syndrome were included. Any patient who sustained an injury to the cervical spine that resulted in gross disruption of the bony architecture was excluded. These included vertebral body fractures with collapse, displaced pedicle fractures, facet joint fractures and / or dislocations and displaced lamina fractures.

3. Data collection

An electronic spreadsheet was designed for capture and collation of data collected from the ASCI register, patient folders, CT scans and MRI scans.

List of variables

- Demographic and epidemiological data: age, gender, employment status, smoking history, alcohol history, mode of injury and previous surgery or myelopathy.
- Pathology and clinical data: date of admission, duration of admission, level and severity of neurological injury and clinical course following injury.
- Imaging data: spinal column characteristics, spinal canal parameters, anatomical level of injury and associated injury phenomena.
- Management data: management strategy, timing of surgical intervention, nature of surgical intervention and occurrence of surgical or general complications.
- Outcome data: clinical progression, duration of hospital stay, discharge destinations, employment prognosis and mortality.

4. Analysis

All data were reviewed by the principal investigator and supervisor before being statistically analyzed.

Ethics and Communication

The protocol for this study was presented to the Surgical Departmental Research Committee for approval, following which it was forwarded to the Human Research Ethics Committee with a copy of the synopsis for approval. The process of data collection and collation commenced as soon as the approval had been granted.

The clinical records of the patients identified on the Acute Spinal Cord Injury (ASCI) register were requested from the medical records department for review and analysis. The patient folders were reviewed in the medical records department and neurosurgical department in order to prevent the loss of documents and to maintain strict patient confidentiality. X-rays, CT scans and MRI scans were procured from the relevant storage facilities and signed out in accordance to departmental policies. The examination of radiological imaging required the use of light boards and computer based viewing software, and was carried out in the neurosurgical department using secured premises and apparatus. The imaging was returned to the radiology records department as soon as the review process was concluded. The collated data was recorded by electronic data sheet.

Patient confidentiality was, and will continued to be, maintained by following a strict protocol. The patient data was entered into a single computer within as short a time period as possible. The computer and research data file is secured by a password that is only know to the principal investigator. The patients' names and confidential information will not be used for publication purposes.

The results of the study will be submitted to a peer review journal for consideration for publication and will be the basis of the accompanying MMed dissertation.

Logistics

This retrospective study was carried out during the normal working hours of the principal investigator, including one month of research allocated time, and after hours. There was no funding allocated for this study.

Part B: Literature Review

Traumatic Central Cord Syndrome (TCCS)

1. Objective
2. Search Strategy
3. Definition
4. History
5. Pathology
6. Imaging
7. Classification and Grading
8. Management
9. Outcome

Objective

The objective of this literature review was to establish the consensus opinion of the research topic regarding the definition, incidence, clinical assessment and grading, management protocols and outcome measures. Although Traumatic Central Cord Syndrome (TCCS) has been recognised and treated for more than 50 years, several key issues are not well defined and clear management guidelines are lacking. With this literature review we hoped to identify these areas and formulate useful questions upon which to base the research protocol.

Search Strategy

A primary literature search of electronic internet databases was carried out, spanning the period 01/01/2000 to 31/12/2012, using the following key phrases:

- Traumatic central cord syndrome
- Central cord injury
- Cervical spine hyperextension injury

Two hundred and twenty six articles were identified using the above criteria, but this number was subsequently reduced to 41 following a review of the abstracts. A secondary search was performed using articles listed in the references of the articles captured with the initial search strategy. The literature reviewed consisted of previous reviews of the topic and series reports.

Definition

Traumatic Central Cord Syndrome occurs almost exclusively in the cervical region and is the most commonly encountered type of incomplete spinal cord injury [1,2], accounting for 45-70% of incomplete and 10-25% of all clinical syndromes following traumatic spinal cord injury [2-4]. TCCS is primarily a clinical diagnosis following a likely injury mechanism that can be strengthened further using appropriate diagnostic imaging modalities. Patients usually present with a combination of motor and sensory deficits. The upper extremities are disproportionately weaker than the lower extremities. Variable sensory loss occurs below the level of the injury. Patients may also have bladder dysfunction, usually urinary retention [6,16,17].

TCCS typically occurs in three distinct patient groups [18]. The majority of patients are older than 50 years of age, have advanced degenerative spondylosis of the cervical spine with an associated narrowing of the spinal canal, and sustain a relatively minor hyperextension type of injury without bony fracture [9,16,18-28]. The second group comprises a younger patient population, with a normal cervical spine, and suffers a high-energy type injury. These patients often sustain a fracture and / or dislocation of

the cervical spine [29,30]. The final and most recently described sub-group present with TCCS as a result of acute central cervical disc herniation [21,31].

History

Sir William Thorburn, Consulting Surgeon at the Manchester Royal Infirmary, first reported the phenomenon in 1887 [32]. In an article published in the journal *Brain*, Thorburn describes it as a "case of 'concussion of the spine' in which spinal cord symptoms supervened on a remote injury, a general shake, or a slight local injury".

In the early 1950's Richard C. Schneider and colleagues defined the clinical syndrome through a series of publications identifying the salient clinical features and discussing the indications and contra-indications for surgical intervention [6]. They described the syndrome of acute central cervical spinal cord injury as:

> "In acute cervical spinal cord injuries, there is a syndrome that suggests acute central cervical spinal cord involvement. It is characterised by disproportionately more motor impairment of the upper than the lower extremities, by bladder dysfunction, usually by urinary retention, and by varying degrees of sensory loss below the level of the lesion. If the findings are caused by central cord destruction with bleeding, hematomyelia, there may be caudad or cephalad extension of the lesion with further progression of symptoms, perhaps culminating in complete tetraplegia or death. But if the symptoms are caused by concussion or contusion, with an edematous type of central cord involvement, there may be gradual return of function in a definite sequence. The amount of recovery depends on the degree of edema present compared to the extent of true destruction of nervous tissue. The lower extremities recover motor power first, bladder function returns next, and finally strength in the upper extremities reappears, with the finer finger movements coming back last. The varying degrees of sensory impairment do not follow any set pattern of recovery."

Taylor and Blackwood of the Department of Surgical Neurology, Brain Injuries Unit, Bangour Hospital illustrated the correlation between cervical spine injuries in patients with normal radiographs and hyperextension injuries as early as 1948 [33], noting in particular that suspicion should be heightened in the presence of facial lacerations or

forehead contusions.

Pathology

Several investigators have demonstrated the biomechanical mechanisms of spinal cord injury in hyperextension injuries. As early as 1951 Taylor performed cadaveric myelography in specimens of varying ages [19]. He performed radiographs with the neck in flexion, neutral position and forced hyperextension and noted a distinct narrowing of the contrast column with the cervical spine in hyperextension. This narrowing was attributed to the compression and bulging of the ligamentum flavum with consequent impingement on the thecal sac. Taylor also noted that anteriorly located disc-osteophyte complexes found in degenerative cervical spines further reduced the cervical canal diameter and acted as points of counter pressure against which the spinal cord was compressed.

The pathological basis for TCCS is less clear-cut. The traditional explanation was based on the supposition that the anatomical distribution of the fibre tracts supplying the upper limbs are located more centrally, and therefore more severely compromised by a centrally located spinal cord contusion or haematoma, whereas the more peripherally situated fibres supplying the lower limbs remain relatively intact [6]. Schneider used the same theory in an attempt to explain the pattern of recovery and resultant residual neurological deficit. He postulated that an area of cord oedema surrounded the central zone of spinal cord destruction. As the oedema resolved with the passage of time the functional integrity of the more peripherally located fibres improved, thereby facilitating the sequential improvement of the lower limbs, bladder, arms and finally the hands.

Another theory, also proposed by Schneider, implicated vertebral artery insufficiency secondary to direct compression. The resultant ischaemic damage to the spinal cord was suggested as an alternate aetiology for acute neurological injury [20].

More recent evidence suggests that the aforementioned explanations are flawed. The corticospinal tract appears to lose its somatotopic organisation distal to the midbrain [34]. Quencer and colleagues correlated magnetic resonance imaging (MRI) findings

with post-mortem histopathological studies of individuals who had sustained central cord type injuries [35]. Not only were the MRI findings inconsistent with a centrally located parenchymal insult, but they also found a predominance of axonal injury within the white matter of the lateral columns of the cervical cord and that the centrally located grey matter was intact. Improvements in medical imaging technology, particularly MRI and MRI angiography, appear to contradict a vascular aetiology for TCCS [36,37]. Collectively, this suggests that the importance of the lateral corticospinal tracts for motor function in the distal upper limbs and hands and that direct injury is more likely responsible for the clinical syndrome encountered with these injuries [35-38].

Imaging

Although the diagnosis of TCCS is fundamentally a clinical diagnosis, medical imaging plays an important role in confirming the diagnosis, describing the anatomical level and extent of the injury, identifying any associated pathology and assisting in planning appropriate management strategies.

Recommended radiographic examination includes the standard emergency room series of antero-posterior, lateral and odontoid view x-rays of the cervical spine [36]. This imaging series may show prevertebral soft tissue swelling, loss of intervertebral disc height, vertebral fractures or dislocations, alterations in vertebral alignment or widening of posterior inter-spinous distances - all of which may indicate an acute cervical spine injury with possible instability. Important pre-existing characteristics may also be clearly demonstrated, including degenerative changes, osteophytes and a stenotic cervical spinal canal - all of which would predispose the patient to sustaining TCCS [37]. Plain radiographs may appear normal, but this does not exclude an injury to the cervical spinal cord [39,40].

Computer tomography (CT) scanning as a modality is gaining increasing popularity for the imaging of traumatic cervical spine injured patients. Improved image quality, reduced scanning times & the ability to digitally reconstruct images in any anatomical plane provides significant advantage over older generation CT scanners and plain

radiographic imaging [41,42]. All of the aforementioned parameters can be easily and more accurately assessed, findings can be digitally recorded, and images can be manipulated and utilised for surgical planning. Surgical intervention can also be augmented with the integration of pre-operative and intra-operative images for improved surgical navigation and instrumentation.

Magnetic resonance imaging (MRI) is the most useful imaging modality for the assessment of TCCS, as with most traumatic spinal cord injuries [36,42]. Utilising the various imaging sequences afforded by MRI can assist with identifying or confirming the mechanism of injury, identify injury to adjacent muscles and ligaments, provide a clinically useful indication of spinal integrity or instability [39,43], as well as identifying and quantifying the spinal cord injury [21,37]. Certain specific imaging characteristics have been shown to particularly useful. Signal hyperintensity within the prevertebral soft tissue on either T2-weighted or STIR image sequences are indicative of muscle and ligament disruption anterior to the vertebral column and correlates with intraoperative findings of damage to the anterior longitudinal ligament (ALL) [21]. The most common finding within the spinal cord is hyperintensity on a T2-weighted image sequence. This intramedullary high signal intensity identifies the anatomical level of the injury and represents either oedema of the spinal cord or microcystic degeneration and subsequent vacuolation. There is also a correlation between site of spinal instability and location of intramedullary high signal intensity [21,42].

Classification and Grading

Spinal cord injuries can be classified in a number of ways, including severity of injury, pattern of injury and level of injury.

The severity of the injury ranges from a complete motor-sensory deficit, through a range of incomplete deficits with varying degrees of motor-sensory preservation, to no discernable deficit. TCCS is usually graded clinically according to either the American Spinal Injury Association (ASIA) Impairment Scale or the Frankel grading systems. The ASIA classification, derived from the Frankel scale, was first published

as the International Standards for Neurological and Functional Classification of Spinal Cord Injury [44-47]. The patient is graded according to the motor and sensory

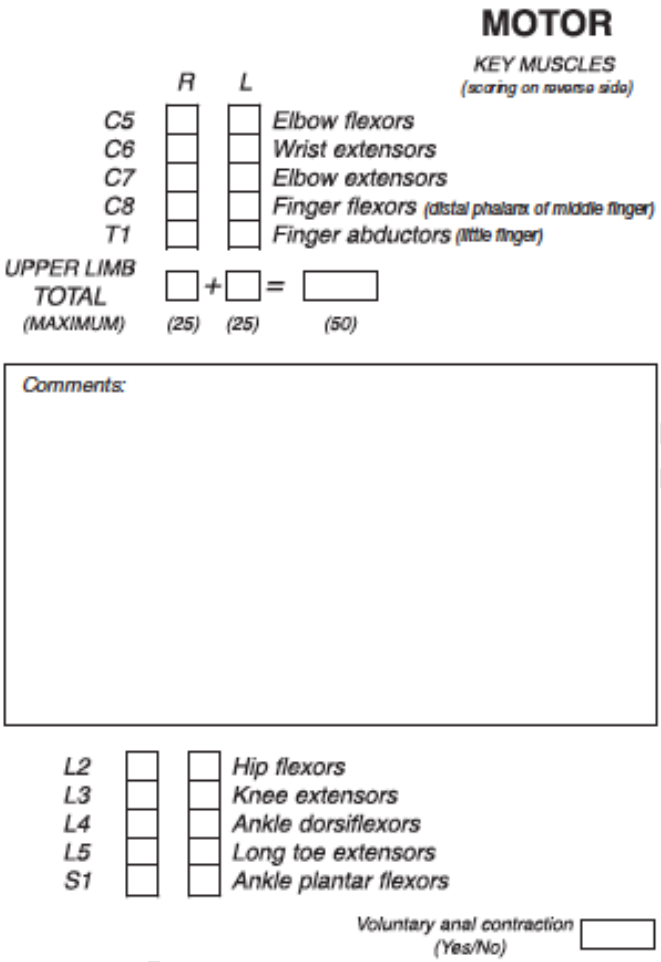

Figure 1: Key motor groups and corresponding myotomes used in the ASIA Standard Neurological Classification of Spinal Cord Injury examination sheet

Grade	Muscle Action
0	Total paralysis
1	Palpable or visible contraction
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against moderate resistance
5	Active movement with full / normal power
NT	Not tested

Table 1: Muscle power grading used for the ASIA Standard Neurological Classification of Spinal Cord Injury examination sheet

scores measured in key muscles and sensory points. A pro-forma score sheet, published as the ASIA Standard Neurological Classification of Spinal Cord Injury examination template, is freely available with no restrictions regarding reproduction for clinical use (see appendix). The results are tabulated, calculated and converted into a scale from A to E according to severity.

ASIA Impairment Scale	
A = Complete:	No motor or sensory function is preserved in the sacral segments S4-S5.
B = Incomplete:	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
C = Incomplete:	Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
D = Incomplete:	Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
E = Normal:	Motor and sensory function are normal.

Table 2: ASIA Impairment Scale

The Frankel grade is similar to the ASIA scale, but reflects functional status rather than muscle power [48]. This distinction is particularly useful in grading TCCS as patients often have muscle power of 3 or more, but function may be significantly compromised by spasticity [2,22,49].

Frankel Grading System	
A	Complete neurological injury, no motor or sensory function below level of injury
B	Incomplete neurological injury, no motor function below level of injury, some sensory function below level of injury
C	Incomplete neurological injury, some motor function below level of injury, but not functional, sensation may or may not be preserved
D	Incomplete neurological injury, some motor function below level of injury, functional in nature, sensation may or may not be preserved
E	Normal motor and sensory function below level of injury

Table 3: Frankel Grading System

The level of the injury is usually described according to its anatomical, or structural, level as well as according to its neurological level. The anatomical level is determined using diagnostic imaging techniques such as CT and MRI [21,36,39,42,43]. There may be a discrepancy between the anatomical level and the neurological level of a number of spinal cord segments. The neurological level is further broken down into a motor level and a sensory level. The motor level refers to the most caudal myotome with full power. Key muscle groups, each representing one of ten myotomes, are tested in order to establish the level of the motor deficit.

The sensory level is determined by the most caudal of the body's twenty-eight dermatome with normal sensation. The ASIA Standard Neurological Classification of Spinal Cord Injury examination sheet requires testing for pinprick and light touch as a surrogate for normal sensory function. There is often a zone of partial preservation (ZPP) spanning several spinal cord segments where sensation is not completely absent, but also not normal. There may also be a difference in both motor and sensory level determinations between the right and left side of the body.

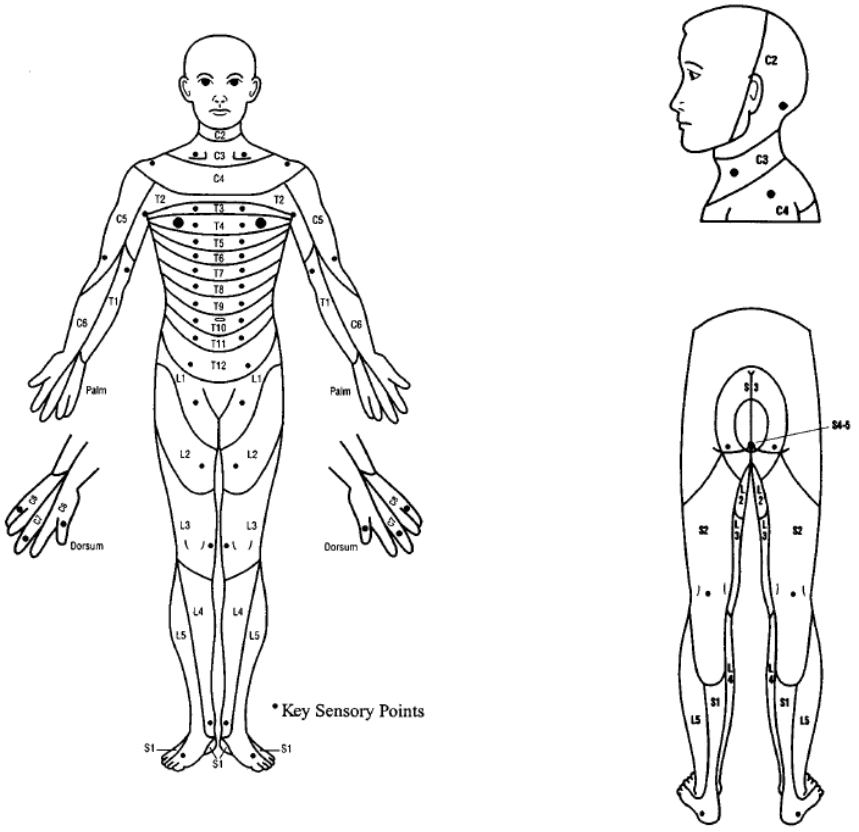

Figure 2: Schematic representation of sensory dermatomes as represented on the ASIA Standard Neurological Classification of Spinal Cord Injury examination sheet

Management

The management of TCCS remains controversial. There is no doubt that surgical techniques and safety have improved tremendously since Schneider advocated a conservative treatment strategy [6] and most clinicians involved in the management of TCCS agree that surgical decompression and stabilisation play an integral role, but there remains much debate around the timing and nature of the surgical intervention [4,9,12-15,18,22-26,28,36,50-60]. Several management options are implemented in specialist spine centres worldwide.

The non-operative management of patients with TCCS is an established treatment strategy, particularly in the scenario of improving neurological function [29]. Many patients present with an acutely injured, swollen cervical spinal cord encased within a multi-level degenerate stenotic spinal canal [61]. In addition, a significant portion of the typical patient population is older than 50 years of age [18] and may have problematic medical comorbidities. To justify the added potential morbidity and mortality of surgical intervention requires evidence of clear clinical benefit. During the evolution of management practice a number of surgeons suggested a delayed approach, allowing the patient to attain a plateau phase of neurological recovery before deciding on the need for surgery [62,63]. This period of waiting also facilitates the optimisation of the patient's general medical condition and the management of comorbidities. The duration of the waiting period is not defined beyond the observation that the patient's neurological status has ceased to improve. Improvements in general patient care, anaesthetic practices and rehabilitative medicine are shortening this time interval and surgical intervention is occurring sooner. The evidence reviewed by Fehlings and colleagues [8,10-15] supported surgery within 72 hours of injury, provided the patient was haemodynamically stable. Data have also shown that if operated on within 24 hours of injury there is a trend towards improved neurological status, a shorter ICU stay, a reduced incidence of associated complications and patients were discharged from hospital sooner [11,12,14,15,18,56,57].

Surgical intervention is widely accepted as the standard of care in patients who present with worsening neurological deficit and radiological evidence of spinal cord compression and this is applied in the setting of TCCS [28,58]. Surgical reduction and

stabilisation of fractures and dislocations occurring in conjunction with TCCS is also an established management strategy [28,56,62].

Outcomes

Determining and grading patient outcomes in TCCS is a complex and somewhat imprecise process [22,49]. There is no outcome measure specific for TCCS, however a number of general spinal injury outcome measures can be used, either in isolation or in combination [22,49,56]. Repeat assessment using a previously utilised clinical grading score can provide an indication of how a patient's neurological function is progressing, or not. Both the ASIA Impairment Scale and the Frankel grading system are useful for this purpose [64]. Using the motor assessment component of the ASIA Impairment Scale, or ASIA Motor Score (AMS), helps identify trends of improvement specific to muscle strength. The general clinical trend is that of progressive neurological recovery with sequential improvement of lower limb function, followed by bladder function, and to a lesser degree improvement of upper limb function. The fine motor functions of the hands are the last feature of recovery, but are often a late finding if at all. Improvement in muscle strength is a hallmark of TCCS, but the degree of function achieved is often severely tempered by the increased muscle tone and overt spasticity of the major muscle groups [2,22,49]. In order to better quantify the specific components of each patient's recovery or rehabilitation, the Functional Independence Measure (FIM) [65] (see appendix) has been used [22,23,56,65]. The FIM scoring system is useful for quantifying a patient's functional abilities and repeat assessments at pre-determined intervals provides an in-depth analysis of both clinical and functional improvement as well as identifying further rehabilitative requirements.

Part C: Manuscript

Hyperextension Injury of the Cervical Spine with Central Cord Syndrome

Crispin Thompson
Registrar, Division of Neurosurgery,
Faculty of Health Sciences,
University of Cape Town,
H53 Old Main Building,
Groote Schuur Hospital,
Main Road Observatory, 7295,
Cape Town,
South Africa
+27214066213 (tel)
+27828986561 (cell)
+27214066555 (fax)
crispin@sai.co.za

David Welsh
Consultant, Division of Neurosurgery,
Faculty of Health Sciences,
University of Cape Town,
H53 Old Main Building,
Groote Schuur Hospital,
Main Road Observatory, 7295,
Cape Town,
South Africa
+27214066213 (tel)
+27214066555 (fax)
capespine@gmail.com

Abstract

Objective Traumatic Central Cord Syndrome (TCCS) is the most commonly encountered type of incomplete spinal cord injury. TCCS typically occurs in patients over the age of 50 years with a narrow spinal canal and follows an acute hyperextension injury of the cervical spine. Our objectives included the reporting of the demographics of the injured patients, their clinical course and outcomes, and the factors that may have influenced these outcomes.

Methods We conducted a retrospective folder review of patients who presented to our facility between January 2004 and December 2008 following hyperextension injury of the cervical spine and with the clinical manifestations of a central cord syndrome. Patient details were obtained from the acute spinal cord injury register at Groote Schuur Hospital and the patient folders, radiographs and magnetic resonance imaging films were reviewed. Predetermined data points were identified, tabulated and analysed, with only information from the injury related admission being included.

Results An ASIA motor score of ≥60 on admission or discharge correlated with an 80% chance of being able to walk at discharge from hospital. An ASIA motor score of ≤50 on admission correlated with an 80% chance of not walking at discharge. An ASIA motor score of ≤ 50 at discharge meant a patient was not only unable to walk, but required placement in a spinal injury rehabilitation centre. Further, if a patient had a cervical spinal canal diameter of ≥8mm they had a 50% chance of clinical improvement and nearly 80% chance of a functional outcome.

Conclusion The Groote Schuur Hospital patient population differs from the international norm, particularly with respect to age and mechanism of injury. The ASIA motor score and cervical spine canal diameter proved to be useful predictors of outcome. Within our patient group timing of surgery did not appear to influence outcome.

Keywords: *Traumatic Central Cord Syndrome · Cervical spine hyperextension injury · Central cord injury*

Introduction

Traumatic Central Cord Syndrome (TCCS) is the most commonly encountered type of incomplete spinal cord injury [1-4]. Sir William Thorburn first reported the phenomenon in 1887 in an article published in *Brain* [4]. In the early 1950's Richard C. Schneider and colleagues further defined the clinical syndrome through a series of publications identifying the salient clinical features and discussing the indications and contra-indications for surgical intervention [6]. Several investigators have demonstrated the biomechanical mechanisms of spinal cord injury in hyperextension injuries. As early as 1951 Taylor performed cadaveric myelography in specimens of varying ages, examined radiographs with the neck in various positions and noted a distinct narrowing of the contrast column with the cervical spine in hyperextension [19]. This narrowing was attributed to the compression and bulging of the ligamentum flavum with consequent impingement on the thecal sac. Taylor also noted that anteriorly located disc-osteophyte complexes found in degenerative cervical spines further reduced the cervical canal diameter and acted as points of counter pressure against which the spinal cord was compressed.

The pathological basis for central cord syndrome is less clear-cut. The traditional explanation was based on the anatomical distribution of corticospinal tract fibres supplying the upper limbs being located more centrally, and therefore more severely compromised by a centrally located spinal cord contusion or haematoma, whereas the more peripherally situated fibres supplying the lower limbs remain relatively intact [6]. More recent evidence suggests that the aforementioned explanation is flawed. The corticospinal tract appears to lose its somatotopic organisation distal to the midbrain [34]. Quencer and colleagues correlated magnetic resonance imaging (MRI) findings with post-mortem histopathological studies of individuals who had sustained central cord type injuries [35]. Not only were the MRI findings inconsistent with a centrally located parenchymal insult, but they also found a predominance of axonal injury within the white matter of the lateral columns of the cervical cord and that the centrally located grey matter was intact. Collectively, this suggests that the importance of the lateral corticospinal tracts for motor function in the distal upper limbs and hands and that direct injury is more likely responsible for the clinical syndrome encountered with these injuries.

Much discussion and disagreement centres on the surgical management of central cord syndrome [4,6,9,12-15,18,22-26,28,36,50-60]. Few fixed indications for surgical intervention are unanimous, however current consensus agrees that there is an established role for surgery. There is further debate as to whether timing of surgery changes the likelihood of improved neurological outcome. Evidence has been presented to support surgical intervention within 24-72 hours of injury [9-15], particularly for patients with vertebral fractures or dislocations, unstable injuries or intervertebral disc herniation [23,51]. Others contend that it is better to delay surgery until the patient reaches a plateau phase of neurological improvement [62,63]. There is more agreement amongst treating surgeons regarding the goals and nature of surgical intervention.

Patients and Methods

Nine hundred and fifty one patients were admitted to the regional acute spinal cord injury (ASCI) unit at Groote Schuur Hospital between January 2004 and December 2008. A systematic review of the ASCI register was performed and a list of patient names was generated based on information available in the patients' discharge summaries. All patients with a history consistent with having sustained a hyperextension type injury of the cervical spine and with a neurological deficit suggesting a central cord syndrome were included. Any patient who sustained an injury to the cervical spine that resulted in gross disruption of the bony architecture was excluded. These included vertebral body fractures with collapse, displaced pedicle fractures, facet joint fractures and / or dislocations and displaced lamina fractures.

Thereafter the patient notes were reviewed for the injury related admission period. A predetermined list of data points were collected from the folders using doctors admission clerking notes, in-patient notes, radiology reports, surgeons' operation notes where applicable, nursing notes, physiotherapy notes and doctor's discharge summaries. Data of interest included limited patient demographics, epidemiological data, information regarding injury mechanism, level of spinal and neurological injury, extent of neurological injury, associated cervical spine injuries and pathologies,

admission and discharge ASIA (American Spinal Injury Association) Impairment Scale [44-47] and Frankel [48] grading, admission and discharge ASIA motor scores, radiological characteristics of the injury, clinical course, presence and nature of surgical intervention, any injury related complications, and limited discharge information. The information was collected using a secure electronic database program.

Frankel Grading System	
A	Complete neurological injury, no motor or sensory function below level of injury
B	Incomplete neurological injury, no motor function below level of injury, some sensory function below level of injury
C	Incomplete neurological injury, some motor function below level of injury, but not functional, sensation may or may not be preserved
D	Incomplete neurological injury, some motor function below level of injury, functional in nature, sensation may or may not be preserved
E	Normal motor and sensory function below level of injury

Table 1: Frankel Grading System

ASIA Impairment Scale	
A = Complete:	No motor or sensory function is preserved in the sacral segments S4-S5.
B = Incomplete:	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
C = Incomplete:	Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
D = Incomplete:	Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
E = Normal:	Motor and sensory function are normal.

Table 2: ASIA Impairment Scale

X-ray and magnetic resonance imaging (MRI) films of the relevant patients were reviewed for any previously overlooked exclusion criteria, evidence of associated soft tissue injury, the presence of acute cervical disc injuries, degenerative changes and any pre-existing cervical spine pathology. Cervical canal diameter was measured on the MRI film using a wall mounted light box, at the level of maximal narrowing

corresponding to the neurological injury, on the closest to midline sagittal slice on a T2 weighted image using the provided scale conversion. Accuracy was checked using digital measuring techniques on a DICOM viewing system and was found to be to within 0.5 millimetres.

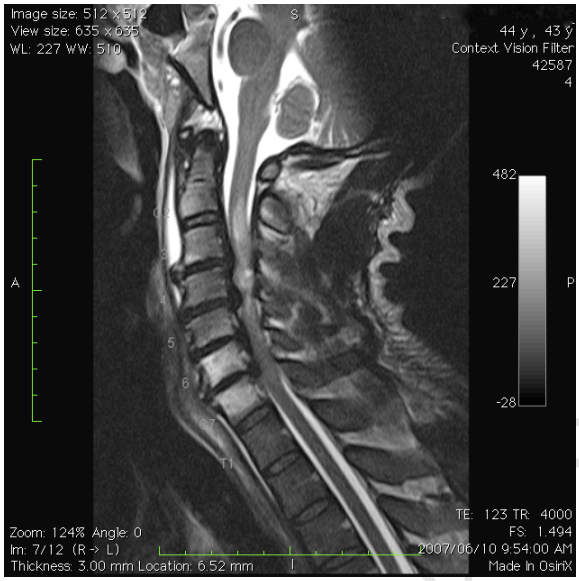

Figure 1: T2 weighted MR image showing a prevertebral fluid collection, oedema of the C6 & C7 vertebral bodies, spondylotic stenosis of the cervical spinal canal from C3-7, disc-osteophyte complexes, with compression of the spinal cord and resultant oedema

Incomplete patient records and imaging further excluded 152 patients. A total of 50 patients and 51 admission episodes were accumulated, with one patient sustaining two central cord type injuries within the period covered. The collected data were tabulated and interrogated by the principal investigator and supervisor in order to identify any useful trends. The data were analysed using SPSS software (version 19.0, SPSS Incorporated, Chicago, Illinois, USA). Chi-squared analysis was used to assess the relationship between cervical canal measurements and the likelihood of requiring surgical intervention, the likelihood of clinical improvement and the likelihood of achieving a functional outcome grade. Chi-squared analysis was used to assess the relationship between patient age and the likelihood of requiring surgical intervention. Significance was set at a *P value* of <0.05.

Results

The selected patient population of 51 admission episodes comprised 42 males and 9 females. The age range was 13-72 years, with a mean age of 41.4 years and a median age of 42.5 years. The scenario of a low energy frontal impact to the head resulting in hyperextension and spinal cord compromise was seen in a relatively small percentage of our patients. A much greater number of high-energy injuries were recorded, including motor vehicle accidents, major falls, violent assault and heavy blunt trauma.

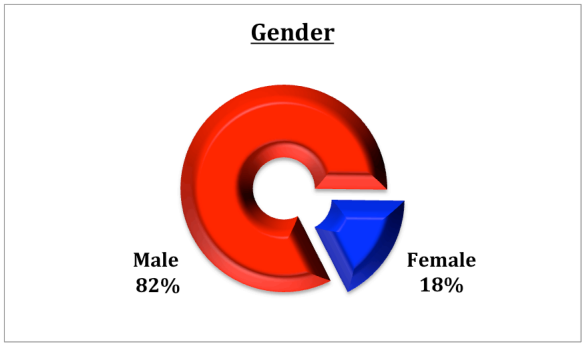

Figure 2: Cohort gender division

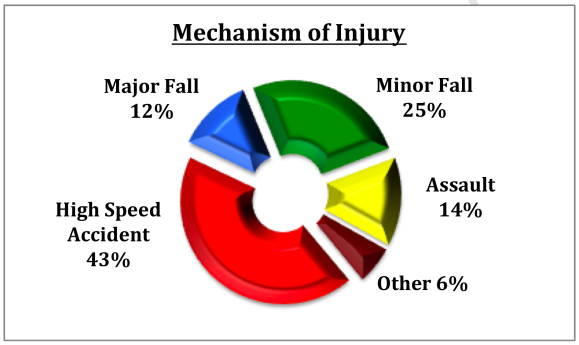

Figure 3: Mechanism of injury

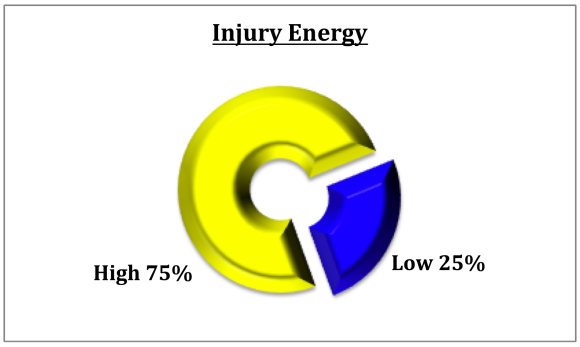

Figure 4: Energy of injury

Only one patient gave a history of pre-existing myelopathy and one patient had undergone previous cervical spine surgery. Twenty eight individuals were employed at the time of their injury, 34 smoked on a regular basis and only 3 admitted that alcohol consumption may have played a role in sustaining the injury.

Eight patients presented with a motor-sensory complete spinal cord injury, whilst the remaining 43 had an incomplete deficit. The admission neurological status of the patients was scored according to both the ASIA Impairment Scale and Frankel Grading System. A discharge Frankel grade of D or E was regarded as a functional outcome for this study.

The most common vertebral level of injury was at the C3/4 disc space (n=16). The most common neurological level was C4 (n=26), followed by C5 (n=13). Despite the high incidence of high cervical cord injury, no patient was dependent on a ventilator for respiration.

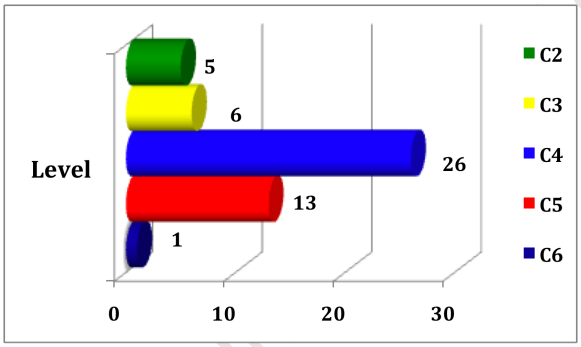

Figure 5: Neurological level of injury

The admission and discharge grading scores were compared in order to identify the sub-group of patients most likely to improve or benefit from more aggressive management strategies. Notable changes in Frankel grading included two patients improving from A to B and A to C respectively, two patients improving from B to C and B to E respectively, and a further five patients improving to an E grading, two from a C grade and three from a D grade. The greatest degree of improvement was primarily from Frankel grades C and D to grades D and E. None of the patients deteriorated to a worse grade on either scoring system. ASIA motor scores were recorded on both admission and on discharge. An admission ASIA motor score of 50

or less implied an 80% chance of not being able to walk by discharge and a score of 60 or more on admission or discharge implied an 80% chance of being independently mobile. A discharge ASIA motor score of 50 or less had a 0% prevalence of walking or being discharged home in our patient series.

Neurological Status	ASIA		Frankel	
	Admission	Discharge	Admission	Discharge
A	8	6	8	6
B	4	3	4	3
C	15	8	24	10
D	23	27	14	25
E	1	7	1	7

Table 3: Comparison of admission and discharge neurological status

We reviewed the MRI images in order to identify any pre-existing abnormalities, as there is a well-described association between an underlying cervical spine pathology, particularly stenosis, and TCCS in the elderly population [9,16,18-28]. Within our patient group the overall incidence of normal cervical spines was 47%, whereas 39% had stenosis of the cervical canal, 12% had a pre-existing autofusion and one patient had ossified posterior longitudinal ligament. The level of neurological injury correlated predictably with the level of vertebral pathology. Over 80% of patients under 40 years had normal cervical spine architecture, with only four patients having a stenotic cervical canal. Of the patients older than 40 years, 79% of individuals had clear radiological evidence of pre-existing pathology.

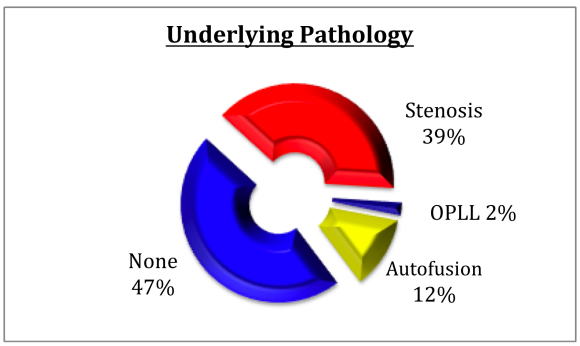

Figure 6: Prevalence of pre-existing structural cervical spine anomaly

On MRI we measured both mid-sagittal canal and cord diameter at the level of maximum compromise and at the next normal level above and below the injury. The average canal and cord diameters at normal levels were 11,3±1.6mm and 7.1±1mm respectively. We looked at clinical improvement and function, based on admission and discharge Frankel grades, with a canal diameter <8mm and ≥8mm (chosen to accommodate average cord diameter + 1SD). Those patients with a canal diameter of ≥8mm had a statistically significant chance of not requiring surgery (*P value* 0,00005) and of achieving a functional outcome (*P value* 0,02030). The correlation between canal diameter and clinical improvement did not achieve statistical significance (*P value* 0,45735)

Canal diameter at Level of Injury	Surgery		Improved Clinically		Functional Outcome	
	Yes	No	Yes	No	Yes	No
<8mm (53%)	25 (93%)	2 (7%)	10 (37%)	17 (63%)	13 (48%)	14 (52%)
≥8mm (47%)	6 (25%)	18 (75%)	12 (50%)	12 (50%)	19 (79%)	5 (21%)

Table 4: Comparison of mid-saggital cervical spine canal diameter in relation to surgery and outcome

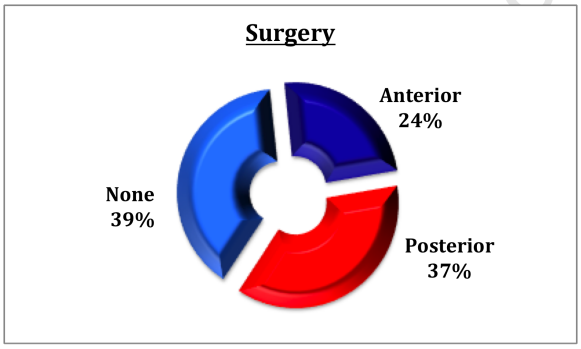

Figure 7: Surgical approaches

Thirty one patients underwent surgery for the management of the injury. Twelve patients were operated on via an anterior approach, the primary indication being discectomy and fusion, and 19 patients had a decompressive laminectomy via a posterior approach, with or without fusion. Time from injury to operation ranged from 1 to 108 days, with a median interval of 11 days. Twenty patients were managed non-operatively. Only one of the patients in our series had early surgical intervention (within 24 hours of injury), improved from a Frankel grade C to grade D, was walking at the time of discharge and was able to go home. Seventeen patients had surgery

within two weeks of their injury, 8 improved at least one Frankel grade and 9 did not improve. Thirteen patients were operated on more than two weeks after sustaining their injury, 4 improved at least one Frankel grade and 9 did not improve. Four patients were operated on more than 30 days following injury and none improved clinically. Ten of the patients managed non-surgically improved at least one Frankel grade and 10 did not improve. A functional outcome was documented in 17 out of 31 surgically managed patients and 15 out of 20 non-surgically managed patients. One of the patients managed non-surgically was discharged with a Frankel grade D deficit and an ASIA motor score of 95, but sustained a second low energy injury seven months later and returned with a Frankel grade C and ASIA motor score of 25. On discharge from the second admission, following a decompressive laminectomy, he had a Frankel grade C deficit, an ASIA motor score of 48 and was unable to walk. The only surgical complication encountered was one superficial wound infection.

Management vs Outcome	Total	Improvement	No Improvement	Functional	Non-Functional
Surgical (≤ 24 hours)	1	1	0	1	0
Surgical (≤ 14 days)	17	8	9	9	8
Surgical (> 14 days)	13	4	9	7	6
Non-surgical	20	10	10	15	5

Table 5: Relationship between surgical intervention, clinical improvement and outcome

At discharge from our ASCI unit 51% of patients were able to mobilise independently or with the aid of a walking frame, 37% of patients were able to return home directly, and 14% of the previously employed individuals were able to return to work. The clinical and functional performance of the patients was only assessed on admission and again on discharge from our hospital, therefore the length of follow-up is short and further changes in functional performance are not accounted for. Only one patient died during the injury related admission.

Patient age of 40 years or less was shown to be a reliable indicator of not requiring surgery, and vice versa (P value 0,00005).

Age vs Management	**Surgical**	**Conservative**
≤ 40 years (43%)	6 (27%)	16 (73%)
> 40 years (57%)	25 (86%)	4 (14%)

Table 6: Relationship between patient age and management strategy

Discussion

The age demographic of our patient cohort varies significantly from the typical elderly male patient population described in the literature [9,16,18-28]. This may be explained, at least in part, by the second noticeable difference. The injury sustained by our patients more often involved a greater force than is typically described. This might result in fewer elderly patients surviving the initial insult as well as younger patients, with structurally normal cervical spine canals, injuring their spinal cords and exhibiting an equivalent neurological deficit.

The measurement of the mid-sagittal cervical canal diameter, at the level of the injury, was performed in order to identify a predictor of outcome. The postulate supposed that if there was sufficient canal volume to accommodate a swollen spinal cord, and allow for spontaneous recovery, then surgery might be avoided. We grouped our patients according to a canal diameter of <8mm and ≥8mm. The dimension was chosen to coincide with the mean cervical spinal cord diameter plus one standard deviation. Patients with a canal diameter ≥8mm had a much lower likelihood of requiring surgery, showed an increased prevalence of clinical improvement and experienced a greater percentage of functional outcome.

Our ASCI unit receives the bulk of its referrals from centres that do not offer any surgical management prior to transfer. This, coupled with resource and logistical restraints within our hospital, precludes the vast majority of patients from undergoing surgery within 24 hours of sustaining their injury. The clinical and functional performance of the patients was assessed on admission and again on discharge from our hospital, therefore the length of follow-up is short and further changes in functional performance are not accounted for. The single patient that was operated on within 24 hours experienced both a neurological and a functional improvement in keeping with the suggestions that early surgery is preferable [8-15]. 47% of patients improved clinically following surgery within two weeks of injury as opposed to 30% operated on after two weeks. This trend of neurological improvement for the patients operated on within 14 days did not translate into a trend of improved functional outcome. 50% of the patients managed non-surgically showed neurological improvement. The superior rate of functional recovery in the non-surgical group

reflects a potential selection bias for surgery amongst the more severely injured patients. These numbers are neither supportive nor contrary to surgical intervention. We excluded patients who required surgery for injury related structural instability in an attempt to better identify neurological indications for surgery.

We quantified the neurological deficit sustained by our patients using both the ASIA and Frankel scoring systems in order to assess which would better reflect their injury pattern and help guide management decisions. The key differences between the two systems are found in the corresponding sub-groups C and D. The ASIA Impairment Scale classifies patients according to muscle power below the level of injury whereas the Frankel Grading System stratifies patients according to functional use of muscle groups below the level of injury. In our opinion the latter scale may prove more useful in scoring patients with TCCS as they may have power of 3/5 or more in the limbs without functional use of the involved limbs, usually as a result of spasticity [2,22,49].

Conclusion

Patients that present to Groote Schuur Hospital following a traumatic central cord injury are not typically representative of the TCCS population described in the international literature. The first key difference is the age group. Two thirds of our patients were under the age of 50 years, whereas the majority of patients are usually over the age of 50 years. Secondly, three quarters of our patients suffered a high-energy mechanism of injury, rather than the typical low energy mechanism. The admission and discharge ASIA motor scores proved useful for predicting functional outcome. Patient age correlated with whether surgery was required. The mid-sagittal cervical spine canal diameter correlated with the need for surgical intervention and functional status at the time of discharge. We were unable to offer any clarity on the benefits of emergency surgery, however the timing of subsequent surgery did not appear to affect the functional outcome within our group.

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Part D: Appendix

ASIA Standard Neurological Classification of Spinal Cord Injury

FIM scale and guidelines

Data Sheets

Human Research Ethics Committee Approval Letter

Dissertations Committee Approval Letter

MMed Guidelines

Dissertation Guidelines

European Spine Journal Guidelines

Patient Name _____

Examiner Name _____ Date/Time of Exam_____

ASIA American Spinal Injury Association

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCoS

MOTOR

KEY MUSCLES (scoring on reverse side)

	R	L	
C5	☐	☐	Elbow flexors
C6	☐	☐	Wrist extensors
C7	☐	☐	Elbow extensors
C8	☐	☐	Finger flexors (distal phalanx of middle finger)
T1	☐	☐	Finger abductors (little finger)

UPPER LIMB TOTAL (MAXIMUM) ☐ + ☐ = ☐ (25) (25) (50)

Comments:

L2	☐	☐	Hip flexors
L3	☐	☐	Knee extensors
L4	☐	☐	Ankle dorsiflexors
L5	☐	☐	Long toe extensors
S1	☐	☐	Ankle plantar flexors

Voluntary anal contraction (Yes/No) ☐

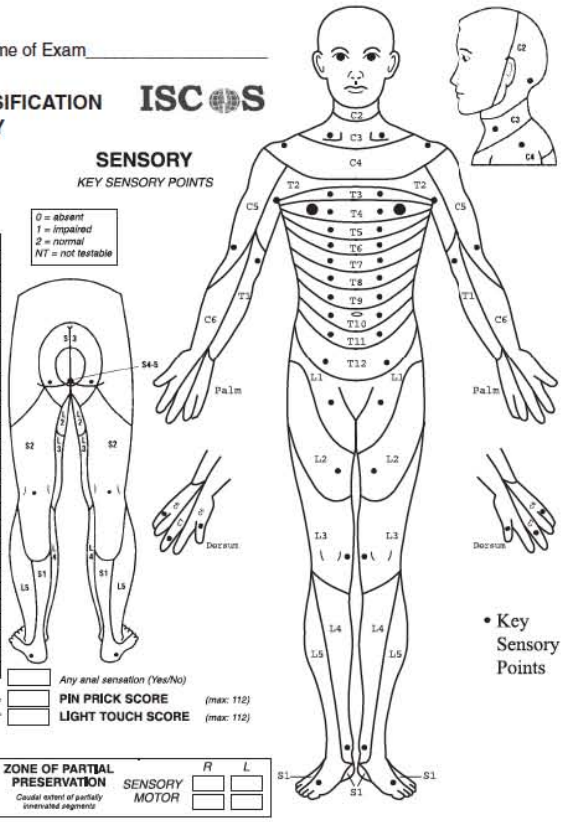
LOWER LIMB TOTAL (MAXIMUM) ☐ + ☐ = ☐ (25) (25) (50)

SENSORY

KEY SENSORY POINTS

	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				
TOTALS (MAXIMUM)	☐ (56)	☐ (56)	☐ (56)	☐ (56)

0 = absent
1 = impaired
2 = normal
NT = not testable



• Key Sensory Points

Any anal sensation (Yes/No) ☐

PIN PRICK SCORE ☐ + ☐ = ☐ (max: 112)

LIGHT TOUCH SCORE ☐ + ☐ = ☐ (max: 112)

NEUROLOGICAL LEVEL (The most caudal segment with normal function)		R	L
	SENSORY	☐	☐
	MOTOR	☐	☐

COMPLETE OR INCOMPLETE? (Incomplete = Any sensory or motor function in S4-S5) ☐

ASIA IMPAIRMENT SCALE ☐

ZONE OF PARTIAL PRESERVATION (Caudal extent of partially innervated segments)		R	L
	SENSORY	☐	☐
	MOTOR	☐	☐

REV 05/06

MUSCLE GRADING

0 total paralysis

1 palpable or visible contraction

2 active movement, full range of motion, gravity eliminated

3 active movement, full range of motion, against gravity

4 active movement, full range of motion, against gravity and provides some resistance

5 active movement, full range of motion, against gravity and provides normal resistance

5* muscle able to exert, in examiner's judgement, sufficient resistance to be considered normal if identifiable inhibiting factors were not present

NT not testable. Patient unable to reliably exert effort or muscle unavailable for testing due to factors such as immobilization, pain on effort or contracture.

ASIA IMPAIRMENT SCALE

☐ **A = Complete**: No motor or sensory function is preserved in the sacral segments S4-S5.

☐ **B = Incomplete:** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.

☐ **C = Incomplete:** Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.

☐ **D = Incomplete:** Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.

☐ **E = Normal:** Motor and sensory function are normal.

CLINICAL SYNDROMES (OPTIONAL)

☐ Central Cord
☐ Brown-Sequard
☐ Anterior Cord
☐ Conus Medullaris
☐ Cauda Equina

STEPS IN CLASSIFICATION

The following order is recommended in determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
2. Determine motor levels for right and left sides.
   Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level.
3. Determine the single neurological level.
   This is the lowest segment where motor and sensory function is normal on both sides, and is the most cephalad of the sensory and motor levels determined in steps 1 and 2.
4. Determine whether the injury is Complete or Incomplete (sacral sparing).
   If voluntary anal contraction = **No** *AND all S4-5 sensory scores* = **0** *AND any anal sensation* = **No**, *then injury is COMPLETE. Otherwise injury is incomplete.*
5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete?
If **YES**, AIS=A Record ZPP (For ZPP record lowest dermatome or myotome on each side with some (non-zero score) preservation)

NO ↓

Is injury motor incomplete?
If **NO**, AIS=B (Yes=voluntary anal contraction OR motor function more than three levels below the motor level on a given side.)

YES ↓

Are at least half of the key muscles below the (single) neurological level graded 3 or better?

NO ↓ AIS=C

YES ↓ AIS=D

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

FIM scale

Self-care

1. Eating
2. Grooming
3. Bathing/showering
4. Dressing upper body
5. Dressing lower body
6. Toileting
7. Swallowing

Sphincters

1. Bladder management
2. Bowel management

Mobility

1. Transfers: bed/chair/wheelchair
2. Transfers: toilet
3. Transfers: bathtub/shower
4. Transfers: car
5. Locomotion: walking/wheelchair
6. Locomotion: stairs
7. Community mobility

Communication

1. Expression
2. Comprehension
3. Reading
4. Writing
5. Speech intelligibility

Psychosocial

1. Social interaction
2. Emotional status

3. Adjustment to limitations
4. Use of leisure time

Cognition

1. Problem solving
2. Memory
3. Orientation
4. Concentration
5. Safety awareness

Seven levels for each item

Level	*Description*
7 - Complete independence	Fully independent
6 - Modified independence	Requiring the use of a device but no physical help
5 - Supervision	Requiring only standby assistance or verbal prompting or help with set-up
4 - Minimal assistance	Requiring incidental hands-on help only (subject performs > 75% of the task)
3 - Moderate assistance	Subject still performs 50–75% of the task
2 - Maximal assistance	Subject provides less than half of the effort (25–49%)
1 - Total assistance	Subject contributes < 25% of the effort or is unable to do the task

Scoring principles

- Function is assessed on the basis of direct observation
- Admission scoring is done within 10 days of admission
- Discharge scoring is done during the last week before discharge
- Scoring is done by a multi-disciplinary team member
- The subject is scored on what they *actually do* on a day-to-day basis, not on what they *could do*
- Do not leave any score blank
- Score 1 if the subject does not perform the activity at all, or if no information is available

- If function is variable, use the lower score

Central Cord Data Collection Form

Patient:
Folder no:
DoB:

Audit no:

Epidemiology

Age	years
Gender	Male / Female
Mode of injury	Minor / Major fall High Speed Accident Assault Other -
Interval from injury to admission	days
Pre-existing myelopathy	Yes / No
Precious cervical spine surgery	Yes / No
Alcohol involvement	Yes / No
Smoker	Yes / No
Employed	Yes / No

Pathology

Vertebral level	C
Level of neurological injury	C
Extent of neurological injury	Complete / Incomplete
Grade of neurological injury	Frankel A B C D E ASIA A B C D E
Disc prolapse	Yes / No
Osteophyte	Yes / No
Canal diameter (level of injury)	mm
MRI (T2 hyperintensity)	Yes / No
Underlying pathology	OPLL / Autofusion / Stenosis / Surgery
Level of underlying pathology	C
Soft tissue injury	Yes / No
Progression (spontaneous)	Yes / No
Progression (following surgery)	Yes / No
Recovery (spontaneous)	Yes / No
Recovery (following surgery)	Yes / No

Surgery

Interval since injury	days
Surgical approach	Anterior / Posterior
Levels	C
Complications	Yes / No

Complications

Pneumonia	Yes / No
Ventilation	Yes / No
DVT	Yes / No

Outcomes

Function at discharge	Frankel A B C D E ASIA A B C D E
Duration of admission	days
Able to walk	Yes / No
Return home	Yes / No
Return to work	Yes / No

Mortality	Yes / No

Admission AISA motor score	Able to walk	Return to home	Return to work	Mortality	Employment
0	No	No	No	Yes	No
0	No	No	No	No	No
0	Yes	Yes	No	No	No
0	No	No	No	No	Yes
0	No	No	No	No	Yes
3	No	No	No	No	No
3	No	No	No	No	No
4	No	No	No	No	Yes
4	No	No	No	No	Yes
6	No	No	No	No	Yes
10	No	No	No	No	No
14	No	No	No	No	No
16	Yes	No	No	No	No
21	Yes	Yes	No	No	Yes
22	No	No	No	No	No
23	No	No	No	No	Yes
25	No	Yes	No	No	No
27	No	No	No	No	Yes
30	No	No	No	No	No
32	Yes	No	No	No	Yes
32	Yes	No	No	No	Yes
44	No	No	No	No	Yes
46	No	No	No	No	No
48	No	No	No	No	Yes
52	No	No	No	No	No
57	Yes	Yes	No	No	Yes
59	No	No	No	No	No
60	Yes	Yes	No	No	Yes
60	Yes	No	No	No	Yes
61	No	No	No	No	No
63	Yes	Yes	No	No	No
64	Yes	Yes	No	No	Yes
68	Yes	No	No	No	Yes
70	No	No	No	No	Yes
70	Yes	No	No	No	Yes
73	No	No	No	No	No
73	Yes	Yes	No	No	No
74	No	No	No	No	Yes
75	Yes	Yes	No	No	Yes
75	Yes	Yes	No	No	Yes
78	Yes	No	No	No	No
80	Yes	Yes	No	No	No
82	Yes	No	No	No	Yes
84	Yes	Yes	No	No	No
86	Yes	Yes	No	No	No
90	Yes	Yes	Yes	No	Yes
95	Yes	Yes	No	No	No
95	Yes	Yes	No	No	Yes
95	Yes	Yes	Yes	No	Yes
96	Yes	Yes	Yes	No	Yes
100	Yes	Yes	Yes	No	Yes

Discharge ASIA motor score	Able to walk	Return to home	Return to work	Mortality
0	No	No	No	Yes
0	No	No	No	No
0	No	No	No	No
3	No	No	No	No
3	No	No	No	No
4	No	No	No	No
4	No	No	No	No
6	No	No	No	No
12	No	No	No	No
16	No	No	No	No
23	No	No	No	No
27	No	No	No	No
42	No	No	No	No
46	No	No	No	No
48	No	No	No	No
48	No	Yes	No	No
48	No	No	No	No
49	No	No	No	No
50	No	No	No	No
60	No	No	No	No
63	Yes	No	No	No
70	No	No	No	No
70	No	No	No	No
70	Yes	No	No	No

Discharge ASIA motor score	Able to walk	Return to home	Return to work	Mortality
71	Yes	No	No	No
71	Yes	No	No	No
71	Yes	Yes	No	No
72	No	No	No	No
73	Yes	No	No	No
73	Yes	Yes	No	No
74	No	No	No	No
75	Yes	No	No	No
81	Yes	Yes	No	No
83	Yes	No	No	No
86	No	No	No	No
88	Yes	Yes	No	No
88	Yes	No	No	No
90	Yes	Yes	No	No
90	Yes	Yes	No	No
90	Yes	Yes	No	No
91	Yes	Yes	No	No
94	Yes	Yes	No	No
95	Yes	Yes	No	No
95	Yes	Yes	No	No
100	Yes	Yes	Yes	No
100	Yes	Yes	Yes	No
100	Yes	Yes	No	No
100	Yes	Yes	No	No
100	Yes	Yes	No	No
100	Yes	Yes	Yes	No
100	Yes	Yes	Yes	No

Interval since injury (days)	Surgical approach)	Level	Surgical complication	Progression(spontaneous)	Progression (following surgery)	Recovery (spontaneous)	Recovery (following surgery)	Duration of admission (days)	Discharge ASIA grade	Discharge AIS score (motor)	Discharge Frankel grade	Change in ASIA score (motor)	Able to walk	Return to home	Return to work	Mortality
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	10	E	100	E	87	Yes	Yes	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	55	D	49	C	35	No	No	No	No
3	Anterior	C3/4	No	No	No	No	Yes	14	D	88	D	71	Yes	Yes	No	No
108	Posterior	C3-6	No	No	No	No	No	22	D	70	D	53	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	6	D	74	D	55	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	5	E	100	E	80	Yes	Yes	Yes	No
27	Posterior	C4-6	No	No	No	Yes	Yes	32	D	63	D	42	Yes	No	No	No
10	Posterior	C4-5	No	No	No	No	Yes	13	D	50	D	28	No	No	No	No
26	Anterior	C3/4	No	No	No	Yes	No	29	C	16	C	-8	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	No	N/a	3	A	0	A	-24	No	No	No	Yes
16	Posterior	C4-6	No	No	No	Yes	No	15	C	42	C	16	No	No	No	No
6	Anterior	C3/4	No	No	No	No	Yes	17	D	91	D	64	Yes	Yes	No	No
4	Anterior	C	No	No	No	No	Yes	26	B	0	B	-28	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	14	D	73	D	44	Yes	No	No	No
106	Posterior	C3-6	No	No	No	Yes	Yes	27	D	88	D	58	Yes	No	No	No
N/a	N/a	N/a	N/a	No	N/a	No	N/a	49	C	46	C	15	No	No	No	No
17	Posterior	C3-6	No	No	No	No	No	15	D	60	D	29	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	2	D	95	D	60	Yes	Yes	No	No
8	Posterior	C3-4	No	No	No	No	No	21	C	48	C	13	No	No	No	No
39	Posterior	C3-6	No	No	No	No	No	178	A	6	A	-30	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	70	D	83	D	45	Yes	No	No	No
6	Anterior	C5/6	No	No	No	No	No	44	A	3	A	-37	No	No	No	No
N/a	N/a	N/a	N/a	Yes	N/a	Yes	N/a	23	D	71	D	30	Yes	No	No	No
12	Posterior	C3-6	No	No	No	No	Yes	28	D	71	D	30	Yes	No	No	No
27	Posterior	C4-5	Yes	No	No	No	Yes	39	D	86	C	44	No	No	No	No
8	Anterior	C3/4	No	No	No	No	No	50	A	0	A	-42	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	6	D	95	D	52	Yes	Yes	No	No
6	Posterior	C3-5	No	No	No	No	Yes	15	C	48	C	5	No	Yes	No	No
11	Anterior	C5/6	No	No	No	No	No	16	D	94	D	51	Yes	Yes	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	7	E	100	E	55	Yes	Yes	Yes	No
12	Posterior	C4-6	No	No	No	No	No	22	A	3	A	-43	No	No	No	No
8	Posterior	C3-5	No	No	No	No	Yes	47	C	27	C	-20	No	No	No	No
15	Posterior	C3-6	No	No	No	No	No	38	B	4	B	-43	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	16	D	71	D	23	Yes	Yes	No	No
1	Anterior	C5/6	No	No	No	No	Yes	12	D	90	D	38	Yes	Yes	No	No
17	Posterior	C0-2	No	No	No	Yes	Yes	52	D	70	D	17	No	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	17	D	75	D	22	Yes	No	No	No
8	Posterior	C3-6	No	No	No	Yes	Yes	18	D	72	D	18	No	No	No	No
2	Anterior	C5/6	No	No	No	No	Yes	12	D	90	D	36	Yes	Yes	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	21	E	100	E	45	Yes	Yes	No	No

Interval since injury (days)	Surgical approach)	Level	Surgical complication	Progression(spontaneous)	Progression (following surgery)	Recovery (spontaneous)	Recovery (following surgery)	Duration of admission (days)	Discharge ASIA grade	Discharge AIS score (motor)	Discharge Frankel grade	Change in ASIA score (motor)	Able to walk	Return to home	Return to work	Mortality
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	12	D	81	D	23	Yes	Yes	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	2	E	100	E	42	Yes	Yes	No	No
10	Anterior	C6/7	No	No	No	No	No	12	E	100	E	41	Yes	Yes	Yes	No
32	Posterior	C4-5	No	No	No	No	No	57	A	4	A	-55	No	No	No	No
20	Posterior	C3-6	No	No	No	No	No	26	D	70	D	11	Yes	No	No	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	4	E	100	E	40	Yes	Yes	Yes	No
N/a	N/a	N/a	N/a	No	N/a	Yes	N/a	19	C	23	C	-37	No	No	No	No
4	Posterior	C3-5	No	No	No	No	No	9	B	12	B	-49	No	No	No	No
7	Anterior	C4/5 & 5/6	No	No	No	No	Yes	15	D	73	D	12	Yes	Yes	No	No
42	Anterior	C3/4 & 4/5	No	No	No	Yes	Yes	43	D	90	D	21	Yes	Yes	No	No
N/a	N/a	N/a	N/a	No	N/a	No	N/a	5	C	48	C	-24	No	No	No	No

Vertebral level	Level of neurological injury	Extent of neurological injury	Underlying vertebral pathology	Level of underlying pathology
None	C4	Incomplete	None	N/a
C5/6	C4	Incomplete	Stenosis	C4-5
C3/4	C2	Incomplete	Stenosis	C3-6
C3/4	C4	Incomplete	Stenosis	C3-7
C2	C2	Incomplete	None	N/a
C4	C4	Incomplete	None	N/a
C3/4	C4	Incomplete	Stenosis	C2-6
C4/5	C4	Incomplete	Autofusion	C2-4 & 5-7
C3/4	C4	Incomplete	Autofusion	C4-6
C3/4	C4	Complete	Stenosis	C3-6
C5/6	C4	Incomplete	Stenosis	C4/5
C3/4	C2	Incomplete	None	N/a
C3/4	C3	Complete	Stenosis	C4-5
C5	C5	Incomplete	None	N/a
C4/5	C4	Incomplete	Autofusion	C3-6
C6	C5	Incomplete	None	N/a
C3/4	C5	Incomplete	Stenosis	C2-7

Vertebral level	Level of neurological injury	Extent of neurological injury	Underlying vertebral pathology	Level of underlying pathology
None	C5	Incomplete	None	N/a
C3/4	C4	Incomplete	Stenosis	C3-6
C2	C2	Complete	Stenosis	C2-7
C5	C5	Incomplete	None	N/a
C5/6	C3	Complete	None	N/a
C5/6	C5	Incomplete	None	N/a
C3/4	C4	Incomplete	Stenosis	C3-4
C3-6	C4	Incomplete	Stenosis	C3-6
C3/4	C3	Complete	Stenosis	C5-6
C3/4	C4	Incomplete	Autofusion	C5-6
C3/4	C4	Incomplete	Autofusion	C5-6
C5/6	C5	Incomplete	None	N/a
C3/4	C5	Incomplete	None	N/a
C3/4	C4	Complete	Stenosis	C3-5
C4	C3	Complete	None	N/a
C3-6	C4	Incomplete	Stenosis	C3-6
C3-5	C2	Incomplete	None	N/a
C5/6	C5	Incomplete	None	N/a
C1	C3	Incomplete	Autofusion	C0-1
C4/5	C3	Incomplete	None	N/a
C3-6	C4	Incomplete	Stenosis	C3-6
C5/6	C5	Incomplete	None	N/a
C1	C4	Incomplete	None	N/a
C4/5	C4	Incomplete	None	N/a
None	C4	Incomplete	None	N/a
C6/7		Incomplete	None	N/a
C4/5	C4	Complete	None	N/a
C3-5	C4	Incomplete	Stenosis	C3-6
None	C4	Incomplete	None	N/a
C5/6	C5	Incomplete	Stenosis	C6-7
C4/5	C5	Incomplete	OPLL	C2-7
C5/6	C5	Incomplete	Stenosis	C3-5
C3-5	C4	Incomplete	Stenosis	C3-5
C3/4	C4	Incomplete	None	N/a

Level of underlying pathology	Age (years)	Underlying vertebral pathology
N/a	13	None
N/a	14	None
N/a	17	None
N/a	17	None
N/a	19	None
N/a	20	None
N/a	21	None
N/a	22	None
N/a	24	None
N/a	24	None
N/a	26	None
N/a	27	None
N/a	28	None
C4-5	29	Stenosis
N/a	30	None
N/a	31	None
N/a	31	None
N/a	35	None
C3-5	35	Stenosis
N/a	36	None
C4-5	38	Stenosis
C3-6	40	Stenosis
C3-6	41	Stenosis
N/a	41	None
C5-6	42	Autofusion
C5-6	42	Autofusion
C3-5	43	Stenosis
N/a	43	None
C3-5	43	Stenosis
C3-6	45	Stenosis
C5-6	46	Stenosis
N/a	47	None
N/a	47	None
N/a	48	None
C2-4 & 5-7	52	Autofusion
C6-7	53	Stenosis
C2-7	53	OPLL
C2-7	54	Stenosis
C3-4	54	Stenosis
C3-6	55	Stenosis
C3-6	58	Autofusion

Age (years)	Discharge Frankel grade
13	F
14	F
17	F
17	F
19	N
20	F
21	F
22	F
24	F
24	F
26	N
27	F
28	F
29	N
30	F
31	F
31	N
35	F
35	F
36	F
38	N
40	N
41	F
41	F
42	F
42	N
43	F
43	F
43	N
45	N
46	N
47	F
47	N
48	F
52	F
53	N
53	N
54	F
54	N
55	F
58	F

Age (years)	Gender	Mode of injury	Discharge Frankel grade	Discharge Frankel grade
31	Male	H	F	E
13	Female	H	F	E
14	Male	H	F	D
17	Male	H	F	E
17	Male	H	N	E
19	Male	H	F	A
20	Female	H	F	D
21	Male	H	F	D
22	Male	H	F	D
24	Male	H	F	E
24	Male	H	N	D
26	Male	H	F	C
27	Male	H	F	D
28	Male	H	N	E
29	Male	H	F	C
30	Male	H	F	E
31	Male	H	N	C
35	Male	H	F	D
35	Male	H	F	D
36	Female	H	F	D
38	Male	H	N	B
40	Male	H	N	C
41	Male	H	F	D
41	Male	H	F	D
42	Male	L	F	D
42	Male	L	N	C
43	Male	H	F	D
43	Male	H	F	D
43	Male	H	N	A
45	Male	H	N	A
46	Male	H	N	A
47	Female	H	F	D
47	Female	L	N	C
48	Male	H	F	D
52	Male	L	F	D
53	Male	H	N	C
53	Male	L	N	B
54	Male	L	F	D
54	Male	H	N	A
55	Female	L	F	D
58	Male	L	F	D

Level of underlying pathology	Age (years)	Underlying vertebral pathology		Age (years)	Discharge Frankel grade		Age (years)	Gender	Mode of injury	Discharge Frankel grade	Discharge Frankel grade
C0-1	58	Autofusion		58	F		58	Male	H	F	D
C3-7	59	Stenosis		59	F		59	Female	L	F	D
C2-7	59	Stenosis		59	F		59	Female	L	F	D
C3-6	59	Stenosis		59	N		59	Male	L	N	C
C2-6	60	Stenosis		60	F		60	Male	L	F	D
C4-6	60	Autofusion		60	N		60	Female	H	N	C
C4/5	61	Stenosis		61	N		61	Male	L	N	C
C3-6	61	Stenosis		61	N		61	Male	H	N	B
N/a	69	None		69	N		69	Male	H	N	A
C3-6	72	Stenosis		72	F		72	Male	H	F	D

Pneumonia	Ventilation	Deep venous thrombosis	Pressure sore	Pneumonia	Ventilation	Deep venous thrombosis	Pressure sore	Pneumonia	Ventilation	Deep venous thrombosis	Pressure sore
No	No	No	No	Yes	Yes	No	Yes	No	No	No	No
Yes	No	No	Yes	No	No	No	No	No	No	No	No
No	No	No	No	Yes	Yes	No	No	No	No	No	No
No	No	No	No	No	No	No	No	No	No	No	No
No	No	No	No	Yes	No	No	Yes	No	No	No	No
No	No	No	No	Yes	No	No	No	No	No	No	Yes
No	No	No	Yes	Yes	Yes	No	No	No	No	No	No
Yes	Yes	No	No	No	No	No	No	No	No	No	No
Yes	Yes	No	No	No	No	No	No	Yes	No	No	No
Yes	No	No	No	No	No	No	No	No	No	No	No
No	No	No	No	No	No	No	No	No	No	No	No
No	No	No	No	No	No	No	No	No	No	No	No
Yes	No	No	No	Yes	Yes	No	No	No	No	No	No
No	No	No	No	No	No	No	No	No	No	No	No
No	No	No	No	No	No	No	No	Yes	No	No	No
No	No	No	No	No	No	No	No	No	No	No	No
No	No	No	No	Yes	Yes	No	No	No	No	No	No

Canal Diameter versus Surgery

Observed

	No	Yes	Total
<8mm	2	25	27
≥8mm	18	6	24
Total	20	31	51

Expected

	No	Yes	Total
<8mm	11	16	27
≥8mm	9	15	24
Total	20	31	51

Difference

	No	Yes	Total
<8mm	7.4	5	12.4
≥8mm	9	5.4	14.4
Total	16.4	10.4	26.8

Chi Squared	0,00005
df	1

Canal Diameter versus Clinical Improvement

Observed

	No	Yes	Total
<8mm	17	10	27
≥8mm	12	12	24
Total	29	22	51

Expected

	No	Yes	Total
<8mm	15	12	27
≥8mm	14	10	24
Total	29	22	51

Difference

	No	Yes	Total
<8mm	0.3	0.3	0.6
≥8mm	0.3	0.4	0.7
Total	0.6	0.7	1.3

Chi Squared	0,45735
df	1

Canal Diameter versus Functional Outcome

Observed

	No	Yes	Total
<8mm	14	13	27
≥8mm	5	19	24
Total	19	32	51

Expected

	No	Yes	Total
<8mm	10	17	27
≥8mm	9	15	24
Total	19	32	51

Difference

	No	Yes	Total
<8mm	1.6	0.9	2.5
≥8mm	1.6	1.1	2.7
Total	3.2	2	5.2

Chi Squared	0,02030
df	1

Age versus Surgery

Observed

	No	Yes	Total
≤ 40 years	16	6	22
> 40 years	4	25	29
Total	20	31	51

Expected

	No	Yes	Total
≤ 40 years	9	13	22
> 40 years	11	18	29
Total	20	31	51

Difference

	No	Yes	Total
≤ 40 years	5.4	3.8	9.2
> 40 years	4.5	2.7	7.2
Total	9.9	6.5	16.4

Chi Squared	0,00005
df	1

Human Research Ethics Committee Approval Letter

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

24 May 2011

HREC REF: 236/2011

Dr C Thompson
Neurosurgery
H53, OMB

Dear Dr Thompson

PROJECT TITLE: HYPEREXTENSION INJURY OF THE CERVICAL SPINE WITH CENTRAL CORD SYNDROME.

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year till the 30 May 2012.

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010) if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC. REF in all your correspondence.

Yours sincerely

signature removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.

Dissertations Committee Approval Letter

Dear Crispin Thompson

Candidature Approval (THMCRI001)

Degree	MMed (Neurosurgery)
Title	Hyperextension Injury of the Cervical Spine with Central Cord Syndrome
Department	Surgery
Supervisor	Welsh, D
Ethics Approval	HREC REF: 236/2011

I am pleased to advise that the Chair of the Dissertations Committee has approved your candidature for the above degree on behalf of the Committee. Formal approval was obtained by publication in the Dean's Circular, Med 07/2011.

Yours sincerely,

Jackie Cogill

Jackie Cogill
Postgraduate Senior Secretary
Room N2.19
Wernher & Beit Building North
Health Sciences Faculty
Anzio Road
Observatory
7925
Tel: +27 21 406 6750
Email: jackie.cogill@uct.ac.za

	UNIVERSITY OF CAPE TOWN **FACULTY OF HEALTH SCIENCES**	
MMed/MPhil Part III (minor dissertation) Guidelines for candidates, supervisors and examiners		

The MMed minor dissertation (or the MPhil dissertation in the case of sub-specialities) is one of three examination components of the MMed/MPhil degree. This minor dissertation carries one third of the weight of a full master's dissertation in terms of its credit weighting.

The dissertation must be a study containing the results of an analytical, quantitative, or epidemiological study carried out by the candidate (for certain disciplines, the candidate may chose instead to do a qualitative study, an audit cycle or a formal systemic review). A case report is not acceptable for the dissertation.

The dissertation must be the result of independent work of the candidate conducted under the guidance and direction of a supervisor(s) and should demonstrate evidence of an ability to undertake research, to adequately interpret results and to comprehensively and critically review the relevant literature. Although the findings of the research need not necessarily be original, they must be seen to advance scientific understanding. The topic and scope of research will depend on the particular disciplines and must be agreed upon in consultation with the supervisor(s).

Research protocol

Candidates intending to register for the MMed/MPhil Part III are required to submit a full research protocol for approval to their respective Departmental Research Committee (DRC). The candidate must also obtain FHS UCT Ethics approval prior to conducting their research. This full research protocol (together

with a copy of the ethics approval letter) must be submitted to the postgraduate administration for approval by the Board of the Faculty of Health Sciences, prior to commencement of the research. For most disciplines, submission of the research protocol should be made no later than the end of year 2.

The research protocol should outline the scope and content of the dissertation and must include the title of the proposed dissertation, name of the supervisor(s) and their brief curriculum vitae.

Submission of dissertations

On completion, the dissertation should be submitted to the Faculty Postgraduate Officer. The candidate should inform the Faculty Officer one month in advance of the intention to submit.

Submission deadlines:

1. March 15th for June graduation
2. August 15th for December graduation

Supervisors will be requested by the Faculty Postgraduate Officer to submit a letter supporting submission. This letter should be supplied by the primary supervisor. If this supervisor is external, the internal supervisor must be kept informed at every stage of the process. Specific submission requirements may be set by individual disciplines.[2]

Note on fees: To avoid attracting fees, dissertations need to be submitted before the beginning of the first quarter (first day of academic year), and before the start of the second semester (mid July) to qualify for a 50% fee rebate.

Supervisors

One cannot overemphasize the importance of identifying a dissertation supervisor as early as possible. The supervisor should be an individual who can relate to the candidate's research project, be available for frequent and regular discussion and advice, and someone with whom the candidate can develop a good working relationship. Where specialised equipment and/or laboratory work is required for the study, the supervisor should assist in facilitating such access to such facilities.

Supervisors may assist candidates in developing scientific communication skills but they are not required to do detailed editing or correction of spelling, grammar, or style. They may refer candidates to the UCT Writing Centre for this purpose.
The primary supervisor may be based outside the candidate's home department, faculty or university. In such a case, an internal (or secondary) supervisor will be required in addition to the primary supervisor, to serve as a guide and link to discipline-specific procedures. Primary supervisors retain responsibilities to the candidate and the university until the dissertation process is complete.

Please note: in order to assist a candidate with a master's research topic the supervisor needs to hold a master's degree or higher, or have relevant research experience. If the primary supervisor does not hold a higher degree or equivalent (such as a Fellowship of The College of Medicine of South Africa), then a secondary supervisor who has a higher degree will need to be appointed in addition to the primary supervisor.

Candidates are strongly encouraged to publish the study with the supervisor(s) as co-author(s). This may require work beyond the graduation date. Such arrangements should be discussed and documented in advance.

2 For Public Health Medicine and Occupational Medicine the dissertation must be submitted for examination at least *4 months* prior to the deadline for registration for the examinations of the relevant College. This is in order to ensure that a final examination mark for the dissertation can be submitted by the candidate to the College of Medicine of South Africa (CMSA) at the time of registration as required by CMSA examination regulations.

The dissertation

Submission of the dissertation should satisfy the following criteria:

1. The title page should contain the candidate's name, dissertation title and the name of the university. It must also state the degree, e.g. Master of Medicine (MMed) in Public Health Medicine, Occupational Medicine, Family Medicine, Surgery, etc. The title page should also include a statement to the effect that the research report is based on independent work performed by the candidate and that neither the

whole work nor any part of it has been, is being, or is to be submitted for another degree to any other university. It must also state that this work has not been published *prior to registration* for the abovementioned degree.

2. The body of the dissertation, which must be structured in 4 parts, should include the following:

   Part A: The *protocol* (as approved by the Departmental Research Committee and Faculty Research Ethics Committee). The protocol should not exceed 4000 words.

   Part B: A *structured literature review* appropriate to the subject matter and methods of the dissertation. The literature review must, amongst other things, show that the student is sufficiently acquainted with the relevant literature and is able to perform a critical appraisal and, if appropriate for the topic, show a good understanding of evidence-based medicine.

   The review should be between 3 000 and 4 000 words.

   A suggested structure for the literature review is as follows:

   a) Objectives of literature review
   b) Literature search strategy, including inclusion and exclusion criteria
   c) Quality criteria - some leeway will be allowed here, as candidates will vary in their ability to appraise studies. This will also vary with the nature of the dissertation.
   d) Summary or interpretation of literature
   e) Identification of gaps or needs for further research
   f) References (which will overlap with but will not be the same lists as in the journal article and protocol)

   Part C: The results of the study must be presented in the form of a *manuscript* of an article for a named peer reviewed journal, meeting all the requirements set out in the "Instructions for Authors" of that journal, including the word count and referencing style. (Unless specially motivated, the journal chosen will need to allow for *at least* 3000 words excluding abstract, tables, figures and references). The "Instructions to Authors" of the journal must be appended. The journal

chosen for publication must be appropriate to the subject matter of the dissertation and accredited by the Department of Education or listed in the citation index of the Institute for Scientific Information (ISI).

Important note: the candidate need not have submitted the article, not is the acceptance of the article and requirement for passing the degree. The norm of practise is to publish the study with the supervisor(s) as co-author(s) and candidates are strongly encouraged to submit their manuscript either before or after examination of the mini-dissertation.

Part D: All *supporting documents* including:

- Questionnaire/data capture instrument
- Consent forms and any related participant information sheets
- Technical appendices, including, if considered necessary, any additional tables not included in the main manuscript for the examiner to have available. These should be accompanied by a brief narrative.
- Official Ethics approval letter from the Faculty Research Ethics Committee

3. The article does *not* have to be submitted to the journal in order to meet academic requirements.

4. A candidate must submit 2 copies of the dissertation in temporary binding, and an electronic copy on compact disc in a universally readable format (e.g. pdf).

Examiners

The full dissertation will be submitted for examination through the Postgraduate office of our Faculty to two external examiners (nominated by the supervisors and HOD).Three examiners will be nominated, two of which are invited to examine, and one held as an alternate. All examiners must be external to UCT. These nominations are circulated to the Faculty Dissertation Committee. It is the *supervisor's (or co-supervisor's)* responsibility to submit names of potential examiners to the Faculty Officer when the candidate is ready to submit.

The examiners will be well briefed regarding the specific requirements and criteria for submission and examination of the mini-dissertation. Such criteria will clearly explain the difference between the mini-dissertation and a Master's degree by dissertation alone.

Details required for each examiner are: academic qualifications, postal and/or physical address, telephone and fax numbers and e-mail address, and one paragraph description of their standing in the relevant field (drawn from their CV if need be.)

The candidate may not be informed of the identity of the examiners. After the outcome of the mini-dissertation has been finalised, the examiners' identities are made known if the examiners have indicated that they do not object to this.

GUIDELINES ON THE LAYOUT AND STYLE OF THE DISSERTATION OR THESIS

To assist you in organising the presentation of your dissertation, the guidelines below may be useful.

DISCUSSION WITH SUPERVISOR REGARDING DISSERTATION/THESIS

Discuss the layout of your dissertation/thesis with your supervisor. During this discussion you will decide what sections to include in the dissertation/thesis, such as:

- The abstract which forms the preface of the dissertation/thesis
- Introduction
- Section on the study design and research methods used
- How many chapters there will be and what each chapter should encapsulate
- The conclusion or summary section

Please note: Supervisors, although they may assist with this, are not required to do detailed editing nor correction of spelling and grammar, or style. Students who need assistance in academic writing are encouraged to make use of support services available, e.g. The UCT Writing Centre.

PAGE SET-UP:

- Left margin at least 4cm; right margin about 2.5cm. This will allow for the binding of the dissertation/thesis
- Use A4page set-up
- Page numbers in the same font as the font you are using for the text. Use fonts such as Arial, Times New Roman, Book Antiqua, or Bookman Old Style. Avoid the "**comic**" fonts.
- Font size 11 or 12
- Set language to English [South Africa] – avoid the American spellings e.g. *behavior*

- Line spacing of 1.5 is recommended. We also suggest that you set your spacing to allow 6pts after each paragraph – this improves the look of the document and you don't have to put in an extra paragraph break.

GENERAL SUGGESTIONS

- Make sure that your tables, graphs, and other graphics are properly numbered and that you refer to them correctly
- Make sure that your write in an easily understood manner. Don't make paragraphs consisting of one sentence. Use shorter rather than long, complicated sentences. Academic writing is meant to be clear, not jargon! The ideal is one idea/thought/result per sentence.
- Mind your grammar
- When you use a term in full (for which there is an acknowledged abbreviation) the first time then put the abbreviation in brackets. After that you can use the abbreviation, but ensure that you write it down correctly. It is always a good idea to include a list of abbreviations used in your text. This will be included in the text just after the Table of Contents
- When you use lots of technical terms it may be a good idea to include a glossary of terms used. You will insert this after the list of abbreviations
- Always do a spell-check once you have completed a paragraph or a section. This will be easier and faster than running a spell-check right at the end. Be very particular with the spelling because there is nothing that irks an examiner as much as spelling error after spelling error.
- Print on only one side of the page
- Decide on which referencing method you will be using and ensure that you do not deviate from that. It is a good idea to stipulate somewhere which referencing method you are using

PRINTING OF THE DISSERTATION/THESIS

- Master's candidates must submit two copies of the dissertation in temporary binding (e.g. ring binding) for examination, and a CD containing the dissertation in one continuous file in a universally readable format. Master's candidates must submit their dissertations to the Manager: Postgraduate Administration on the specified dates (see ***Dates to Remember*** below)
- Doctoral candidates (MD) must submit three copies of the thesis. Three (3) copies must be temporary binding, and a CD containing the dissertation in one continuous file in a universally readable format.
- Doctoral candidates (MD) must submit their theses to the DDB Officer on the specified dates (see ***Dates to Remember*** below)
- Doctoral candidates must submit 3 copies of the thesis in temporary binding, and a CD containing the thesis in one continuous file in a universally readable format. Doctoral candidates must submit their theses to the DDB Officer on the specified dates (see ***Dates to Remember*** below)

TITLE PAGE

Title of dissertation

by

STUDENT: FULL NAMES
STUDENT NUMBER

SUBMITTED TO THE UNIVERSITY OF CAPE TOWN
In (partial if the degree was by coursework AND dissertation) fulfilment of the requirements for the degree

M Sc…. (name of degree)

Faculty of Health Sciences

UNIVERSITY OF CAPE TOWN

Date of submission
Supervisor [s]:

Name and Department and University

DECLARATION PAGE

You must include a signed and dated declaration in the front of your dissertation/thesis. Please use the standard format shown below:

DECLARATION

I, ……, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: ……

Date: ……

DATES TO REMEMBER FOR 2011

Master's candidates

JUNE GRADUATION

If you wish to graduate in June 2011 then you have to:

- Give a letter of *Intention to submit* to the Manager of the Postgraduate Unit not later than 15 January 2011
- Submit your dissertation by not later than 05 March 2011

[Note 1: If you submit your dissertation before the start of the new academic year (05 February 2011) then you do not have to reregister or pay fees again.

Note 2: If, however, you receive a grade of "Revise and Resubmit" then you must reregister and pay fees again w.e.f. the date on which you received the notification of the result]

DECEMBER GRADUATION

If you wish to graduate in December of any particular year then you have to:

- Give a letter of *Intention to submit* to the Manager of the Postgraduate Unit not later than 20 July of that year
- Submit your dissertation by not later than 15 August of that year

Doctoral Candidates

JUNE GRADUATION

If you wish to graduate in June 2011 then you have to:

- Give a letter of *Intention to submit* to the Administrator of the Doctoral Degrees Board not later than 10 January 2011
- Submit your thesis by not later than 05 February 2011

[Note 1: If you submit your thesis before the start of the new academic year (05 February 2011) then you do not have to reregister or pay fees again.

Note 2: If, however, you receive a grade of "Revise and Resubmit" then you must reregister and pay fees again w.e.f. the date on which you received the notification of the result]

DECEMBER GRADUATION

If you wish to graduate in December of any particular year then you have to:

- Give a letter of *Intention to submit* to the Administrator of the Doctoral Degrees Board not later than 20 June of that year
- Submit your thesis by not later than 15 August of that year

European Spine Journal

Info for articles

Types of papers

Original Articles should have no more than 2,500 words with an abstract of 150 words and 25 references

Review Articles should have no more than 3,500 words and 50-70 references

Letters to the Editor are limited to 500 words and 5 references

Manuscript Submission

Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Permissions

Authors wishing to include figures, tables, or text passages that have already been published elsewhere are required to obtain permission from the copyright owner(s) for both the print and online format and to include evidence that such permission has been granted when submitting their papers. Any material received without such evidence will be assumed to originate from the authors.

Online Submission

Authors should submit their manuscripts online. Electronic submission substantially reduces the editorial processing and reviewing times and shortens overall publication times. Please follow the hyperlink "Submit online" on the right and upload all of your manuscript files following the instructions given on the screen.

Title Page

The title page should include:

The name(s) of the author(s)

A concise and informative title

The affiliation(s) and address(es) of the author(s)

The e-mail address, telephone and fax numbers of the corresponding author

Abstract

Please provide an abstract of 150 to 250 words. The abstract should not contain any undefined abbreviations or unspecified references.

Keywords

Please provide 4 to 6 keywords that can be used for indexing purposes.

Text Formatting

Manuscripts should be submitted in Word.

Use a normal, plain font (e.g., 10-point Times Roman) for text.

Use italics for emphasis.

Use the automatic page numbering function to number the pages.

Do not use field functions.

Use tab stops or other commands for indents, not the space bar.

Use the table function, not spreadsheets, to make tables.

Use the equation editor or MathType for equations.

Note: If you use Word 2007, do not create the equations with the default equation editor but use the Microsoft equation editor or MathType instead.

Save your file in doc format. Do not submit docx files.

Manuscripts with mathematical content can also be submitted in LaTeX.

Headings

Please use no more than three levels of displayed headings.

Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section before the reference list. The names of funding organizations should be written in full.

References

Citation

Reference citations in the text should be identified by numbers in square brackets. Some examples:

1. Negotiation research spans many disciplines [3].
2. This result was later contradicted by Becker and Seligman [5].
3. This effect has been widely studied [1-3, 7].

Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. Do not use footnotes or endnotes as a substitute for a reference list.

The entries in the list should be numbered consecutively.

Journal article

Gamelin FX, Baquet G, Berthoin S, Thevenet D, Nourry C, Nottin S, Bosquet L (2009) Effect of high intensity intermittent training on heart rate variability

in prepubescent children. Eur J Appl Physiol 105:731-738. doi: 10.1007/s00421-008-0955-8

Ideally, the names of all authors should be provided, but the usage of "et al" in long author lists will also be accepted:

Smith J, Jones M Jr, Houghton L et al (1999) Future of health insurance. N Engl J Med 965:325–329

Article by DOI

Slifka MK, Whitton JL (2000) Clinical implications of dysregulated cytokine production. J Mol Med. Doi:10.1007/s001090000086

Book

South J, Blass B (2001) The future of modern genomics. Blackwell, London

Book chapter

Brown B, Aaron M (2001) The politics of nature. In: Smith J (ed) The rise of modern genomics, 3rd edn. Wiley, New York, pp 230-257

Online document

Doe J (1999) Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. Available via DIALOG. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999

Dissertation

Trent JW (1975) Experimental acute renal failure. Dissertation, University of California

Always use the standard abbreviation of a journal's name according to the ISSN List of Title Word Abbreviations, see www.issn.org/2-22661-LTWA-online.php