Title: SPINE TRAUMA: PATTERN, CAUSES AND SURGICAL OUTCOME

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1. INTRODUCTION

Fracture of the spine, can occur whenever forces applied to the spinal column exceed the strength and stability of the spinal column unit. Common injuries resulting in fractures of the spine include falls from a height; motor vehicle crashes, pedestrian accidents; and penetrating trauma, including gunshot wounds and stabbings.

Trauma related to military action occurs in war zones. Spinal injuries resulting from natural disasters including storms and earth quakes, and tsunami, have been documented in recent years.

Among a sample of earthquake victims multilevel spinal injuries occurred in nearly 30%. The lumbar spine was most commonly injured. Thoracic injury contributed to the majority of the neurologic injury while lumbar injury seldom resulted in permanent neurologic damage.[1]

Pain is the primary morbidity in most patients with spine fractures. Spinal pain may be seen in patients with acute fractures and fractures associated with advanced age. Other common forms of morbidity are lower extremity weakness or paralysis.

Mortality in patients with spine fractures is primarily the result of associated injuries to the spleen, liver, aorta, and pelvis. Delayed mortality may be associated with urinary tract infections if the injury resulted in a neurological dysfunction of bladder control, bed sores, and respiratory problems especially in patients with cervical spine injuries.

2.0 LITERATURE REVIEW

2.1 Epidemiology

Systematic epidemiologic data on traumatic spine fractures are rare and differ depending on the area studied and on the treating centre. The studies available from western countries reveal typical and comparable data on incidence, localization, and mechanisms of injury. Spine injuries are more frequent in men (2/3) than in women (1/3) and peak between the ages of 20 and 40 years. [2, 3,4,5,6] Approximately, 160000 patients/year sustain an injury of the spinal column in the United States. The majority of these injuries comprise cervical and lumbar (L3–L5) spine fractures. However, between 15%and 20%of traumatic fractures occur at the thoracolumbar junction (T11–L2), whereas 9–16% occur in the thoracic spine (T1–T10).[7]

About 50–60% of thoracolumbar fractures affect the transition T11–L2, 25–40% the thoracic spine and 10–14% the lower lumbar spine and sacrum.[8, 9]
In a study by Magerl and Engelhardt[5] on 1446 thoracolumbar fractures, most injuries concerned the first lumbar vertebra, i.e., 28 %(*n*=402), followed by T12 (17%, *n*=246) and L2 (14%, *n*=208). The epidemiologic multicenter study on fractures of the thoracolumbar transition (T10–L2) by the German Trauma Society studied 682 patients and revealed 50% (*n*=336) L1 fractures, 25 %(*n*=170) T12 fractures, and 21 %(*n*=141) L2 fractures.[6]
In the series by Michael Heinzelmann and Guido A Wanner at the University Hospital in Zürich demonstrated a very similar distribution for operated spine fractures (1992–2004, *n*=1744): 20%cervical spine (*n*=350), 8%thoracic spine T1–T10 (*n*=142), 62% thoracolumbar spine T11–L2 (*n*=1075), and 10% lumbosacral spine L3-sacrum (*n*=176).[10]

The susceptibility of the thoracolumbar transition is attributed mainly to the following anatomical reasons:

1) The transition from a relatively rigid thoracic kyphosis to a more mobile lumbar lordosis occurs at T11–12.
2) The lowest thoracic ribs (T11 and T12) provide less stability at the thoracolumbar junction region compared to the rostral thoracic region, because they do not connect to the sternum and are free floating.
3) The facet joints of the thoracic region are oriented in the coronal (frontal) plane, limiting flexion and extension while providing substantial resistance to anteroposterior translation.[7] In the lumbosacral region, the facet joints are oriented in a more sagittal alignment, which increases the degree of potential flexion and extension at the expense of limiting lateral bending and rotation.

The cervical spine, being the most mobile part of the spine, is susceptible to injury than other parts of the spine.

Spinal cord injury occurs in about 10–30%of traumatic spinal fractures.[11, 12]
In thoracolumbar spine fractures (T1–L5), Gertzbein[3] and Magerl et al.[5] reported 35.8% and 22% neurological deficiencies, respectively. The epidemiologic multicenter study on fractures of the thoracolumbar transition (T10–L2) by the German Society of Traumatology,[6] revealed neurological deficiencies in 22–51%, depending on the fracture type (22% in Type A fractures, 28%in Type B fractures, and 51% in Type C fractures, according to the AO classification).
Complete paraplegia was found in 5%of the patients with fractures of the thoracolumbar transition.

2.2 Mechanisms of injury

At the time of injury, several forces may act together to produce structural damage to the spine. However, most frequently, one or two major forces, defining the major injury vector, account for most of the bony and ligamentous damage. The most relevant forces are:
i) pure axial compression and flexion compression

ii) flexion/distraction
iii) hyperextension
iv) rotation
v) shear

i) Pure axial Compression and axial compression

While axial loading of the body results in anterior flexion forces in the lordotic cervical and kyphotic thoracic spine, mainly compressive forces occur in the straight thoracolumbar region.[13] Axial loading of a vertebra produces endplate failure followed by vertebral body compression.[14] Depending on the energy, the axial load may result in incomplete or complete burst fractures, i.e., vertical fractures with centripetal displacement of the fragments.[15, 16] The posterior elements are usually intact; however, with severe compression, significant disruption of these elements may occur.
The combination of an axially directed central compressive force with an eccentric compressive force anterior to the axis of rotation (centre of nucleus pulposus) typically leads to wedge compression fractures. Herein, the vertebral body fails in (wedge) compression, while the posterior ligamentous and osseous elements may remain intact or fail in tension, depending on the energy level of the injury. In the latter case, the injury is classified as flexion-distraction injury. Violent trauma is the most common cause of compression fractures in young and middle-aged adults.
The most frequent causes are motor vehicle accidents and falls from a height, followed by sports and recreational activity injuries. In the elderly population, osteoporotic compression fractures following low-energy trauma are most common.

ii) Flexion/Distraction

Flexion forces cause eccentric compression of the vertebral bodies and discs and cause tension to the posterior elements. If the anterior wedging exceeds 40–50%, rupture of the posterior ligaments and facet joint capsules must be assumed.[17]
In flexion/distraction injuries, the axis of flexion is moved anteriorly (towards the anterior abdominal wall), and the entire vertebral column is subjected to large tensile forces. These forces can produce:

-) pure osseous lesion
-) mixed osteoligamentous lesion
-) pure soft tissue (ligamentous or disc) lesion

Distraction leads to a horizontal disruption of the anterior and/or posterior elements. A distraction fracture that extends through the bone was first described by Chance.[18] This lesion involves a horizontal fracture, which begins in the

spinous process, progresses through the lamina, transverse processes, and pedicles, and extends into the vertebral body. Depending on the axis of flexion the vertebral body and disc may rupture or may be compressed anteriorly as described above. Although any accident providing significant forward flexion combined with distraction can produce this type of injury, the typical cause is a motor vehicle accident with the victim wearing a lap seat belt. These injuries are associated with a high rate of hollow visceral organ lesions, typically of the small bowel, colon or stomach, but also pancreatic injuries have been reported.[19, 20]

iii) Hyperextension

Extension forces occur when the upper part of the trunk is thrust posteriorly. This produces an injury pattern that is the reverse of that seen with flexion. Tension is applied anteriorly to the strong anterior longitudinal ligaments and anterior portion of the anulus fibrosus, whereas compression forces are transmitted to the posterior elements. This mechanism results in a rupture from anterior to posterior and may result in facet, lamina, and spinous process fractures.[21] Denis and Burks reported on a hyperextension injury pattern that they termed lumberjack fracture-dislocation.[22] The mechanism of this injury is a falling mass, often timber, striking the midportion of the patient's back. The injury involves complete disruption of the anterior ligaments and is an extremely unstable injury pattern. These injuries are the result of a reversed trauma mechanism. The intervertebral disc ruptures from anterior to posterior. The lesion may proceed into the posterior column and is then unstable against extension and shearing forces.

iv) Rotational Injuries

Both compressive forces and flexion-distraction mechanisms may be combined with rotational forces and lead to rotational fracture dislocations. As rotational forces increase, ligaments and facet capsules fail and lead to subsequent disruption of both the anterior and posterior elements. A highly unstable injury pattern will develop, i.e., the posterior ligaments and joint capsule will rupture and the anterior disc and vertebral body will disrupt obliquely or will be compressed.

Rotational forces may further be combined with shearing forces and lead to most unstable fractures (slice fractures, Holdsworth).[23] These patients have often been thrown against an obstacle or hit by a heavy device. Thus, the patients often

have widespread dermabrasions and contusions on the back.

v) Shear

Shear forces produce severe ligamentous disruption and may result in anterior, posterior or lateral vertebral displacement.[14] The most frequent type is traumatic anterior spondylolisthesis that usually results in a complete spinal cord injury.

2.3 Classification

Vertebral spine injuries are very heterogeneous in nature. Most important for the understanding and treatment of these injuries is the evaluation of spinal stability or instability, respectively. However, the conclusive evaluation of this question is difficult because the term "instability" is not yet clearly defined in the context of spinal disorders.

Several classifications of spinal injuries have been introduced based primarily on fracture morphology and different stability concepts. White and Panjabi.[24] defined clinical instability of the spine as loss of the ability of the spine under physiologic loads to maintain relationship between vertebrae in such a way that there is neither damage nor subsequent irritation to the spinal cord or nerve root and, in addition, there is no development of incapacitating deformity or pain from structural changes.

Physiologic loads are defined as loads during normal activity, incapacitating deformity as gross deformity unacceptable to the patient, and incapacitating pain as discomfort uncontrolled by non-narcotic analgesics.

2.3.1 Denis Classification

The middle column became a central part of the classification of spinal injuries according to Denis[2], which is in widespread use in the United States. Accordingly, the vertebral column is divided into three columns.[2]

i) anterior column

ii) middle column

iii) posterior column

The anterior column consists of the anterior longitudinal ligament (ALL), the anterior anulus fibrosus, and the anterior half of the vertebral bodies. The middle column consists of the posterior longitudinal ligament (PLL), the posterior annulus fibrosus, and the posterior half of the vertebral bodies. Finally, the posterior column

consists of the bony neural arch, posterior spinous ligaments and ligamentum flavum, as well as the facet joints.

Denis considered the middle column to be the key structure. A relevant injury to the middle column was therefore the essential criterion for instability. According to the Denis classification, rupture of the posterior ligamentous complex only creates instability if there is concomitant disruption of at least the PLL and posterior anulus. However, the middle column is not clearly defined either anatomically or biomechanically, i.e., the middle column bony part resists compression forces, and the ligamentous part resists distraction forces. Although the three column concept by Denis raised several concerns, his classification is still frequently used, because it is simple and includes all the injury patterns most commonly seen. Denis distinguished minor and major injuries: minor injuries included fractures of the articular, transverse, and spinous processes as well as the pars interarticularis. Major spinal injuries were divided into compression fractures, burst fractures, flexion-distraction (seat-belt) injuries, and fracture dislocations.

2.3.2 AO Classification

The AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation) classification introduced by Magerl et al. in 1994[18] is increasingly being accepted as the gold standard for documentation and treatment of injuries of the vertebral spine.

The AO classification is based on the “two column theory” described by Holdsworth.[23, 25] and Kelly and Whitesides. [26, 27]The AO classification considers the spine to comprise two functionally separate supportive columns. The anterior column consists of the vertebral body and the intervertebral discs and is loaded in compression. The posterior column consists of the pedicles, the laminae, the facet joints, and the posterior ligamentous complex, and is loaded in tension. According to the common AO classification system, injuries are categorized with increasing severity into types:

-) Type A: compression injuries
-) Type B: distraction injuries
-) Type C: rotational injuries

Type A injuries are the result of compression by axial loading (e.g., compression and burst fractures). Type B injuries are flexion-distraction or hyperextension

injuries and involve the anterior and posterior column. Disruption may occur in the posterior or anterior structures. Type C fractures are the result of a compression or flexion/distraction force in combination with a rotational force in the horizontal plane (e.g., fracture dislocations with a rotatory component). Each type is classified into three major groups (1–3) of increasing severity.
The important morphological criteria of instability according to the AO classification are injuries to the ligaments and discs. A graded classification is useful because there is a range from "definitely stable" to "definitely unstable" fractures. Fractures are considered stable if no injury to ligaments or discs is evident, e.g., pure impaction fractures (Type A1). Structural changes of the spine under physiologic loads are unlikely. Slightly unstable fractures reveal partial damage of ligaments and intervertebral discs, but heal under functional treatment without gross deformity and without additional neurological deficit. This is the case in a frequent type (A3), the so-called incomplete superior burst fracture (A3.1.1). Highly unstable implicates a severe damage of the ligaments and intervertebral discs, as it occurs in the fracture Types A3, B, and C.

2.4 Clinical Presentation

The clinical assessment of patients with a putative trauma to the spine has three major objectives, i.e., to identify:
i)the spinal injury
ii) neurological deficits
iii) concomitant non-spinal injuries

I) Spinal Injuries

It is obvious that the management and the priorities differ between a life-threatening polytrauma that includes a spinal injury and a monotrauma of the spine. In the case of a polytrauma, about one-fourth to one-third of patients have a spinal injury.[28] In a series of 147 consecutive patients with multiple trauma, Dai et al.[29] found a delayed diagnosis of thoracolumbar fractures in 19%, confirming an earlier study by Anderson et al,[30] in which 23% of patients with major thoracolumbar fractures were diagnosed after the patient had left the emergency department. A delay in the diagnosis of thoracolumbar fractures is frequently associated with an unstable patient

condition that necessitates higher-priority procedures than thoracolumbar spine radiographs in the emergency department.

However, with the routine use of multi-slice computed tomography (CT) in polytraumatized patients, the diagnostic work-up is usually adequate, [3132] and delayed diagnosis of spine fractures should become rare. Multiple burst fractures occur in approximately 10–34%. [33,34, 35]

II) Neurological Deficit

An accurate and well-documented neurological examination is of great importance. With an inaccurate or incomplete examination and a subsequent variation of the patient's neurological deficit, it will be unclear if the situation has changed or if the initial assessment was simply inappropriate. In the case of a progressive neurological deficit, this may hinder urgent further management, i.e., the need for a surgical intervention with spinal decompression. Importantly, the examination has to include the "search for a sacral sparing" which will determine the completeness of the deficit and the prognosis.

III) Concomitant Non-spinal Injuries

About one-third of all spine injuries have concomitant injuries.[28, 36, 37] In a review of 508 consecutive hospital admissions of patients with spinal injuries, Saboe et al.[37] identified the presence of associated injuries in 240 (47%) individuals. Most frequently found concomitant injuries were:

- head injuries (26%)
- chest injuries (24%)
- long bone injuries (23%)

2.5 History

The history of a patient who sustained injury to the spine injury is usually obvious. The cardinal symptoms are:

- pain
- loss of function (inability to move)
- sensory- motor deficit
- bowel and bladder dysfunction

The history should include a detailed assessment of the injury, i.e.:

- type of trauma (high vs. low energy)
- mechanism of injury (compression, flexion/distraction, hyperextension, rotation, shear injury)

Fractures of the spine usually result from high-energy trauma such as traffic crashes and falls from a great height. Recreational activities frequently associated with spinal injuries are skiing, snowboarding, paragliding or horse riding. A spinal fracture should be suspected in any patient who has had a high-energy trauma. Consequently, patients should be treated as if they have a spinal injury unless proven otherwise.[38] On the contrary, vertebral compression fractures can also occur in less severe accidents or more or less spontaneously in elderly patients with osteoporotic bones.[39]

2.6 Physical Findings

Similarly to the assessment of the patient with a cervical spine injury, the initial focus of the physical examination is on the assessment of vital functions, and neurological deficits. The goal is to immediately secure vital functions, which can be compromised in polytraumatized patients and patients with a spinal cord injury. Often hypotension and hypovolemia is encountered both in polytraumatized and spinal cord injured patients. Importantly, secondary deterioration of spinal cord function that results from hypotension and inadequate tissue oxygenization has to be avoided by timely and appropriate treatment.

A thorough neurological examination is indispensable. The spinal cord usually terminates at the level of L1 in adults, although it may extend to L2 in some patients. Therefore, fractures at the thoracolumbar junction may result in a variety of neurological injury types and symptoms, i.e., damage to distal spinal cord with complete/incomplete paraplegia, conus medullaris with malfunction of the vegetative system, cauda equine, and thoracolumbar nerve roots.

Thoracolumbar factures may damage the parasympathic centres located in the conus medullaris. This injury will lead to bladder dysfunction, bowel dysfunction as well as sexual dysfunction. In the case of damage to the cauda equina

or in a combination with damage to the conus medullaris, a more diffuse distribution of lower extremity paresthesia, weakness and loss of reflexes is found.
Radiculopathy can be identified by a segmental pattern of sensory alterations that do not have to be combined with motor dysfunction.
The inspection and palpation of the spine should include the search for:

- skin bruises, lacerations, ecchymoses
- open wounds
- swellings
- hematoma
- spinal (mal)alignment
- gaps

2.7 Imaging Studies

The radiographic examination is an extension of the physical examination that confirms clinical suspicions and documents the presence and the extent of many injuries. Similarly to the "clearance of the cervical spine,[38] the clinical assessment is of great importance to evaluate the necessity of imaging studies. In the alert patient who has no distracting injuries, and is not affected by sedative drugs, alcohol, or neurological deficit, the requirement for imaging is guided by clinical symptoms. The absence of back pain and tenderness has been shown to exclude a thoracolumbar injury.[40]
Modern imaging studies such as computed tomography (**CT**) and magnetic resonance imaging (**MRI**) have substantially improved the diagnosis of osseous and discoligamentous injuries after spinal trauma.

2.8 Operative Treatment

General Principles

There is a general trend towards operative treatment of unstable fractures, [3, 41] mostly because surgical stabilizing allows for:
i) early mobilization of the patient
ii) diminished pain
iii) facilitated nursing care (polytraumatized patients)
iv) earlier return to work

v) avoidance of late neurological complications

However, evidence suggests that there is no difference as regards neurological recovery (Frankel score or ASIA score) and no substantial difference in functional long-term outcome between the operative and non-operative treatment.[42] This is clearly valid for compression fractures that are relatively stable, i.e., A1 and A2 fractures, according to the AO classification. Quite frequently, however, studies presented in the literature analyze a mixed cohort of fracture types without further differentiation, which leaves their results somewhat inconclusive.

In burst fractures, there is often some degree of canal compromise with a potential risk of neurological injury. Hence, progressive neurological deterioration in the presence of substantial canal compromise is an indication for surgical decompression and stabilization. Importantly, neurological status, spinal stability, degree of deformity of the injured segment, degree of canal compromise, and associated injuries are the most relevant factors that need to be considered when deciding on operative or non-operative treatment for patients with a spine fracture.

Spinal Cord Decompression

The severity of a spinal cord injury is related to the force and duration of compression, the displacement and the kinetic energy. Many animal models, including primates, have demonstrated that neurological recovery is enhanced by early decompression.[43] However, this compelling evidence has not been able to be translated into patients with acute spinal cord injury. This may in part be due to: (1) heterogeneous injury patterns and to (2) the absence of thoroughly designed and well-performed randomized controlled trials. However, a number of studies have documented recovery of neurological function after delayed decompression of the spinal cord (months to years) after the injury.[44, 45, 46, 47, 48] The improvement in neurological function with delayed decompression in patients with cervical or thoracolumbar spinal cord injury who have plateaued in their recovery is noteworthy and suggests that compression of the cord is an important contributing cause of neurological dysfunction. Although many clinical studies do not support the concept that surgery improves neurological deficits, most investigators recommend early surgical decompression in cases of an incomplete spinal cord injury and persistent compression of neurogenic structures.

Timing of Surgery

The timing of surgery remains controversial. While one randomized controlled trial showed no benefit of early (<72 h) decompression,[49] several recent prospective series suggest that early decompression (<12 h) can be performed safely and may improve neurological outcomes.[43]

La Rosa et al.[50] published a meta-analysis on the issue of early decompression in acute spinal cord injury. They reviewed 1687 patients in studies published up to 2000. Patients were divided into three treatment groups: early decompression (<24 h), delayed decompression (>24 h), and conservative treatment. Statistically, early decompression resulted in better outcomes compared to both delayed decompression and conservative management. Because the analysis of homogeneity demonstrated that only data regarding patients with incomplete spinal cord injury who underwent early decompression were reliable, the authors concluded that early decompression can only be considered a practice option. Currently, there are no standards regarding the role and timing of decompression in acute spinal cord injury. Also, the presence and duration of a therapeutic window, during which surgical decompression could attenuate the secondary mechanisms of spinal cord injury, remains unclear. In a recent article, Fehlings et al.[43] provide evidence-based recommendations regarding spinal cord decompression in patients with acute spinal cord injury. Animal studies consistently show that neurological recovery is enhanced by early decompression. One randomized controlled trial showed no benefit to early (<72 h) decompression. Several recent prospective series suggest that early decompression (<12 h) can be performed safely and may improve neurological outcomes. Currently, there are no standards regarding the role and timing of decompression in acute spinal cord injury. On the other hand, no significant adverse effects of early decompression have been documented. In the absence of clear guidelines from the literature, early decompression of compressed neurological structures appears to be best practice.

2.9 Surgical Techniques

If surgical treatment is chosen, further debate arises over the appropriate type of approach. Similarly to the treatment decision of conservative vs. operative, scientific evidence is lacking for the superiority of one surgical technique over the

other, a large variety of surgical techniques are available.

Finally, it depends on the surgical expertise of the surgeon and their preference which technique is chosen. It is difficult to base treatment recommendations on treatment outcome in the literature

Posterior Approach

Posterior Monosegmental Reduction and Stabilization

The group of Gotzen et al.[51, 52] was the first to publish their results after monosegmental reduction and stabilization. In their initial report,[51] 14 patients with unstable compression fractures Grade II were treated by posterior one-level internal fixation (9 patients had stabilization with plates and cerclage wire, 5 with internal fixator). The results were compared to a series of 11 patients with equivalent fractures treated non-operatively. The authors conclude that posterior single level stabilization and fusion is a recommendable surgical procedure. In their second publication, Junge et al.[52] describe the technique, which always included a posterior allogenic bone grafting and to some extent also transpedicular bone grafting. The 2-year follow-up of 39 patients demonstrated that 17 patients (43%) were completely free of pain and 17 patients were only sensitive to weather changes or had minor pain during great physical stress. However, five patients (13%) had pain even during slight physical stress or at rest. Importantly, no implant fatigue failure was noted although five minor complications occurred.

In a similar small series of 18 patients undergoing posterior monosegmental stabilization, Defino et al. [53] report a clinical and radiological follow-up after 2–12 years (mean 6.6±3 years) to demonstrate that posterior monosegmental fixation is an adequate and satisfactory procedure in specific types of thoracolumbar spine fractures. Clinical evaluation revealed low residual pain rates and a high level of patient satisfaction with the final result. Functional evaluation showed that 95.5% of the patients returned to work on a full-time basis and presented with a low disability index. Radiographic evaluation demonstrated increased kyphosis in the fixed vertebral segment during the late postoperative period, accompanied by a reduced height of the intervertebral disc. There was no implant failure, and no signs of pseudoarthrosis were observed in any patient.

Posterior Bisegmental Reduction and Stabilization

The bisegmental, two-level posterior approach (short segmental stabilization) is the "working horse" of the posterior techniques that allows a secure fixation of the pedicle screws in the intact vertebra one level above and below the fracture. With this construct, a good reduction and stable fixation is reliably achieved.

Fredrickson et al.[54] studied the mechanisms of ligamentotaxis to reduce the intracanal fragment of a burst fracture. Examination of anatomic data provided by microtome section indicated that the fibers that actually reduce the intracanal fragment originate in the anulus of the superior vertebra in the midportion of the endplate and insert into the lateral margins of the intracanal fragment. Investigations using MRI confirmed that these obliquely directed fibers account for the indirect reduction of the fragment. Further studies demonstrate that the posterior longitudinal ligament provided only a minor contribution in the reduction of the fracture in comparison to the attachments of the posterior portion of the anulus fibrosus.

Harrington et al. [55] studied the biomechanics of indirect reduction of bone retropulsed into the spinal canal in vertebral fracture and made several clinically relevant observations. It was not possible to produce an anteriorly directed force in the posterior longitudinal ligament at less than 35% canal occlusion, partly because the posterior longitudinal ligament stands away from the midbody of the vertebra. Regardless of the relative sagittal plane angulation of the vertebrae, distraction was the governing factor in generating force in the posterior longitudinal ligament. Because positioning the vertebrae in lordosis before applying distraction significantly slackens the posterior longitudinal ligament, it is suggested that distraction be applied before angular positioning of the vertebrae is performed. However, this procedure risks overdistraction with deleterious results for the spinal cord

Posterior Reduction and Multisegmental Stabilization

Multilevel stabilization is indicated for the very unstable thoracolumbar luxation fractures (Type C lesions) which usually cannot be accurately reduced and stabilized with a short two-level construct. Usually, fixation of two to three segments above and below the injury is recommended for a stable fixation. Unstable fractures of the thoracic spine that need to be stabilized are often combined with a significant thorax trauma or a polytrauma. In these patients, an early posterior stabilization with additional bone grafting allows for (1) a stable fixation of the spine with restoration of the dorsal tension band function, (2) the possibility of early and orthosis-free mobilization in the intensive care unit or later in a center of rehabilitation, and finally (3) bony fusion.

Anterior Approach

From the biomechanical point of view, it is obvious that the damaged spine has to be treated according to the injury mechanism and the site of injury. In a flexion injury (e.g., Chance fracture) with fracture of the pedicles and the vertebral body, stabilization can be performed by a dorsal approach and restores the tension band function until bony healing has occurred. Similarly, the biomechanics of the anterior column has to be considered in the case of a burst fracture. About 80% of the axial load of an intact spine is supported by the anterior column. When the anterior column is substantially injured, the anterior support is dramatically reduced to about 10%, leaving 90% of the load to be resisted by the implant and the posterior elements. These general biomechanical considerations support the use of an anterior load sharing support (e.g., by a tricortical bone graft or a cage).

The primary indications for the anterior approach are:

i) insufficient spinal decompression

ii) insufficient anterior column restoration

Spinal canal compromise in patients presenting with neurological deficits which cannot adequately be resolved by a dorsal approach alone requires anterior decompression. An additional indication is a vertebral body fracture with substantial comminution and dislocation which cannot be adequately restored by a

posterior approach alone.[56]

However, Type A fractures can be treated by an anterior approach alone. Kaneda et al.[57] reported a study on 150 consecutive patients who had a burst fracture of the thoracolumbar spine and associated neurological deficits. The patients were managed with a single-stage anterior spinal decompression, strut grafting, and anterior spinal instrumentation. At a mean of 8 years (range 5–12 years) after the operation, radiographs showed successful fusion of the injured spinal segment in 140 patients (93%). Ten patients had a pseudarthrosis, and all were managed successfully with posterior spinal instrumentation and a posterolateral arthrodesis. Despite breakage of the Kaneda device in nine patients, removal of the implant was not necessary in any patient.

Wood et al.[58]conducted a prospective randomized study to evaluate differences in radiographic, clinical, or functional outcomes when individuals with stable burst fractures of the thoracolumbar junction (T10–L2) without neurological deficit are treated with either a posterior fusion with instrumentation or anterior reconstruction, fusion, and instrumentation. Of 43 enrolled patients, 38 completed a minimum 2-year follow-up (average: 43 months; range: 24–108 months). Eighteen patients received a posterior spine fusion and 20 an anterior approach. There were 17 “complications” including instrumentation removal for pain in 18 patients treated posteriorly, but only 3 minor complications in 3 patients treated anteriorly. Patient-related functional outcomes were similar for the two groups. The authors concluded that although patient outcomes are similar, anterior fusion and instrumentation for thoracolumbar burst fractures may present fewer complications or additional surgeries. Hence, using minimally invasive techniques (see below) the collateral damage can significantly be reduced, which increases the indications for the anterior approach in stable thoracolumbar fractures.

3.0 PROBLEM STATEMENT

Spinal cord injury (SCI) is a devastating neurological injury, resulting in varying degrees of paralysis, sensory loss and sphincter disturbance which are permanent and irreversible in cases. It was labelled as "an ailment not to be treated" in the Edwin Smith papyrus 5000 years ago.[59] Unfortunately not much has changed, in many parts of the world known as the underdeveloped countries. SCI has been studied in detail in the Developed world, and thousands of manuscripts have been published in the last few decades. These include large scale epidemiologic surveys, multicenter research on interventions in acute SCI, reports on complications from acute and chronic SCI, results of rehabilitation interventions and functional outcomes. But all this covers only a part of the world population.

More than 80 percent of the world's population lives in the more than 100 developing countries,[60] but we know little about SCI form this part of the world. There can be many reasons such as constraints of resources and research funding, priority of curable diseases over incurable SCI lesions, and lack of general interest in the medical community to address a prolonged and often permanent disability

Spinal fractures in the cervical thoracic and lumbar spine occur in all nations, as a result of accidents and industrial injuries. The burden of such injuries is proportionate to the number of motorized vehicles. In the developing nations of Asia and Africa, spinal fractures are sometimes associated with spinal tuberculosis as well. Trauma related to military actions, natural calamities like earth quakes and landslides, and other community violence, also play a major role to spine injuries.

The spinal injuries result in serious morbidity, lending the victims motor and sensory useless, hence reduce the workforce to the nation. Also the incapacity poses difficulties to family members, in taking care of those affected and thus reduces local productivity
Rehabilitation centres for spinal injured persons are scarce, not well staffed, and moreover not specialized enough to take care of victims, and in other countries, or other parts of the countries are nonexistent, making spinal injury a major social economic problem.

4.0 RATIONALE OF THE STUDY.

There are no established national trauma or spinal cord injury registries in developing countries. Similarly there is no population based data on spinal cord injury available from the majority of developing world countries. This is complicated by the fact that medical record keeping is poorly managed in most of the hospitals[61]. Most of the data are single centre hospital based surveys representing less than 15 countries of the developing world [62,62,64,65,66,67,68,69,70,71,72,73,74]. Many of them are retrospective surveys. The general demographics of spinal cord injury in the developing world share some similarities with the epidemiological pattern reported from the developed countries. For example spinal cord injury is primarily a disease of the young males. But there are many important differences as well that need to be considered. Motor vehicle accidents are the leading causes of death in the developed countries followed by falls.[66] The reverse is true for most of the developing countries[63, 64, 70, 73]. Diving and sports injuries are another important cause of traumatic spinal cord injury in the Western world[75]but this has rarely been reported from the developing countries. Among the non traumatic spinal cord injury, spinal tuberculosis is still an important cause in the underdeveloped countries of the world, [76] while it is rarely seen in the developed countries nowadays.

South Africa being one of the third world countries is one of the fast developing countries economically in Africa. Thus the effect of spinal cord injury poses threat to its growing economy, as much of the affected individuals are involved in important social economic sectors of development. Also the government uses much money in the initial management of the affected patients, as the radiological investigations and fixation instruments are very expensive to run; moreover rehabilitation care of such patients is too costly, and rehabilitation centres are very scarce

The pattern causes and surgical outcome of cervical, thoracic and lumbar spine injury, are not well documented at Chris Hani Baragwaneth Hospital, South Africa and definitely in most resource limited countries of the third world.
Therefore the study provides a data base on the profile of this incapacitating condition.

Also this study is designed as a partial fulfilment of the requirement for the degree of Masters of Science in Neurosurgery, of Muhimbili University of Health and Allied Sciences.

5.0 OBJECTIVES.

5.1 Main objective

To determine the pattern, causes and surgical outcome of cervical, thoracic and lumbar spine trauma at CHBH.

5.2 Specific objectives

1) To determine the pattern and causes of spine trauma according to age and sex at CHBH
2) To determine the levels of skeletal injury of spine and neurological status on admission of patients with spine trauma at CHBH
3) To determine the type of surgical management of patients with spine trauma at CHBH
4) To determine the treatment outcome of patients with spine trauma at CHBH

6.0 METHODOLOGY

6.1 Study area:

This was a hospital based study, which was conducted in the neurosurgical department, at Chris Hani Baragwaneth Hospital, in Soweto, Johannesburg. South Africa. CHBH is the largest referral and teaching hospital, of the University of Witwatersrand. It is located in the South West Township (SOWETO), a suburb of Johannesburg in South Africa.

6.1 Study area:

This was a hospital based study, which was conducted in the neurosurgical department, at Chris Hani Baragwaneth Hospital, in SOWETO, Johannesburg. South Africa.

6.3 Study population:

All patients who were admitted in neurosurgical unit with a diagnosis of spine injury during period of study.

6.4 Sample size:

All medical records of patients who were admitted in neurosurgical unit, between January 2008 to November 2010, with cervical thoracic and lumbar spine trauma, who underwent surgery, were taken to constitute the sample size.

6.5 Inclusion criteria:

All patients with cervical, thoracic and lumbar spine trauma, who underwent surgery, included in the study.

6.6 Exclusion criteria:

All patients with cervical, and thoracolumbar trauma who did not undergo surgery, were excluded from the study.

6.7 Ethical considerations

The proposal was submitted in the ethical committee of the University of Witwatersrand for clearance, and permission was sought from the hospital management, through the head of the unit. The consideration to protect the right of human subjects and scientific enquiry was taken into considerations.

Confidentiality in handling patient's data, and use of identity number rather than names were issues of ethical considerations.

6.8 Data collection:

Data was filled in a structured questionnaire by the investigator from medical records of patients included in the study. Information on demographic data, causes, levels of skeletal spine injury, neurological status on admission, type of surgical procedure, and outcome of the

patient regarding neurological recovery, according to ASIA performance scale, duration of hospital stay, and mortality, was obtained from the patient's medical records.

6.9 Data analysis:

Data collected, was coded into valuables and was entered into statistical package of social sciences (SPSS 16) for analysis

7.0 RESULTS

A total of 80 medical records of patients admitted and treated at Chris Hani Baragwanath academic hospital Johannesburg, in the unit of neurosurgery were available for the study. The study period was 3 years, from January 2008 – November 2010.

All of these patients sustained various levels of spine injury and they were managed surgically by the doctors present in the unit during that period.

The age ranged from 4 years to 87 years with a mean age of 36.09 years.

The most affected individuals were in the age group 21-40 years (58.75%), followed by the age group 41-60 years (31.25%). Table 1, and 2, summarizes the results

Table 1; The distribution of spine injury according to age group (years)

Age group	**Number of pts**	**Percent**
0 -- 20	5	6.25
21 - 40	47	58.75
41 - 60	25	31.25
61+	3	3.75
Total	80	100

Males constituted the majority of patients (73.75%), females were 21(26.25%) with a male to female ratio of 3:1

Table 2; The distribution of spine injury according to age and sex

		Age group (years)				Total
		≤20	21-40	41-60	61+	
sex	**male**	5 6.25%	35 43.75%	17 21.25%	2 2.5%	59 73.75%
	female	0 .0%	12 15.0%	8 10.0%	1 1.25%	21 26.25%
Total		5 6.25%	47 58.75%	25 31.25%	3 3.75%	80 100.0%

Motor vehicle crashes (MVC) were the leading cause of spine injury and constituted 52.5%. This included the occupants of motor vehicles as well as the pedestrians who were knocked down by cars. The others group was the second most affected 26.25%, this group included patients with fractures due to recreational activities like diving into shallow water, sports and stab to the spine and child abuse. Table 3 shows these facts. Males were more at risk of injury for almost all causes as compared to females. Table 4

The cervical spine was the most affected segment of the spine 47.5%, and the motor vehicle crashes caused more of these injuries compared to others (25%). Table 5

Table 3; The distribution of causes of spine injury

causes	Number of pts	Percent
MVC	42	52.5
FFH	8	10.0
GSW	9	11.25
others	21	26.25
Total	80	100.0

Table 4; The correlation between causes of spine injury and sex

	causes				
sex	**MVC**	**FFH**	**GSW**	**others**	**Total**
male	32 40.0%	8 10.0%	7 8.75%	12 15.0%	59 73.75%
female	10 12.5%	0 .0%	2 2.5%	9 11.25%	21 26.25%
Total	42 52.5%	8 10.0%	9 11.25%	21 26.25%	80 100.0%

Table 5; The distribution of causes and levels of skeletal injury of spine

Spine level	causes				Total
	MVA	FFH	GSW	others	
Cervical spine	20 25.0%	6 7.5%	3 3.75%	9 11.25%	38 47.5%
Thoracic spine	13 16.25%	1 1.25%	0 .0%	7 8.75%	21 26.25%
Lumbar spine	9 11.25%	1 1.25%	6 7.5%	5 6.25%	21 26.25%
Total	42 52.5%	8 10.0%	9 11.25%	21 26.25%	80 100.0%

Clinical presentation of patients

On admission to hospital most patients had complete neurological deficit, i.e. ASIA A (48.75%) and only a minority of patients (2.5%) had intact neurological function. i.e. ASIA E. See Table 6.

Most patients with complete neurological deficit belonged to MVA category as a causative factor of spine injury (27.5%). However, this was not statistically significant ($p > 0.05$) see table 7.

There was no strong correlation between the neurological status of the patients on admission to hospital and skeletal level of spine injury. See Table 8

Table 6; The pattern of clinical presentation of patients on admission to hospital

Neurologic status	Number of pts	Percent
ASIA A	39	48.75
ASIA B	7	8.75
ASIA C	18	22.5
ASIA D	14	17.5
ASIA E	2	2.5
Total	80	100.0

Table 7; The relationship between the neurological status and causes of spine injury

Neurological status	causes				
	MVA	FFH	GSW	others	Total
ASIA A	22 27.5%	4 5.0%	4 5.0%	9 11.25%	39 48.75%
ASIA B	4 5.0%	2 2.5%	0 .0%	1 1.25%	7 8.75%
ASIA C	10 12.5%	1 1.25%	3 3.75%	4 5.0%	18 22.5%
ASIA D	5 6.25%	1 1.25%	2 2.5%	6 7.5%	14 17.5%
ASIA E	1 1.25%	0 .0%	0 .0%	1 1.25%	2 2.5%
Total	42 52.5%	8 10.0%	9 11.25%	21 26.25%	80 100.0%

p>0.005

Table 8; The relationship between neurological status on admission and level of skeletal injury

Neuro logical status	Skeletal level			Total
	C-spine	T- spine	L- spine	
ASIA A	13 16.25%	14 17.5%	12 15.0%	39 48.75%
ASIA B	4 5.0%	1 1.25%	2 2.5%	7 8.75%
ASIA C	11 13.75%	4 5.0%	3 3.75%	18 22.5%
ASIA D	9 11.25%	2 2.5%	3 3.75%	14 17.5%
ASIA E	1 1.25%	0 .0%	1 1.25%	2 2.5%
Total	38 47.5%	21 26.25%	21 26.25%	80 100.0%

Six patients died during the period of the study, constituting mortality rate of 7.5%

The patients who show neurological improvement after surgical intervention constituted 46.25% overall. However a very small proportional of patients who presented with complete

neurological deficit on admission had some degree of neurological recovery 3(3.8%), i.e. majority of patients who presented with ASIA A remained the same despite surgical intervention (37.5%). Thus patients with residual neurological function stood a better chance to recovery. This included 7.5%, 16.25%, and 16.25% of patients in ASIA E, ASIA C and ASIA D respectively. All of the patients who died presented to the hospital with complete neurological deficit. Table 9 illustrates these results.

The mean hospital stay was 40 days, with a minimum of 2 days and maximum of 343 days.

Table 9; Correlation between neurological status on admission and surgical outcome

Neurological status	**outcome**			
	improved	**remained same**	**died**	**Total**
ASIA A	3 3.75%	30 37.5%	6 7.5%	39 48.75%
ASIA B	6 7.5%	1 1.25%	0 .0%	7 8.75%
ASIA C	13 16.25%	5 6.25%	0 .0%	18 22.5%
ASIA D	13 16.25%	1 1.25%	0 .0%	14 17.5%
ASIA E	2 2.5%	0 .0%	0 .0%	2 2.5%
Total	37 46.25%	37 46.25%	6 7.5%	80 100.0%

The neurological recovery was higher in patients of age group 21-40 years (23.75%) followed by those in age group 41-60 (18.75%). However it the same age groups that show higher proportional of patients with no neurological improvements 28.75% and 12.5% as seen in table 10 below.

Table 10; The relationship between age and neurological outcome

Age group	outcome			
	improved	remained same	died	Total
0-20	2 2.5%	3 3.75%	0 .0%	5 6.25%
21-40	19 23.75%	23 28.75%	5 6.25%	47 58.75%
41-60	15 18.75%	10 12.5%	0 .0%	25 31.25%
61+	1 1.25%	1 1.25%	1 1.25%	3 3.75%
Total	37 46.25%	37 46.25%	6 7.5%	80 100.0%

In this study, the surgical modality was mainly anterior and posterior approach, and it was dictated by the level of skeletal injury. Most of cervical spine injuries were approached

anteriorly, while most of thoracic injuries and all of lumbar spine injuries were approached posterioly. Table 11

Table 11; The distribution of modality of surgical stabilization and level of skeletal spine injury

Level of spine injury	Surgical approach		Total
	anterior approach	posterior approach	
C-spine	33 41.25%	5 6.25%	38 47.5%
T- spine	6 7.5%	15 18.75%	21 26.25%
L- spine	0 .0%	21 26.25%	21 26.25%
Total	39 48.75%	41 51.25%	80 100.0%

There was no obvious benefit which was observed regarding to the surgical approach

Table 12; The relationship between surgical modality and neurological outcome

Neurological outcome		Surgical modality		
		anterior approach	posterior approach	Total
	improved	21 26.25%	16 20.0%	37 46.25%
	remained same	13 16.25%	24 30.0%	37 46.25%
	died	5 6.25%	1 1.25%	6 7.5%
Total		39 48.75%	41 51.25%	80 100.0%

8.0 DISCUSSION

Traumatic spine injuries are major contributors to death and disability in the population. The presence of a spinal fracture or dislocation with or without spinal cord injury requires different therapeutic interventions and involves distinct potential long-term consequences. Lack of pre hospital care and specialized facilities, account for poor results in this group of patients. This leads to severe complications like bed sores, respiratory infections, urinary tract infections, extremity spasms and contractures which complicates and pose great challenges in the management of these unfortunate patients.

Appropriate timing for surgical intervention following destabilizing cervical or thoracic and lumbar spine trauma remains controversial. As Todd J, et al puts it in their series, states that, clinical investigators have failed to provide convincing evidence that the timing of surgery significantly affects neurological outcome in most situations.[77] Nevertheless, early surgical stabilization of the injured spine has been shown to provide significant non neurological benefits such as more rapid patient mobilization, facilitation of treating associated injuries, reduction in rates of pulmonary and pressure sore complications, reduction in duration of intensive care unit and hospital stays, and a decrease in overall medical costs.[77]

The cause of spine injury varies with age and particularly sex, with males being three to four times as likely to sustain an injury as females. Epidemiological studies have proved this fact. A study done in Singapore by Balachandran N, on the causes, pattern and effect of spinal cord injury revealed that males were more affected than females with a ratio of 5:1. The same findings were observed by Kawu K et all in Lagos, where there were 372 patients with SCI, 299 (80.4%) males and 73(19.6%) females showing a male to female ratio of 4.1:1. Udosen A.M et all observed a male to female ratio of 4:1.[78, 79, 80] These same findings have been observed in the current study where the males constituted 59 (73.75%) and females 21 (26.25%) with male to female ratio of 3:1.

The young adults were the age group most affected in the current study with mean age of 36.09 years. The age group 21 -40 years constituted 58.75% of all injuries followed by adults of age group 41 – 60 years (31.25%). However the elderly constituted the minority 3.75%, probably due to co morbid conditions of this group of patients, most might have been treated conservatively. The distribution of this incapacitating condition to the young age is devastating, because, it is the kind of individuals who are involved in productivity and people

at their prime of life. This poses a big challenge to developing countries because the economy could be affected due to lack of human resources. Also because of the prevalent social customs in the underdeveloped regions, the majority of patients with SCI are already married at the time of their injury.[73] This goes to the advantage of the patient as after discharge from the hospital, the spouse remains the only and most dedicated care giver in many cases. The divorce rates after SCI are high in the developed world, but this isn't the case for most of the developing countries.[73] In comparison to this study, studies done elsewhere, show that the young age is affected mostly in both developed and developing world.

Kattail D F. et all in Canada revealed that the mean age was 50 years.[81] Also a study by Kawu K in Lagos Nigeria found the mean age of spine injuries to be 36.9 +/- 12.3[79]. And Udosen A.M observed a mean age of 36 years.[80]

Motor Vehicle crashes (MVC) ware the most common cause of spine cord injuries in this study and constituted 52.5% of all causes. MVC in this study was defined to include the occupants of the cars: drivers and passengers, motor cyclists and the pedestrians who were knocked down by moving vehicles. Falls from a height (FFH) and gunshot wound spine (GSW) contributed to the causes of spine injuries by 10% and 11.25% respectively. In the category of others which contributed to the causes by 26.25%, included recreational activities like sports, diving into shallow waters, stab wounds to spine and child abuse. This is in accordance with other studies elsewhere in the world. Udosen M. A et all in Calabar, Nigeria, found out that motor traffic crashes constituted 85.7% of all causes of spine injuries. Kattail D.F concluded that, although demographic profile has been steady over the last four decades, the frequency of more severe spine trauma at the lumbosacral levels due to falls has increased overtime.[81] Also Joosse, Pieter et all in Jakarta Indonesia in his study observed that ninety-five patients (98%) sustained blunt trauma, with motor vehicle crashes being the most common cause (68%).[82]

The commonest skeletal level of spine injury in this study, was the cervical spine which constituted 47.5% of all spine injuries, this is due to the fact that, the cervical spine is the most mobile part of the spine and thus it is at increased risk of extreme motion, either hyper

flexion or hyper extension, which results into ligaments destruction and facetal dislocations. Moreover, the cervical spine is the only part of the spine column which is not restrained in car occupants, and the head rests may not offer adequate support to the cervical spine. The thoracic and lumbar spine levels constituted 26.25% each. These findings contrasts those by Udosen M A, et all who found out that, the commonest site of injury was the lumbar region 6 (43%) while cervical and thoracic regions contributed 5 (35.7%) and 3(21.4%) respectively.[80]

However, in one series the relative involvement of different spinal levels in injury were; cervical 60%, thoracic 8%, thoracolumbar 20% and lumbar 10%.[83]

Robertson, Angus; et all in their series, observed that, the thoracic spine was most commonly injured in motorcyclists (54.8%), and the cervical spine was most commonly injured in car occupants (50.7%).[84] These results coincide with the observation found in the current study in which the motor vehicle crash constituted 25% of cervical spine injury, compared to fall from a height and gunshot wounds which constituted 7.5% and 3.75% respectively. Balachandran N, in Singapore, found out that, the most common causes of spinal injuries in Singapore were industrial accidents (34.5% or 280) and road traffic accidents (33.1% or 269). 44.1% had cervical injuries, 29.6% had thoracolumbar injuries (TIO-LI), 20.8% had lumbar injuries and 0.9% had sacral injuries.[78] This information is vital, because apart from seat belts in the cars, other measures to protect the cervical spine need to be put in place in order to reduce this devastating injury.

The clinical presentation of the patients on admission to the hospital, varied depending on the severity of spine injury and state of cord or canal encroachment. In this study most patients presented with complete quadriplegia or paraplegia. Others had partial neurological deficit ranging from preservation of sensation to essentially intact motor and sensory function. The patients were graded according to ASIA impairment scale (American Spinal Injury Association) which is a modified Frankel Neurological Performance scale.

On admission to hospital 48.75% of all patients had complete neurological deficit and were classified as ASIA- A. 8.75% of patients were classified as ASIA- B, ASIA- C and ASIA –D

represented 22.5% and 17.5% respectively. Only 2 (2.5%) patients had completely normal neurological function. i.e. ASIA –E.

Motor vehicle crashes were responsible for the majority of patients with complete neurological deficit 27.5%. However, the neurological status of the patient on admission did not seem to correlate with skeletal level of spine injury. Table 8 of results.

Udoseni A.M, in his series observed that, Clinical presentation were; paraplegia 11 (78.6%), quadriplegia 2 (14.3%) and spinal shock 1 (7%).[80]

Several epidemiological studies have shown interesting evidences, that the severity and outcome of spine injury in the developed world is different from that encountered in developing countries though the pattern may be the same.

Most of the patients in the developed world have incomplete cervical spine injury at presentation. In contrast the commonest pattern reported from the developing world is of complete paraplegia.[63, 64, 70, 73] Possible causes of this disparity are Immobilization and log roll of a suspected SCI patient at the trauma site is of utmost importance as it prevents further neurological deterioration and cord compression.[85]Spinal board is the standard of care in the developed world for evacuation and transport of a SCI patient.[86] Pre Hospital trauma care, first aid at site and infrastructure for transport of spinal trauma patients are inadequate in most of the developing countries.[87, 88] Ambulance rescues services, if any, are available in major cities only. Most of the patients are initially managed by the by standers, with no training in first aid. All kind of transports (including buses, auto rickshaws, jeeps, carts, homemade hammocks and even animal backs) totally unsuitable for transport of a suspected SCI patient are used.[70, 72, 73] In many instances spinal immobilization and log roll is not performed, even by the ambulance staff.[73] An organized pre-hospital care is very rare. This can be one of the reasons that complete injury is the most common mode of presentation at admission in the developing world. The other possibility is that a patient with cervical spine injury is unlikely to survive the poor pre-hospital care and careless handling of the spine at the trauma site, thus resulting in a large number of paraplegics at the time of presentation.

Plain radiographs can miss fractures, especially facet fractures. The detailed evaluation of a suspected SCI needs advanced radiological imaging techniques like Computerized Tomographic (CT)-scan and Magnetic Resonance Imaging (MRI), to see the extent of damage to the vertebral column, spinal cord and asses the spinal stability.[90] Radiology is not well established and advanced imaging techniques are not available in many of the hospitals in the developing world.[80, 91, 92] It has been estimated that more than half of the low income countries do not have established neuro- rehabilitation and neuroradiology services.[93] Management based on plain X-rays of the spine often results in treatment failure and prolonged periods of immobilization and morbidity for the patient.

There are only few centres established in the developing world catering for a small population. The ones which are available many a times don't have all the members of a standard multidisciplinary rehabilitation team available.[73] As a result most of the SCI in the developing world are managed in the neurosurgical, orthopaedic and even in general surgical wards,[80,94] with no established protocols for SCI management and rehabilitation. In many cases the treating physician/surgeon lacks the skills of spinal instrumentation/fixation and conservative management. Moreover a case of orthopaedic or general surgery takes precedence over a SCI as "there is not much to offer to a SCI patient".

In this study, the surgical modality was mainly anterior approach and posterior approach. No patient was treated by combined modality of surgery.

The anterior approach was performed in most of cervical spine injured patients 41.25%, in which either anterior cervical discectomy or fusion (ACDF) was performed, or corpectomy and fusion by use of cage was performed. Only 5 (6.25%) patients with cervical spine injury were surgically approached posteriorly.

Most of the thoracic spine injuries 18.75% and all of the lumbar spine injuries 26.25% were surgically approached posteriorly. Six (7.5%) of thoracic spine injuries were approached in the anterior fashion, either transthoracic or retroperitoneally corpectomy and cage fusion.

The modality of surgical approach did not reveal any benefit in the final outcome of the patients. Table 12 of results. This could be due to the fact that, the choice of the surgical treatment was not directed at proper patient selection, but due to the convenience of better surgical approach to that particular level. However, Verlaan J.J et al in his study on Surgical Treatment of Traumatic Fractures of the Thoracic and Lumbar Spine, five surgical subgroups were recognized: posterior short-segment (PS), posterior long-segment (PL), reports on both posterior short- and long-segment (PSL), anterior (A), and anterior combined with posterior (AP) techniques. Although none of the five techniques used was able to maintain the corrected kyphosis angle. The functional outcome after surgery seems to be better than generally believed.[95]

The neurological recovery of patients after surgical stabilization, did not improve much in patients who presented to the hospital with complete neurological deficit, i.e. ASIA –A. Only 3 (3.75) patients in this subgroup showed improved neurological recovery for at least one or two scores above. 37.5% of patients previously in ASIA –A remain paraplegic at the time of discharge.

Patients who had partial neurologic function had a potential of recovery after treatment and course of physiotherapy. Of 18 (22.5%) patients who on admission had a performance score of ASIA –C 13 (16.25%) had their neurological function improved. And 13 (16.25%) of 14 (17.5%) with ASIA –D on admission to hospital improved. This is in accordance to the observation done by Verlaan J.J et al who concluded that partial neurologic deficits had the potential to resolve irrespective of treatment choice.[95] However, there was no correlation between neurological recovery and age of the patients. Table 10 of results.

Six patients in this study died, constituting a mortality rate of 7.5%. This mortality was low compared to that reported by Udosen A.M who reported a mortality of 14.3%.[80]

In a study by Joosse, Pieter et al in Jakarta The predicted mortality was 14% and the observed mortality was 29%.[82]

The mean hospital stay was 40 days. This was because, Chris Hani Baragwanath Hospital is the referral hospital serving other hospitals. That being the case, the bed occupancy is always

limited as it takes all neurosurgical patients, and there is no rehabilitation centre. Thus patients get treated and discharged to rehabilitation centres, to give room for other admissions of patients.

9.0 CONCLUSION

Spine and spinal cord injury has emerged as a significant cause of morbidity and mortality in South Africa and third world countries at large. The patients are mostly male adult, sustaining injury following MVC. The cervical spine was the most common level of injury with complete neurologic deficit predominating on admission to hospital. Neurologic outcome was satisfactory in a high number of the patients with incomplete injury, irrespective of the age and mode of surgical approach.

Moreover, in many parts of the developing world, including South Africa, even today spinal cord injury is neglected and poorly managed. Research is sparse and data is missing. The demographics, epidemiological pattern of spine injury in the developing world is different from the developed world and this should be considered while formulating polices for the spinal cord injury in future. Large scale multicentre trials or population based surveys are needed to assess the true magnitude of the problem in the developing world. Trauma evacuation protocols need to be developed and pre hospital care of suspected spinal cord injury patient should be improved. Regional and national spinal injury centres providing comprehensive treatment and multidisciplinary rehabilitation should be established. There is a need to establish peer support groups to further the cause of spinal cord injury in the developing world.

10.0 RECOMMENDATIONS

- **Training of trauma and neurosurgeons and reinforcement of road safety measures**

Public enlightenment on road safety measures and use of proper protective devices including seat belts and helmet could reduce the high morbidity associated with Spinal cord injuries. Training of more trauma spine surgeons/neurosurgeons in the developing world is highly recommended.

- Public awareness of how to assist a spine injured patient at the scene, would help reduce conversion of incomplete to complete spine injury
- Early referral of patients and early surgery may improve outcome of patients

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12.0 APENDECES;

I. QUESTIONNAIRE

1. Age
2. Sex
3. What was the mechanism of spine injury
   i) MVC (car occupants, pedestrians, motor cyclists)
   ii) FFH
   iii) GSW spine
   iv) Others .....
4. What was the radiological level of skeletal injury
   i) Cervical spine (C1—C7)
   ii) Thoracic (T1—T12)
   iii) Lumbar(L3—L5)
5. What was the neurological status of the patient on admission (prior surgery)
   i) Paraplegia/ quadriplegia (ASIA –A))
   ii) Intact sensation (ASIA - B)
   iii) Motor useless (ASIA -C)
   iv) Motor useful (ASIA - D)
   v) Normal power (ASIA - E)

6. Type of surgical modality
   i) Posterior fusion
   ii) Anterior fusion
   iii) Combined anterior - posterior
7. Post surgery outcome
   i) Neurologically improved
   ii) Remained the same
   iii) died

8. Duration of hospital stay

Appendix II

PERFOMANCE OUTCOME SCORES OF SPINE INJURY

1) FRANKELNEUROLOGICAL PERFORMANCE SCALE

Frankel A	Complete neurological impairment below the level of cord injury
Frankel B	Cord injury with intact sensation globally
Frankel C	Motor useless, no fine tasks like finger grip
Frankel D	Motor useful, power grade >3
Frankel E	Intact neurological function

Appendix III

2) ASIA IMPAIRMENT SCALE

(a modified Frankel Neurological Performance Scale)

Score	description
A	**Complete;** no motor or sensory function preserved
B	**Incomplete;** sensory but no motor function preserved below the neurologic level(includes sacral segments S4-5)
C	**Incomplete;** motor function preserved below the neurologic level(more than half of key muscles below the neurologic level have muscle strength grade<3)
D	**Incomplete;** motor function preserved below the neurologic level(more than half of key muscles below the neurologic level have a muscle strength grade>3)
E	**Normal;** Sensory and motor function normal