University of Nairobi

FACULTY OF HEALTH SCIENCES

TEST PERFORMANCE OF CERVICAL SPINE RADIOGRAPHY AS COMPARED TO COMPUTED TOMOGRAPHY IN DIAGNOSING TRAUMATIC CERVICAL SPINE INJURIES INADULTS WITH HEAD INJURY AT THE KENYATTA NATIONAL HOSPITAL

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H58/7944/2017

A PROPOSAL FOR A THESIS TO BE SUBMITTED IN FULFILLMENT OF THE DEGREE OF THE MASTER OF MEDICINE IN ORTHOPEDICS SURGERY, OF THE UNIVRESITY OF NAIROBI

June, 2023

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I hereby declare that the work contained in this proposal is completely my own, original work, and was not previously submitted, in whole or in part, for application for any other degree.

I declare that any sources consulted or any external contributions have been fully referenced and credited. Furthermore, this declaration acknowledges my full understanding of the national policy on research, the University of Nairobi policy on plagiarism and of the ethical requirements of the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee.

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LIST OF ABBREVIATIONS AND ACRONYM

ACRONYM	FULL FORM	ACRONYM	FULL FORM
ROM	Range of motion	OCD/OCF/AOD/CCJ	Occipitocervical Dissociations/ Occipitocervical Fractures/Atlantoaxial Dissociation/Craniocervical Junction
HDU/ICU	High Dependency Unit/Intensive Care Unit	ACR-AC	American College of Radiology—Appropriateness Criteria
CCR	Canadian Cervical Spine Rule	EAST/WAST	Eastern/Western Association for the Surgery of Trauma (of the United States)
NEXUS	National Emergency X-radiography Utilization Survey	BAI/BDI	Basion Axial Index/Basion Dens-Interval
MPR	Multiplanar Reconstruction	SCIC	Sub-axial Cervical Spine Injury Classification System
SPSS	Statistical Package for Social Sciences	AOSIS	Association Osteosynthesis Spinal Injury Score
LMIC	Low-and-middle Income Countries	PPE	Personal Protective Equipment
MRI	Magnetic Resonance Imaging	C-n/T-n	Cervical/Thoracic Vertebra number

SCIWORA	Spinal Cord Injury Without Obvious Radiological Abnormality	CTJ	Cervico-thoracic Junction
ATLS	Advance Trauma Life Support	SPSS	Statistical Package for Social Sciences
ROC	Receiver-Operating Characteristic	AP	Anteroposterior
STWG	Spine Trauma working Group	HDU/ICU	High Dependency Unit/Intensive Care Unit
		LOC	Level of Consciousness
CSR	Cervical Spine Radiography	ISS	Injury Severity Score
CDR	Clinical Decision Rule	SAC	Space Available for Spinal Cord
CSR	Cervical Spine Radiograph/Radiography	STASCIS	Surgical Timing in Acute Spinal Cord Injury Study

OPERATIONAL DEFINITIONS

Cervical spine injury—Damage to any part of cervical spinal column and that may or may not impact thespinal cord and its function.

Complete Spinal Injury— Refers to loss of all sensory and motor functions below the level of the lesion including bowel and bladder functions.

Incomplete Spinal Injury—Involve sparing of some ascending or descending tracts below the level of the lesion and include syndromes as Brown Sequard, Central Cord Syndromes, among others.

Non-Contiguous Injuries—are lesions of the spinal column that have a normal intervening vertebral segment in the same or another spinal segment.

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ABSTRACT

Background:Cervical spine injuries pose a significant challenge in resource-limited settings, particularly in Africa, due to their high mortality and morbidity rates. Different regions of the world have different approaches to evaluating cervical spine trauma in adults with head injury, with Europe using structured protocols and the United States recommending Computed Tomography as the standard screening tool. However, in Africa, there is a lack of consistent of radiological care for head injury patients, which can lead to financial burden emanating from dual imaging, missed injuries, medico-legal issues, and potentially fatal consequences including neurological deterioration and even death. It is therefore essential to determine the local sensitivity of cervical spine radiography in diagnosing cervical spine injuries in adult patients with head injury, as compared to computed tomography of the cervical spine.

Objective of the Study:To establish the sensitivity of two-viewplain radiography of the cervical spine as compared to computed tomography of the cervical spine in adult patients presenting with head injury, a suspicion for traumatic cervical spine injury at the Kenyatta National Hospital.

Methodology: This cross-sectional study will include 52 consecutively recruited adult participants with head injury defined by a Glasgow Coma Scale (GCS) of 14 or below. The participants will undergo 2-view plain radiography namely anteroposterior and lateral and computed tomography of the cervical spine with multiplanar reconstruction. The results will be independently interpreted and reported by two consultant radiologists. Patient demographic characteristics, mechanism of injury, sensitivity, specificity, positive and negative predictive values of 2-view cervical spine radiographs as compared to the gold standard, computed tomography of the cervical spine. Presence, type and fitness of any pre-hospital cervical spine

collar will also be recorded. Measures of relative efficacy will be calculated, and statistical analyses will be conducted using the Receiver-Operating Characteristic (ROC). A desired level of confidence will be 95% and a P value of < 0.05 shall be considered to be statistically significant and categorical variables will be presented in graphs and tables.

Utility of the Study:The findings from this study will provide insight into the initial radiological care of adult patients with head injury and particularly the diagnostic accuracy of 2-views plain radiography and its role in resource-limited settings, in Africa, where access to advanced imaging techniques may be limited. In addition, information from this study will facilitate the development of clinical protocols for radiological care of adults with head injury and suspected cervical spine injury, thereby potentially improving the quality of care for this high-risk patient population.

CHAPTER ONE:INTRODUCTION

1.1Background

Cervical spine injuries (CSI) can be debilitating and fatal, even without accompanying head injury. Early and accurate detection of cervical spine injuries, particularly for patients at high risk, such as those with head injury is critical to improving outcomes[1,2.]

Computed Tomography Scan (CT) is considered the gold standard of radiological care for the demonstration of cervical spine fractures or injuries and outperforms Cervical Spine Radiography (CSR) in the detection of cervical spine injuries[3,4]

There is an ongoing debate regarding the choice of radiological modality for the initial evaluation of cervical spine injuries in adult patients with head injury[5]. In most Western countries, structured cervical spine imaging protocols exist for patients with head injury that commence often with computed tomography[6]. In rare but selected cases, investigations for suspected traumatic cervical spine injury often include, magnetic resonance imaging (MRI)[7]

The American College of Surgeon's (ACS) Advanced Trauma Life Support (ATLS) recommends computed tomography of the cervical spine for patients with head injury regardless of the severity of head injury, implying the centrality of CT scans in the assessment of cervical spine trauma in North America [8]

In the African context, the issue of radiological evaluation of the cervical spine relies heavily on the decision of medical practitioners at the first point of clinical contact. These practitioners are usually medical generalists who may not be familiar with both the clinical and radiological clearance of cervical spine injuries under circumstances of head injury

While the acute imaging of the cervical spine in patients with head injuryin Africalacks structure or radiological guide, it leans heavily towards cervical spine radiography as the imaging modality of first choice[9]

At Kenyatta National Hospital (KNH), the approach to radiological evaluation for patients with head injury appears to be inconsistent, with some clinicians pairing both CT scans of the head with that of the cervical spine, in no particularly stratified manner such as utilization of the Glasgow Coma Scale (GCS), while others may first request plain radiography before supplementing with CT scan. This variability in the standard of radiological care may result in dual imaging of the cervical spine, and their attendant high financial cost and could potentially carry negative clinical consequences for the patients

JW Kinyanjui reported in 2015, while studying the pattern and outcome of spinal injuries at the Kenyatta National Hospital, that patients first undergo plain radiography of the cervical spine before receiving computed tomography, which he noted as the dominant institutional practice. While the practice may be rooted in the institution, it does not stratify patients based on their risks or suspicion for cervical spine injury. Conversely, the other common practice is that of patients with head injuries of varying degrees receiving non-contrast CT scan of the head but also being assessed with CT scan for cervical spine injuries in the same setting[10]

This practice, while commendable, is not religiously adhered to or based on clearly defined patients' selection criteria, and often leaves out many deserving patients with head injuries and possible cervical spine fractures, potentially placing them at risk of neurological deterioration.

An important step towards improving the radiological care for patients with head injury and suspected cervical spine trauma is to document the sensitivity of cervical spine radiography in diagnosing cervical spine injuries as compared to the radiological standard of care, the computed tomography of the cervical spine at Kenyatta National Hospital.

This would provide clarity critical for enhancing the quality of care and patients' safety, as well as the efficiency of the imaging modality for the institution and patients[11]

1.2 Statement of the problem

Although cervical spine radiography (CSR) is still widely used for diagnosing cervical spine injuries in patients with head injury in Africa and other regions due to reasons such as wide availability and resource limitations, it is known to miss up to 46% of significant injuries to the cervical spine. This increases the risk of patients developing neurological deterioration and other fatal complications. To prevent delays in diagnosing cervical spine injuries, North America has shifted its approach towards initial diagnosis, with CT replacing plain radiography as the initial radiological modality for screening patients with head injury

Among the reasons cited are high pooled sensitivity for computed tomography in comparison to plain radiography, at 98.7% to 54% respectively[12]

In addition, dual imaging with both plain films and CT scans comes at a high cost. This is exacerbated by the fact that plain films alone have high repeat rates owing to their inadequacy in illuminating pathologies. Because of this reason, some practitioners and centers opt to proceed straight to CT scan in risk-tailored patient groups such as those with associated head injuries and because CT scan is more likely to pick subtle injuries that would otherwise be missed by inadequate plain radiographs[13]

Finally, cervical spine injuries are associated with high morbidity and mortality rates, more so in patients with concurrent head injuries. As such, it is imperative to exercise caution when dealing with these injuries. Although there is a lack of readily available data on the global mortality rate of cervical spine injuries, country-specific publications have provided insight into mortality and morbidity rates.

An example of such a study was conducted by Kieweski et al in Poland, which reported a mortality rate of 16.7% for patients with cervical spine injuries. Similarly, Frielingsdorf of South Africa's Groote Schuur Hospital found a slightly lower mortality rate of 13.8% for patients with cervical spine injuries.[14, 15]

At Tanzania's Muhimbili Orthopedics Institute, Zuckerman et al discovered a mortality rate of 25.7% for cervical spine injuries, which was higher than the rates found in Poland and South Africa. This difference in mortality rates may be attributed to the developmental state of Tanzania. Typically, countries with lower and middle-income status have worse trauma outcomes than those with higher gross developmental indices.[16]

In Kenya, JW Kinyanjui conducted a prospective study on pattern, management, and outcomes of spinal injuries at the Kenyatta National Hospital in 2015 and found mortality and morbidity rates of over 40% for patients with cervical spine injuries. Similar findings were reflected in a study conducted by JG Kiboi, which reported a mortality rate of 45% in patients who had both head and cervical spine injuries. [17]

Concerns regarding the initial radiological evaluation of CSIs using CSR, including inadequate and low sensitivity and specificity of CSR in diagnosing CSIs as compared to CT, high financial costs associated with dual imaging, and high morbidity and mortality rates are some of the motivation for this study. Moreover, global trends in the radiological evaluation of CSIs in patients with head injury, including the paradigmatic shift in most of Europe and the US to wide utilization of CT, have also prompted the need to address these concerns.

Although logistical constraints such as limited implants availability and other resource-related factors may result in delays in early surgical interventions, establishing the local sensitivity and specificity of CSR as compared to CT in adult patients with head injury would be a vital measure towards addressing these issues and could potentially enhance outcomes among this critical patient population

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of the Basic and Radio-Anatomy of the Cervical Spine

This passage provides an overview of the basic anatomy of the cervical spine, which is a critical part of the human spinal column that is composed of seven cervical vertebrae (C1-C7). Of the seven vertebrae of the cervical spine, C1, C2, and C7 are considered atypical and the remaining four, C3 through C6, being typical vertebrae.

The cervical spine protects the spinal cord, provides a conduit for neurovascular bundles, and permits various neck movements. The upper cervical spine (C1 to C2) is more equipped for robust neck movements than the lower cervical spine (C3 to C7). The three atlanto-axial joints permit lateral rotation of the head, while the atlanto-occipital joint enables flexion and extension of the head.[18]

Knowledge of normal variant anatomy is critical in ensuring that maldeveloped structures are distinguished from pathologies on radiological images, and especially when such structures are situated in junctional regions such as the occipito-cervical area. In addition, variant anatomy may shadow important injuries and it is thus crucial that congenital anomalies are picked when present.

Below is a list ofdevelopmental anomalies of the cervical spine that are of radiological interest, as they straddle the cervico-thoracic junction and may mimic or artefact important injuries on cervical spine radiographs.

Table 1: Radio-anatomy of the developmental anomalies of the cervical spine

Developmental anomaly of the craniocervical junction	Embryological premise of the anatomical variant
Condylus Tertius	• The bow of the fourth somite fails to integrate. • May be seen as a singleor multiple ossified remnants at the caudal end of the basi-occiput. • Has been termed the “third” occipital condyle.
Posterior Rachischisis	• Developmental cleft of the posterior arch of the atlas. • May occur bilaterally in which case it would be posterolateral rachischisis. • Can mimic Jefferson’s fracture.
Anterior Rachischisis	• Developmental cleft of the anterior arch of the atlas. • Often seen in association with posterior rachischisis.

OsTerminale	• Failure of the fusion of the secondary ossicle, otherwise called the "terminal ossicle" to the remainder of the Odontoid process. • Can mimic Odontoid Type I fracture.
OsOdontoideum	• Represents an independent ossicle situated superior to the dens and body of the axis, where the odontoid would normally be found. • May simulate Type II odontoid fracture.

Source: Offiah, C.E. and Day, E. 2017; The craniocervical junction: Embryology, anatomy, biomechanics and imaging in Blunt trauma, Insights into imaging

It is important to be aware that anomalous anatomy may present as cervical spine fractures, especially in junctional areas like the occipito-cervical and cervico-thoracic junctions, as well as in other areas. This can be a significant challenge when plain radiographs are used as the imaging modality, particularly for patients with decreased levels of consciousness. Although different radiological tools have varying strengths in visualizing specific anatomical structures, both plain radiographs and computed tomography can show osseous elements to some extent. However, Magnetic Resonance Imaging (MRI) is the most effective in detecting pathologies of muscular, ligamentous, and soft tissues [19]

2.2 Epidemiologic considerations

The global prevalence of traumatic cervical spine injuries among all trauma patients is reported to be 3.7%, while among all spinal injuries, the cervical spine accounts for a disproportionate percentage, ranging from 39% to 53%. In the United States, the estimated prevalence of cervical spine injuries among over 1 million blunt trauma patients managed annually ranges from 2% to 10% of all trauma cases across that country. Importantly, the prevalence of cervical spine injuries is higher in patients with reduced level of consciousness compared to those who are alert, with rates of 7.7% and 2.8% respectively[20]. These findings align with a correlation observed by Demetriades at a major hospital in Johannesburg, South Africa, where a low Glasgow Coma Scale score was associated with an increased incidence of cervical spine injuries[21]

In Kenya, cervical spine injuries account for more than half (55%) of all traumatic spinal injuries, with a majority occurring in the subaxial cervical spine region. All these statistics emphasize that cervical spine injuries constitute a significant proportion of spinal injuries.

Furthermore, the majority of cervical spine injuries occur in relatively young individuals aged between 20 and 50 years, with Gunby reporting a median age of 31.8 years. There is also a notable male preponderance, as only 25% of all traumatic cervical spine injuries occur in females, as observed by Gunby in 1981. This observation is consistent with a 10-year multicenter study conducted by Uche et al. in Southeastern Nigeria, which found a male-to-female ratio of 3:1, similar to studies conducted elsewhere[22]

2.3 Significance of Cervical Spine Trauma

One of the reasons why traumatic cervical spine is receiving attention from practitioners and researchers is that it carries both high morbidity and mortality.

In an analysis of mortality in patients following cervical spine trauma in Poland, J. Kieweski, demonstrated a 16.7% mortality rate. This was in keeping with Frielingsdorf, who described mortality outcomes of cervical spine injuries at Groote Schuur Hospital in Cape Town, South Africa and found an overall death rate of 13.8% among patients.

In the East African region, Zuckerman found a mortality rate of 25.7% in a study that looked at the presentation, treatment, and mortality at the Muhimbili Orthopedics Institute.

Importantly, cervical spine mortality is evidently higher in certain demographics than others. For example, among elderly population, those aged 65 years and above are more likely to die from cervical spine injuries than adults younger than 65 years. For example, Olerudstudied mortality of 65 patients with cervical fractures in Sweden and gleaned that 25 died from their injuries, representing a mortality of 38.4%. Such high mortality in the elderly as observed in Sweden was replicatedin a study by Arunesh Singh that looked at mortality of cervical spine injuries and found a mortality of 47.5% in the Indian sub-continent. [23]

In Kenya, cervical spine injuries carry significant high mortality of 40%, with another 40% sustaining lifelong neurological sequelae, majority of whom are in the economically productive segment of the population [24]

The disability in cervical spine trauma is attributable to the high incidence of injury to the spinal cord as demonstrated by Burke, Sekhon and Fehlings that cervical spine injuries are responsible for between 49-55% of all spinal cord injuries and about 57% of significant injuries to other organs, otherwise termed as associated injuries, both of which negatively impact patients and their families medically and socio-economically[25]

2.4 Clinical Criteria for Radiological Evaluation of Cervical Spine

When clearing the cervical spine in the setting of blunt trauma, multiple validated resource tools commonly referred to as Clinical Decision Rules (CDR) have been developed to triage those that would require radiological evaluation. The most widely used protocol for the clearance of cervical spine is the National Emergency X-radiography Utilization Study Criteria, known by the acronym NEXUS[26,27]

The NEXUS system was developed for the low-risk patients who would accrue no benefit from cervical spine radiography or any other more advance imaging modality

A typical NEXUS Low Risk patient is one without posterior midline cervical spine tenderness; not intoxicated; has no painful or distracting injuries; lacks focal neurological deficit and has a normal level of alertness. Failure to fulfill any of the NEXUS criteria implies that cervical spine imaging be undertaken, usually commencing with plain radiography for some centers but also computed tomography for others.[28]

Like the NEXUS criteria, the Canadian C-Spine Rule (CCR) consist of five low-risk criteria; three high-risk criteria and an additional requirement for an active range of motion.

The high-risk criteria consist of age equal or more than 65 years, a dangerous mechanism of injury and neurological deficit localizable to the upper extremity. Attainment of any of the high-risk criteria automatically leads to utilization of radiography. The CCR's five low-risk criteria include delayed onset of cervical pain, absence of midline posterior cervical tenderness, ambulation at any time after blunt trauma, simple rear-end car accident, maintenance of a sitting position while at the emergency as well as active range of motion of the neck. [29]

Like the NEXUS criteria, fulfillment of any of the Canadian C-Spine Rule's low-risk criteria in addition to an active range of motion of the neck means that the patient is at low-risk of cervical spine injury and does not require routine cervical spine radiography to be cleared of cervical spine trauma. However, presence of any of the CCR's three high-risk criteria mandates cervical spine imaging.

The third and the least deployed resource tool in the clinical clearance of cervical spine is the American College of Radiology's Appropriateness Criteria (ACR-AC). The ACR-AC protocol covered 178 diagnostic entities with their corresponding 875 sub-categories. Spine trauma as a standalone entity has close to 14 variants, each of which has appropriateness score based upon the clinical situation and probable radiation exposure levels for each of the radiological modalities including plain radiographs, CT scan and MRI, [30]

A survey of 126 physicians affiliated to academic medical centers in the United States established that only 3 physicians frequently employed the ACR-AC as a resource protocol for deciding optimal radiological modality including clearance of cervical spine following blunt trauma. While none of the three decision tools make no direct reference to head injury, all

patients presenting with blunt trauma and reduced level of consciousness are believed to be at risk for cervical spine injuries and cervical spine clearance is considered part of their trauma evaluation

While computed tomography is readily available in Kenya, all patients including the high-risk groups often undergo plain radiography as the initial screening radiological modality. This is followed by either a CT scan or an MRI, making the cost for radiological care prohibitive.

Consideration as to whether there would be empirical ground to just proceed to computed tomography of cervical spine in unevaluable patients such as those with head injuries given the inadequacy of cervical spine radiographs remains contested, for resource reasons, among others.

Finally, in instances where CT cervical spine is ordered in patients with head injury and suspected cervical spine injury, the approach and decision are unclear as it is not based on any existinginstitutional protocols.

Primary assessment recommendation for cervical spine trauma in the United States is Computed Tomography. However, some practitioners believe that the cervical spine can never really be “cleared” based on computed tomography alone as it has been shown to miss ligamentous injuries [31]

2.5 Mechanisms and Patterns of Cervical Spine Injuries

The most common mechanism of injury for cervical spine trauma worldwide is motor vehicle accidents, constituting over 50% of all cervical spine injuries. The other mechanisms including fall from significant heightcapped at about 10 feet; low energy falls in the geriatric population, and assaults such as results from direct blows to the cervical spine contribute to the remaining 50% of cervical spine injuries

Locally, JW Kinyanjui conducted a prospective study of the pattern of spinal injuries, management, and outcomes at the Kenyatta National Hospital, and surmised that road traffic accidents comprised the most common mechanism of cervical spine injury at 55%, while 37% of the injuries were a result of fall from height. The study also discerned that C4 and C5 were the most injured vertebrae. These findings are in keeping with a 5-year retrospective study undertaken at the University of Nairobi and Kenyatta National Hospital by JG Kiboi andthat established road traffic accidents to be the prevalent mechanism of cervical spine injury at 36%, followed closely by fall from height at 27%.

Shrago et al sought to establish the association between head injury and cervical spine injuries anddiscovered that upper cervical spine injuries of C1, C2 and C3 often occur in concurrence with head injury, compared to injuries at the lower region of the cervical spine. In fact, 50% of cervical spine injuries in patients with head injury were seen in the upper cervical spine; 34% in the middle and 10% in the lower end of the cervical spine. [32]

Hideo I et al studied the association between head trauma and cervical spine injury, spinal cord injury or both, among Japanese subjects and established that both cervical spine and spinal cord cords injuries were both associated with head trauma. Not only did the study discovered an association between head trauma on the one hand and spinal cord and cervical spine injury on the other. It reiterated Shrago's findings that the more severe the degree the of head injury, the more proximal the cervical spine trauma and the more severe the extent of spinal cord injury. This goes to show that proximity of the cervical spine segment to the head is important in predicting the prevalence as more cervical spine trauma would be anticipated at the upper cervical spine than any other area of the cervical spine[33]

2.6 Classifying Cervical Spine Injuries

Classification systems have been consistently used by clinicians and researchers to describe mechanisms and patterns of cervical spine injury. Over the years, numerous classification schemes have been developed with the aim of improving upon previous systems. Holdsworth, for instance, emphasized the importance of classifying spinal fractures to guide treatment decisions, highlighting the stability conferred by the posterior ligamentous complex. Allen and Ferguson introduced a mechanistic system dividing the cervical spine into six classes based on different injury types. Other schemes, like Harris et al., made minor modifications to the Allen and Ferguson design[.34, 35,36]

Holdsworthexemplify this phenomenonbecause he brought to fore not only the factors that should determine classification but also the importanceof classifying spinal fractures in the first places: to guide treatment decision. In doing this, henoted that certain injury patterns were "stable" whereas others where "unstable". In particular, he pointed out that the posterior ligamentous complex was instrumentalin conferring stability to the spinal structure. In addition, Holdsworth, who derived his findings from a study of 2000 patients divided the spinal column into "anterior" and "posterior" columns, a concept that has persisted to this day, even if he didn't separate the cervical from the thoracolumbar spinal regions

Allen and Ferguson in 1982 studied 165 patients with cervical spine injuries and drew a mechanistic system that divides the cervical spine into 6 classes, namely: compressive flexion and extension; distractive flexion and extension; vertical compression and lateral flexion.

Other schemes such as that by Harris et al didn't depart significantly from the Allen and Ferguson design except only in nomenclature.

While no classification system has found universal acceptance. Some proposalsare more widely used than others and one of such classifications that has been broadly affirmed over the yearsis the Subaxial Cervical Spine Injury Classification System (SCICS) as developed by the Spine Committee of the Association of Osteosynthesis (AO Spine). This system borrowed from the Thoraco-Lumbar Injury Classification and Severity Score (TLICS) as well as from the preceding cervical spine injury scoring systems such as Sub-Axial Injury Classification and Severity Score (SLIC) which was produced by Spine Trauma Working Group Subcommittee (STSG), and the Allen and Ferguson classification scheme, among others. Importantly, the concern with the SLIC and the Allen & Ferguson systems is that they have poor inter-observer reliability and thus are inferior at helping with standardizing and guiding treatment decision making compared to the SCICS system

The superiority of the SCICS lies in the fact that it incorporates four important descriptors such as injury morphology; facet involvement; neurological status and patient specific modifiers and assigns incremental alpha-numeric characters suggesting increasing severity.

With regards to morphology, the SCICS approach provides 3 mechanistic subclasses: compression denoted as A injuries; tension band injuries considered as B injuries and finally translational or C injuries.

Type A or compressive injuries are subdivided into 5 groups and B into 3 subcategories, which are A0-A4 and B1-B3, respectively.

Facet injuries are further divided into 4 subclasses ranging from the nondisplaced F1 to the dislocated F4 injuries. More so, neurological status is sub-organized into 6 areas, N0-N4 and NX, with increasing numerical or alphabetical character, once again implying graduated complexity of the injury.

The fourth and final category is that involving patient-specific modifiers which include: capsulo-ligamentous injury with no disruption; significant disc herniations; presence of an underlying metabolic bone disease or stiffening condition and the involvement of vertebral artery, identified as M1-M4, in that order

JA Canseco et al, conducted a global cross-sectional survey in 2020 and developed the Sub-axial Cervical AO Spine Injury Score (AOSIS) to supplement the SCICS with regards to the development of an algorithm for accurately predicting surgical intervention likened to the Thoraco-Lumbar Injury Classification System[37]

While the classification systems above discussed at length the sub-axial spine, injuries of the upper cervical spine have proven more lethal and are likely to be missed on plain radiographs and may often require further characterization with computed tomography, but also with angiographic and magnetic resonance imaging studies. In addition, injuries to the upper cervical spine have the potential for being overlooked particularly in patients with head injuries, who usually have reduced level of consciousness. This usually leads to delays in recognizing injuries and determining the next course of action as well as preventable disabilities. This certainly does not imply that only the upper cervical spine (C0-C2) contains injuries at risk of being missed.

Indeed, subtle injuries of the subaxial cervical spine and cervical-thoracic junctions, among others present a diagnostic challenge for practitioners

2.7 Pattern of Upper Cervical Spine Injuries

2.7.1 CCIPITAL CONDYLES FRACTURE

These are rare fractures of the base of the skull resulting from varied mechanisms as axial loading or direct blow and are potentially fatal. In addition, they present with cranial nerve injuries and attempting to elicit cranial nerves IX-XII palsies is an important clinical consideration in patients with occipital condyle fracture.

Anderson & Montesano in 1998 provided a mechanistic classification for occipital condyle fractures while also incorporating stability and formulated 3 groups namely:

Anderson and Montesano consider Type 1 and 2 occipital condyle fractures to be both comminuted but minimally displaced and stable whereas Type 3 fractures are inherently unstable.While the forces that produce Type 1 and Type 2 fractures result from axial loading and direct blow respectively; the rotatory and lateral flexion forces pull the avulsed alar ligament making it unstable

Tuli et al sought to develop a classification system that rationalize the approach to treatment of patients with OCFs and noted that the Anderson and Montesano system did not have distinctive treatments for Type 1 and Type 2 OCFs. Because of this, Tuli and colleagues devised a classification anchored on not just the different treatment approaches for various subgroups, but on the stability of the Occiput-Atlas-Axis joint complex (C0-C1-C2).

Thus, whereas Tuli type 1 are the stable, undisplaced OCFs that require no treatment; type 2A is also grouped as a stable but displaced fracture which can be treated with a rigid collar while

Type 2B, can be treated either surgically or with Halo traction owing to the instability of the cranio-cervical junction [38,39,40]

2.7.2 ATLANTO-OCCIPITAL DISLOCATION

Traumatic atlanto-occipital dislocation like occipital fractures are also rare but fatal injuries of the cervical spine. The lethal nature of this injury is attributable to either the attendant ponto-medullary stretch or laceration resulting in respiratory compromise or may be vascular in nature, involving the carotid and vertebral artery lesions. Biomechanically, the severance of alar and tectorial ligaments as well as osseous stabilizers of the cranio-cervical joint complex are a pre-requisite step to atlanto-occipital dislocation, which involves high energy force that typical originates from multiple directions

Atlanto-occipital injuries have been grouped into altanto-occipital injuries (proper), commonly known as traumatic atlantooccipital dislocation and occipital condyle fractures.

2.7.3 ATLAS FRACTURE

Fractures of the Atlas constitute about 7% of all cervical spine injuries and occur either solely or in combination with the axis. Many classification systems have been developed to describe different fractures of the C1 and incorporating varied mechanisms. This includes isolated fractures of the anterior and posterior arches; combined fractures of the two arches termed Jefferson's fracture and fractures involving the lateral masses and the transverse processes. Many systems recognize fractures other than Jefferson's to be benign and recommend conservative approaches for their management.

The stability of Jefferson's fracture is based on the integrity of the transverse atlantal ligament. Whereas severance or avulsion of the ligament makes the fracture unstable, its preservation confers stability to traumatic C1 fracture.[38,39]

2.7.4 AXIS FRACTURE

Many authors have categorized axial injuries into odontoid, isthmus and fractures occurring around the body. As such fractures of the isthmus have been called “Hangman’s” while those occurring around the body have been termed “Miscellaneous” fractures. Many authors have placed the incidence of axial fractures at between 15-18% of all cervical spine injuries. In addition, axial fractures have a biphasic mechanistic occurrence with those resulting from high energy trauma and happening among younger patients on the one hand and those occurring in the elderly population because of trivial trauma on the other. The mechanism may be varied but includes a mix if hyperextension, hyperflexion, and axial loading.[38,40]

2.7.4.1 Odontoid Fractures

Depending on the location and the geometry of fractures, odontoid injuries have been subdivided into Type 1, involving the Odontoid tip; Type II, occurring at the base of the Dens and Type III extending into the axial body. Type II injuriesare the most recurring fractures of C2 and the most challenging to treat owing to high incidence of non-union and as such, effort should be made to recognize and treat them early[39]

2.7.4.2 Traumatic Spondylolisthesis of Axis

While many authors have collectively referred to factures of the lateral mass, pars interarticularis and lamina as “Hangman’s” suggesting allusion of death to judicial hanging, Traumatic Spondylolisthesis of the Axis typically refer to the fractures of the pars interarticularis.

The mechanism usually results from a series of events commencing with hyperextension of the cervical spine, loading the pars often bilaterally and followed by secondary flexion that results from disruption of the posterior longitudinal ligament, which finally leads to C2/C3 disc subluxation. The position of the fracture configuration; extent of antero-posterior deviation;

integrity of the posterior longitudinal ligament and facetal dislocation are some of the considerations that are made when grouping Hangman's fracture into stable and unstable for deciding treatment.

Like prior fractures mentioned, osteosynthesis following unstable Hangman's comes from surgical treatment while immobilization alone usually brings about healing in stable fractures

Besides the injuries of the cranio-cervical junction, the other anatomical region of importance is the cervico-thoracic junction, where injuries are likely to be missed.[40]

2.7.5 CERVICO-THORACIC JUNCTIONAL INJURIES

The cervicothoracic junction is an inflection point where the cervical spine transition to the less mobile thoracolumbar. While injuries at this area are usually not life threatening, and consist of fractures and fracture-dislocations mainly, they present difficulty during surgical fixation and are also poorly visualized when imaged radiographically. Evans et al reported the incidence of cervicothoracic junction injuries at 2.4% of all cervical spine injuries, among 587 cervical spine injuries that were studied over a 26 year-period

2.8 Radiology of Cervical Spine Trauma

2.8.1 LATERAL VIEW

Lateral cervicalspine radiograph provides the most accurate view of the cervical spine and when technically adequate, can visualize about 70% of traumatic cervical injuries.Among the prominent features that clinicians look for in a lateral cervical spine radiograph are the cervical spine contours as described by Harris et al. These contours include the following lines: anterior vertebral line; posterior vertebral line; spinolaminar line; posterior spinous line or spinous process line. As well, the lateral cervical spine radiograph provides information on soft tissue shadow or retropharyngeal space widening; cervical spine curvature; subluxation and loss of vertebral height and other signs of fractures.

When any of the contour lines is disrupted,it calls for further evaluation and invariably for cervical spine immobilization just as when fractures are noted.

Additionally, the odontoid peg should also be continuous posteriorly with the posterior vertebral line.The lateral cervical spine view shows a corticated ring projected over the base of the Odontoid and body of Axis.

The circle, known as the Harris's Ring, may sometimes be deficient at the superior and the anterior poles, which are often within the spectrum of normal appearance. Disruption of the ring is suggestive of fractures either at the base of the Odontoid or body of Axis.[40,41]

2.8.1.1 Important lateral cervical spine parameters

The other crucial measurements of the cranio-cervical junction include the following:

2.8.1.1.1 Basion-Dens and axial intervals

Basion-Dens interval is a line drawn from the Basion to the tip of Dens and is considered normal when less than 12mm. On the other hand, the Basion Axial Interval is the horizontal distance between the Basion and the anterior aspect of the posterior arch of the Atlas. Just like the BDI, a value of less than 12mm is considered normal for BAI.This is the other important radiographic measure of the distance between the posterior inferior margin of the atlas and the anterior aspect of dens.

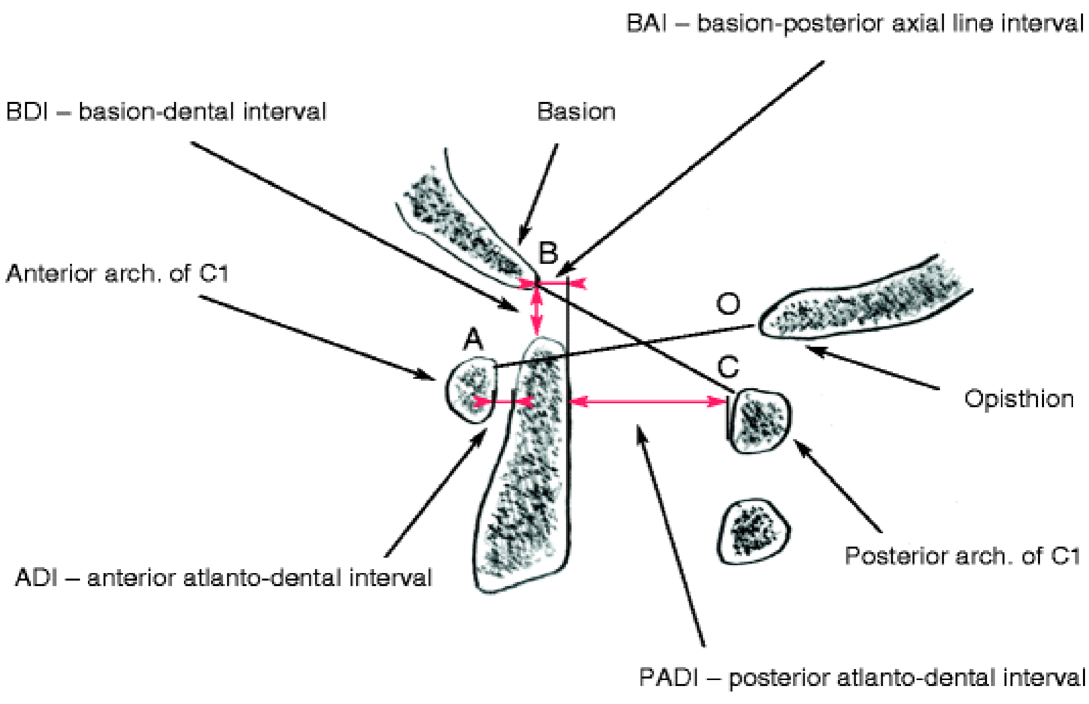


Figure 2: Copied from the Textbook of Special Radiology, By Choutka, 2010.

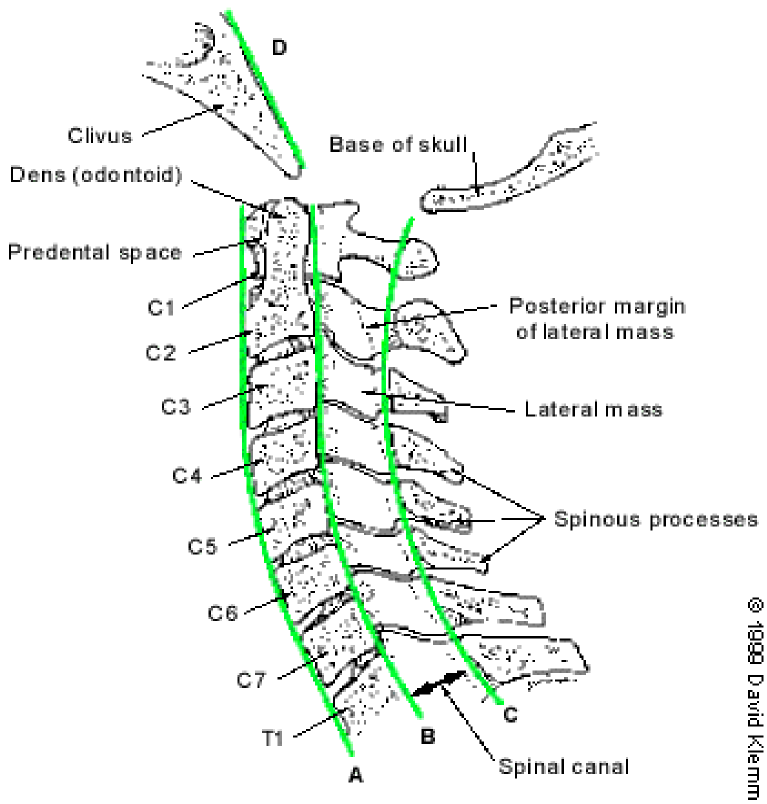
2.8.1.1.2 Atlanto-dental Index

This is the other important radiographic measure of the distance between the posterior inferior margin of the atlas and the anterior aspect of dens. In uninjured subjects, it measures less than 3mm.

2.8.1.1.3 Power's Ratio

Power's ratio measures the relationship between the occiput and the vertebral column and is sensitive primarily for anterior occipito-cervical dislocation. The first distance, which is the numerator runs from the Basion to the posterior aspect of the arch of C1 or the spinolaminar line and is termed the AB distance. The second line, or the CD distance runs from the Opisthion to the anterior arch of Atlas. A ratio greater than 1 is indicative of anterior translation of the head over the vertebral column, or anterior translational injuries while a ratio of less than 0.5 is demonstrative of posterior occipito-cervical dislocation. Though it's recommended that these measurements are taken on plain film, they can also be taken from computed tomographic images.[41,42]

Figure 2: Schematic Presentation of the lateral view of the Cervical spine



Schematic presentation of the lateral cervical spine showing (1) Anterior vertebral line; (2) Posterior Vertebral Line; (3) Spinolaminar line and (4) Posterior Spinous line. And an x-ray depiction of the same.

2.8.2 NON-LATERAL CERVICAL SPINE RADIOGRAPHS

Anteroposterior View

The antero-posterior projection is among the cervical spine radiographic views that provides the least information. However, practitioners should ensure that the spinous processes are centrally situated along the midline;disc spaces are equal in size; vertebral heights are all similar and that adding an anteroposterior view improves the adequacy to more than 75% as C. Moulton, et al demonstrated in study involving 120 cervical spine trauma patients in Salford, Englandmargins of the lateral masses are smooth[43]

2.8.2.1 SWIMMER'S VIEW

Because the shoulders obscure the cervicothoracic junction in lateral cervical spine radiographs, it may often become necessary to have the swimmer's view for the visualization of the cervicothoracic junction. To be able to undertake this view, the arms aremoved away from the cervicothoracic field, either over the head or the posteriorly[43]

2.8.2.2 OPEN-MOUTH ODONTOID

This is an anteroposterior projection of upper cervical spine taken while the mouth is open

While initially developed to visualize the bony continuity of the Odontoid process of C2, it is useful in picking fractures of C1, assessing the integrity of the transverse atlantal ligament using the Rule of Spence and in evaluation of C0-C1 fractures. It also assessed helps with the assessment of alignment of the lateral masses of C1 and C2. A combined C1-C2 overhang of about 7mm is indicative of disrupted transverse ligament. While it is often challenging to perform open-mouth Odontoid views in patients with reduced level of consciousness, CT scans for the upper cervical spine may be considered[43]

2.9 TECHNICAL ADEQUACY

From a population of 273 patients studied at the Royal Perth Hospital in Western Australia, the probability of missing a cervical spine fracture in a technically adequate radiograph was 6.1% whereas the miss rate for technically inadequate film was at 6.9%. This means that even when the plain films are competently done, subtle and debilitating injuries can be invariably missed owing to the inferiority of plain radiography in visualizing injuries.

One of the features that researchers look out for in deciding about the adequacy of the cervical spine film is the demonstration of the complete cervical spine. This completeness often implies that radiographs envelopes the entirety of the cervical spine from occiput all the way to the upper border of thoracic one vertebra.

While it may not be entirely possible to obtain perfect, error-free radiographs, some of these modalities can be optimized to ensure more accurate radiological results such as to position patients appropriately for a particular view. As well, other ways of improving visualization at either the junctional areas or through the entirety of the cervical spine include utilization of computed tomography, particularly for bony injuries

Poor Sensitivity and Specificity of Plain Films for Cervical Spine Injuries

A meta-analysis conducted by Homes and Akkinepalli of the University of California, Davis, compared the test performance of computed tomography and plain radiograph in visualization of cervical spine injuries following blunt trauma and found a pooled sensitivity of CT and plain radiographs to be 98% and 52%, respectively. Further, the results concluded that CT scan remarkably outperformed plain radiographs in the detection of cervical spine injuries in adult patients at high risk for cervical spine injuries such as those with concomitant cervical spine injuries. However, for patients at minimal risk of cervical spine injuries, the study recommended that plain radiography remains as the imaging modality of first choice.

In another study, also undertaken in the United States, 1687 patients reviewed at the University of Alabama Trauma Center established that 45% of cervical spine injuries were missed with plain radiography, compelling the institution to undertake CT scans on all patients with blunt trauma and requiring clearing of cervical spine, despite absence of head injury or preservation of consciousness [44]

While assessing the suitability of the Eastern Association for the Surgery of Trauma (EAST) guideline, for the evaluation of cervical spine following blunt trauma, Gale et al concluded that plain radiography was inadequate in the full assessment of cervical spine trauma. And that CT should replace plain radiography in the acute cervical spine trauma with specificities of 99.2% and 31.6%, respectively[45]

This finding closely resembled those of the University of Florida's Department of Surgery, where a cohort of 1099 underwent both plain films and CT scans. Out of the 116 fractures identified on CT scan, 46 had been missed on previous cervical spine radiography, constituting 35.3 % of all the fractures

2.10 comparing Performance in Patients with Reduced Level of Consciousness

Several studies have been carried out to ascertain the test performance of computed tomography and plain radiography in the evaluation of cervical spine trauma in patient with reduced level of consciousness which is commonly seen in head injured patients.

In a prospective comparison of multisliced computer tomography with 3-dimensional reconstruction with 3-views plain radiography among 667 patients, in 2007, Mathen et al found that CT outperformed plain radiography as a screening modality of first choice for general visualization of acute c-spine injuries, with an overall sensitivity and specificity of CT scan at 100% and 99.5%, respectively, and those of plain radiography at 45% and 97.4%, respectively. Interestingly, 55.5% of the injuries that had previously been missed on plain radiograph were found on assessment with computed tomography.

In Canada, Demetriades et al, in 2010 recommended that computed tomography be the sole radiological intervention for clearing cervical spine in adults with altered mental status. The study did not support the use of dynamic flexion-extension radiographic studies in the obtunded adult patient population owing to the possibility that it could worsen cervical spine injurie and established that CT scan had a high sensitivity of 97.5% in that patient population.

In addition, John Berne from the University of Southern California set out to prospectively determine the value of computed tomography in 58 adults with blunt trauma, multiple injuries and who were also unevaluable, and requiring intensive care and established that CT scan was more reliable compared to plain radiography in the identification of cervical spine injuries in adult patients who were had concomitant traumatic brain injury. Specifically, the author reported sensitivity of 60% in plain radiographs compared to 90% for CT scans.[12,21,47]

In a 2003 prospective study by Diaz et al, 1006 adult patients with suspected cervical spine trauma and altered mental status were examined. The study found that computed tomography (CT) was more effective than five-view cervical spine radiographs in identifying injuries, detecting 52.3% of previously missed injuries. Additionally, the five-view radiographs failed to identify 93.3% of unstable occipital condyle fractures. While both radiographs and CT had a specificity score of 100%, the sensitivity of radiographs was 44% compared to 100% for CT[48]

Another prospective study by Schenarts et al in the United States focused on diagnosing upper cervical spine injuries in adults with head injuries. The study revealed that up to 45% of clinically significant upper cervical spine injuries were initially missed with plain films, highlighting the superiority of CT in identifying injuries between the C0-C3 region.[49]

A systematic review conducted by Cain et al in the United Kingdom compared the diagnostic accuracy of CT and plain radiography in identifying cervical spine injuries. The review concluded that the choice of diagnostic modality should be based on the relative risk of the patient. High-risk patients, such as those with concomitant head injuries, would benefit from CT scanning as the initial imaging modality, while low-risk patients would undergo plain radiography for screening.The study demonstrated that initial CT scans identified all unstable cervical spine injuries, and additional plain radiographs did not reveal any previously unidentified injuries but delayed the clearance process.[50]

There is ongoing debate regarding the utility of cervical spine flexion-extension radiographs in the evaluation of acute cervical spine trauma. Some authors argue that these radiographs still have a role, particularly in detecting ligamentous injuries, while others believe that dynamic flexion-extension fluoroscopic studies provide limited value where spine motion is restricted, which is often the case in acute tender spinal injuries, and especially following negative plain radiographs.[51]

2.11 Computed Tomography vs Plain Radiography in Patients with Head Injury

The utility of plain radiographs in diagnosing cervical spine injuries in adults with head injuries is dependent on the risk factors. The risk of cervical spine injuries in head injury patients is estimated at 4.5%, which significantly increases in patients with a Glasgow Coma Scale score of 8 or below, reaching up to 10% according to some authors. Patients with severe head injuries are more likely to have false negative plain radiographs due to technical inadequacies. In addition to patients with head injury are also those with clavicular and facial injuries where the incidence of cervical spine injuries and specifically upper cervical spine injuries rises as described by William, Pandrich and PK Njoroge, locally

Thesleff added that patients with intracranial lesions are at an increased risk of having concomitant cervical spine injuries, adding non-contrast CT Head to Glasgow Coma Scale of less than 15, as important proxies of head injury.[52,53,54,55]

It is important to note that the actual incidence of these injuries is still dependent on the imaging modality utilized to detect them. The diagnostic yield of detecting unstable fractures in the assessment of cervical spine injuries is critical in preventing avoidable neurologic complications. This highlights the necessity of utilizing computed tomography (CT) screening, as it offers superior sensitivity compared to plain radiography. However, authors such as Neifeld found CSR to be valuable in the identification of high-risk cervical injuries, further complicating the debate, but also implying CSR as an important modality for evaluating high-risk CSI in resource-constrained settings, in spite of the wide availability and acceptance of the CT cervical spine.[56]

Therefore, CT scanning is recommended as the primary radiological screening tool for high-risk patients, such as those with polytrauma, distracting injuries, junctional areas and concomitant head injuries.

Table 2: Summary of the diagnostic accuracies of computed tomography as compared to plain radiography of the cervical spine. Table drawn from articles published by the authors listed below by Holmes and Mathen, among others.

Study	Imaging	Sensitivity	Specificity	Positive	Negative

	Modality of the Cervical Spine			Predictive Value	Predictive Value
Holmes &Akinnepalli, 2005	Computed Tomography	98%			
	Plain Radiography	52%			
Bailitz,2009	Computed Tomography	100%			
	Plain Radiography	36%			
Mathen,2017	Computed Tomography	100%	95%	95.2%	100%
	Plain Radiography	45%	97.4%	62.8%	94.7%

2.12 optimizing Radiological Care of the Cervical Spine in Patients with Head Injury

Radiographic evaluation of the junctional cervical spine areas as the cervico-thoracic spine and the occipito-cervical area has been shown to miss important injuries.

In a study of 100 patients presenting to the emergency department with severe trauma in the United States, and who were imaged with computed tomography and AP, lateral and Swimmer's view. The study established that 8% of the craniocervical junctional injuries that were missed on plain radiography where visualized upon examination with CT scan. These injuries included Atlanto-occipital and Occipital condyle fractures.

This finding was reiterated by Link et al who noted that cervical junctional injuries such as occipital condyle fractures, C1 all the way to C3 fractures are likely to be missed on plain radiograph, suggesting the limited role of plain radiographs in elucidating fracture of the cranio-cervical region.

In addition, cervicothoracic computed tomography was also found to be superior at demonstrating injuries than plain radiography in patients with polytrauma including those with concomitant head injuries

2.13 Non-contiguous cervical spine injuries

The other issue is that of the best modality for diagnosing non-contiguous spine injures, which are injuries with at least a normal intervening vertebra, and that can occur at any part of the spinal column as documented by Sharma et al. Non-contiguous injuries constitute about 10% of the all spinal injuries. Because non-contiguous injuries by their nature have a mobile segment between them, they often require surgical intervention and usually a CT is required for appropriate assessment, including preoperative evaluation, as described by Shear and Vaccaro et al. [57,58,59,60]

2.14 SPINAL CORD INJURIES WITHOUT RADIOLOGICAL ABNORMALITY (SCIWORA)

SCIWORA is a clinically appreciable posttraumatic myelopathy that occur in the absence of positive radiological findings mainly radiographic but also CT and MRI.

While its’s a vertebro-radiological entity seen in children because of laxity afforded to the pediatrics vertebra-ligamentous complex, it has now been described in adults.

Owing to difficulties in classifying SCIWORA and the fact that there are often other extra-spinal morbidities, a segment of the spine research community has come up with the term Adult SCIWORA to describe this disease entity that is mainly seen in the cervical spine but much less in the thoracic and lumbosacral region. Finally, SCIWORA was described in patients that had undertaken radiographic assessment, and it's likely that some of the more advance diagnostic modalities may pick features such as bony bruising in SCIWORA and thus heightening the radiological recognition[61]

2.15 Cervical Spine Immobilization

Cervical spine immobilization is a common practice in prehospital settings for suspected cervical spine trauma. It is widely recognized for its role in preventing further instability and managing acute cervical spine trauma. It is particularly useful in the conservative treatment of certain nondisplaced fractures. A systematic review conducted by MB Patel et al., focusing on cervical collar clearance in patients with decreased level of consciousness, highlighted the importance of CT scans in the initial evaluation of head injuries and recommended collar removal after a negative CT.

Early mobilization of the cervical spine, performed by medical emergency assistants at the accident scene, has been shown to reduce the risk of secondary injuries. The discontinuation of the cervical spine immobilization protocol can be based on negative 3-views plain radiographs or negative computed tomography, even for unconscious patients. This approach is commonly followed in the United Kingdom and Africa.

However, in certain cases, particularly in the United States, some entities advocate for additional requirements such as negative MRI or negative dynamic fluoroscopic studies. These modalities are highly sensitive in detecting ligamentous injuries of the cervical spine, and if they show normal results, it usually indicates an intact cervical spine. Failure to meet these requirements suggests the need to continue cervical immobilization.

Clinicians must carefully balance the risk of missed injuries against the potential harm of prolonged immobilization. This consideration is crucial when making decisions regarding cervical spine mobilization. It is important to note that around 25% of patients with head injuries may not regain full radiological function, emphasizing the need for cervical spine mobilization regardless of the level of consciousness.[62]

2.16 Limitations of Cervical Spine CT

While the CT scan carries the additional benefitof superior visualization and 3-dimensional manipulations otherwise termed as cuts, all of which increase sensitivity and specificity and thus improving the detection of cervical spine injuries, the computed tomography of the cervical spine exposes the body and particularly organs like the thyroid gland to 14 times the radiation dose than would have resulted from single examinationof the cervical with plain radiography

To quantify this, CT scan of the cervical spine emits to the body about 28.7 mGy of radiation compared 2.4 mGythat is emitted from the plainradiography of the cervical spine[63]

Secondly, computed tomography picks almost of the bony injuries of the cervical spine but misses about 6% of the ligamentous injuries that can be easily picked by either dynamic flexion-extension radiographs or the Magnetic Resonance Imaging.

Thirdly,J Berne concluded that plain radiography of the cervical spine was superior in accurate identification of 93% of the subluxation and dislocations compared to only 54% of the subluxations seen on computed tomography, which is considered the ideal initial imaging modality for cervical spine trauma patients with concomitant head injuries

2.17 Sensitivity of Cervical SpineRadiography as compared to the Computed Tomography of the Cervical Spine

The comparative sensitivity of CST vs CT in diagnosing cervical spine injuries is well-established. In the United States, for example, among the over 10 million blunt trauma patients screened for cervical spine injuries, only 2% of both plain radiographs and CT scans indicate the presence of cervical spine injuries. This means that 98% of the radiological images obtained show normal findings implying that majority of cervical spineimaging performed among alert patients are likely to result in negative findings.

This tendency for the cervical spine radiographs to be negative in alert patients has led certain authors to be quip that plain radiographs be preserved for low risk patients and higher order imaging devices such as CT be used in patients at increased risk of cervical spine injuries.

Ghanta and Davis emphasized this thinking that plain radiography of the cervical spine has limited utility in the acute evaluation of cervical spine injuries and is no longer considered a routine evaluation tool. In addition, Hashem, Thomasand Griffenboth contend that there appears to be no role for cervical spine radiographs in the evaluation of cervical spine injuries in patients with head injury.[64,65,66,67]

The comprehensive evaluation of cervical spine injuries heavily relies on CT scans due to their exceptional diagnostic capabilities in the identification of unstable fractures and minimization of the risk of potential neurological complications. For instance, Diaz et al demonstrated that CT scans detected approximately 17% of fractures, previously missed by CSR and most of which classified as unstable.

In the initial radiological evaluation of adults with head injury and suspected cervical spine trauma should take into account various factors such as specificity, sensitivity, cost, and availability. While it is essential to carefully balance these considerations with the potential risk of diagnostic delays that may occur if any injuries are missed, it is crucial to prioritize the imaging modality that offers the highest sensitivity for detecting unstable injuries.

The ultimate goal is to ensure timely and accurate diagnosis while minimizing the potential for adverse patient outcomes.

As stated by Cain et al, the choice of appropriate screening imaging should follow a risk-stratified approach. Patients with head injuries and suspected cervical trauma should undergo CT evaluation without the need for plain radiography. Conversely, patients at a low risk for cervical spine injuries may undergo plain radiography as the primary imaging modality for initial assessment. This approach ensures prudent utilization of radiological resources while effectively visualizing all significant injuries. This position echoes that of Blacksin who recommendedutilization of cervical spine CT where upper cervical spine injuries are suspected, particularly occipital condyles and C1 & C2.[68]

One of the factors contributing to the growing preference for CT scans over cervical spine radiographs (CSR) is the recognized inadequacy of CSR. BM Ndeleva's study conducted at Mulago National Hospital, Uganda, revealed that approximately 58.6% of CSR were deemed inadequate. This finding has been supported by Gerrelts and echoed by other researchers, further reinforcing the limitations of CSR as a standalone diagnostic tool for evaluation pf cervical spine trauma.[69,70]

Certain radiological devices are capable of identifiying structures that are important inthe determination of cervical spine instability and subsequent treatment intervention, as reported by

Joaquim who found that determination of the status of upper cervical spine ligaments was important in deciding whether the patients would be treated surgically or conservatively [71]

Like ligamentous instability, timing of surgical decompression can be determined by the choice of radiological modality as CSR, owing to their inadequacies, can result in delayed intervention as espoused by Seybold as well as Fehlings and Vaccaro in their landmark study: STASCIS, which established an improvement in clinical outcome of up to two ASIA grades if surgical decompression is undertaken within 24 hours of spinal injury[72,73]. Adopting a risk-stratified approach, such as the NICE guidelines on the management of cervical spine injuries as often captured in hospital-basedcervical spine protocol in other places and function just as clinical decision rules, could lead to improvements in clinical outcomes

Theologis et al found that cervical spine protocols exist in only 57% of level trauma 1 hospitals in the United States. While such protocols are variable, they provide a standardized approach of caring for cervical spine patients and their adoption in major trauma hospitals should be encouraged. Utilization of cervical spine protocols could optimize the use of radiological resources, minimize unnecessary delays in diagnosis, forestall untoward clinical outcomes, and ensure that all important injuries are promptly identified and addressed.[74,75]

2.2 Conceptual Framework

Independent Variables		Dependent Variables

- Demographic Factors—Age and Gender
- Clinical Features—Cervical Spine symptoms and GCS
- Mechanism and pattern of cervical spine injury
- 2-views plain radiography
- Reformatted computed tomography of the cervical spine
- Presence of Cervical Spine precaution

⇒

- Cervical spine injuries diagnosed with cervical spine radiography
- Cervical spine injuries diagnosed with computed tomography of the cervical spine
- Type of cervical collars worn by patients and their fit

2.3 Justification for the Study

Several studies examining the sensitivity of cervical spine radiography as compared to cervical spine computed tomography (CT) have been conducted in North America and Europe. However, the local sensitivity of cervical spine radiography in Kenya and the surrounding region remains unknown.

Considering the projected increase in road traffic accidents and the rise in medico-legal litigations related to these incidents, it is imperative to ensure high-quality care for patients with concurrent head and cervical injuries. Additionally, the advantages of CT scans, such as better sensitivity for cervical spine injuries and faster clearance of the cervical spine, have been well-documented.

This study aims to fill the current knowledge gap by investigating the sensitivity of cervical spine radiography in our local context. The findings of this study will provide valuable clarity on the appropriate approach to imaging in patients with head injuries and potential cervical spine involvement. The results may support the adoption of a risk-stratified approach, where selected high-risk patients proceed directly to CT scans, or they may provide evidence to support the practice of conducting radiographs in all patients, regardless of risk, thereby ensuring prudent resource utilization.

By conducting this study, may help contribute to improving patient care, optimizing resource allocation, and enhancing clinical decision-making in the management of head and cervical injuries. It is essential to gather local data to ensure that our practices align with the specific needs and circumstances of our patient population.

2.4 Study Objectives

2.4.1 RESEARCH QUESTION

What is the diagnostic accuracy of cervical spine radiography as compared to cervical spine computed tomography scan in diagnosing cervical spine injuries in adult patients with head injury?

2.4.2 BROAD OBJECTIVE

To establish the diagnostic accuracy of cervical spine radiography as compared to cervical spine computed tomography scan in diagnosing cervical spine injuries in adult patients with head injury

2..4.3 SECONDARY OBJECTIVES

1.To establish the demographic characteristics of adult patients presenting with head injury at the Kenyatta National Hospital

2.To determine the sensitivity, specificity, positive predictive value, and negative predictive value of two-view cervical spine radiographs in diagnosing cervical spine injuries in adult patients with head injury.

3.To determine the sensitivity, specificity, positive predictive value, and negative predictive value of computed tomography of the cervical spine in diagnosing cervical spine injuries in adult patients with head injury.

4. To establish type and fitness of cervical spine immobilization.

CHAPTER THREE: METHODOLOGY

3.1 Study Design

This is a cross-sectional, observational study among adult patients presenting with head injury, a clinical suspicion for cervical spine trauma defined by Glasgow Coma Scale of less than 15

3.2 Study Description and Setting

The study shall be undertaken at the following unit of the Kenyatta National Hospital, namely, the accident and emergency department, orthopedics, general surgical and critical care units of the Kenyatta National Hospital, an 1800-bed capacity major referral facility located in Nairobi, Kenya.

3.3 Study Duration

The Study shall run from September 30, 2022 to July 31, 2023.

3.4 Study Population

This will comprise adults (18 years and above) subjects presenting with head injury at the accident and emergency department, all surgical wards, theatres and critical care units of Kenyatta National Hospital.

3..4.1 INCLUSION CRITERIA

Adults, defined as someone who has reached the legal limit of full age as capped at 18 years in accordance with CAP 33 of the constitution of the Republic of Kenya, that is presenting head injury diagnosed either with Non-Contrast CT scan of the Head or evidenced by GCS of 14 or below.

Availability of both CT scans with multiplanar view—sagittal, axial and Coronal and 2-standard views plain radiographs, lateral and Antero-posterior.

3.4.2 EXCLUSION CRITERIA

Those with either plain radiography or computed tomography but not both.

(Patients with incomplete series of plain radiographs or computed tomographic images)

Non-traumatic cervical spine injuries

Patients who next-of-kins have declined to consent for participation in the study

Patients with penetrating cervical spine injuries

3.5Sample Size Determination

The sample size determination for this study will follow that of the cross-sectional design as described by Andrew Fisher in 1998 and as adopted by the World Health Organization in 2002.

N=Z x Z x P(1-P)/dxd, where:

N is the sample size for the study

Z is the Z statistics for a level ofconfidence chosen which in this case of this proposal will be 95%

P is the expected prevalence or proportion as surmised from the literature review, and in this case, the prevalence of cervical spine injury in patients with head injuries.

d is the precision or measure of acceptable error chosen at 0.05.

95% confidence interval with a Z statistic of 1.96 will be utilized for this study.

The institutional incidence of cervical spine injuries in head injuries is 3.5%, which represents a proportion of 0.035, as established by E. Soicher, in Johannesburg, South Africa[21, 76]

1.96 x 1.96 x 0.035(1-0.035)/0.05 X 0.05

3.8416 x 0.035(0.965)/O.0025

0.12975/0.0025

51.90

=52

3.6 Study Procedure

All adult participants with head injury and have both 2-views plain radiography—anteroposterior, lateral, and computed tomography of the cervical spine with 3 cuts namely, sagittal, coronal and axial.

Images will be read by the principal investigator, and a consultant radiologist for the presence, location, mechanism of cervical spine injury and the principal investigator will record the findings in password protected Kobo-tool box.

Where the images obtained are interpreted by the principal investigator and a consultant radiologist and a discrepancy exist between the findings of the principal investigator, and the findings as reported by consultant radiologist, the discrepancy will be resolved by consensus.

The reviewers will not be blinded to each other's interpretation.

Participants will be assessed for presence of cervical spine precaution.

3.7 Data collection

A study questionnaire will be used to collect patients' demographic characteristics; Glasgow Coma Scale; mechanisms and location of injury; neurologic level of injury and presence or absence of spinal cord injury. In this regard, a total number of cervical spine injuries diagnosed through either of the modalities will be recorded. As well as any prehospital cervical spine precaution undertaken, it's presence, what it is and whether it was done correctly.

3.8 Ethical Considerations

Patients will be de-identified and all data shall be kept in the possession of the principal investigator.

An informed consent and aims of the study shall be explained and sought from the patient or co-patient, who will be the next of kin to the patient.

Approval for this study will be sought from supervisors, and the ethical committee of the Kenyatta National Hospital and University of Nairobi.

3.9 Data Management, Quality Assurance and Safekeeping

All data collection tools, the hard and soft copies will be kept in the safe custody of the principal investigator. Where necessary, password protected folders will be used and research assistant will be trained on safe handling of the data.

3.10 Statistical Analyses

Categorical variables will be compared using Chi-square test or Fisher's exact test where the expected subgroup size is smaller than five.

Continuous variables will be presented as medians and ranges and analyzed with the Mann-Whitney test.

The Bland-Altman difference plot will be used to compare two radiological modalities of plain radiography and computed tomography.

Receiver-Operating Characteristic (ROC) analysis will be used to evaluate diagnostic tests and predictive models, sensitivity, specificity, negative and positive predictive values will be determined, and comparison drawn between plain radiography and computed tomography.

The data shall be presented using appropriate tables, figures, and infographics where possible.

3.11 Study Results Dissemination

The findings of this study will be submitted to the thematic unit of orthopedic surgery, and the medical library of the Faculty of Health Sciences, University of Nairobi, for reference by the broad Kenyatta National Hospital community.

As well, the study will be submitted to peer reviewed journals for possible publication.

3.12 Study limitations and remediation strategies

The major limitation for this study is that the overall sensitivity of 2-views plain radiography has been shown to be 75%, which is much lower than what the ideal standard 3-views plain radiography would provide.

Because of the small sample sized nature of the study, and the potential impact that it can have on the validity of the results, the study recruitment will continue beyond the mathematically established number to increase the number to about 100 participants.

During the conduct of the study, there was a challenge in obtaining 2-views plain radiography as a majority of patients already had cervical spine computed tomography.

3.13 Covid-19 safety precautions

Infection prevention measures in general and Covid-19 infection will be observed by the research teams and participants including acquisition and donning of personal protective equipment (PPE) such as masking.

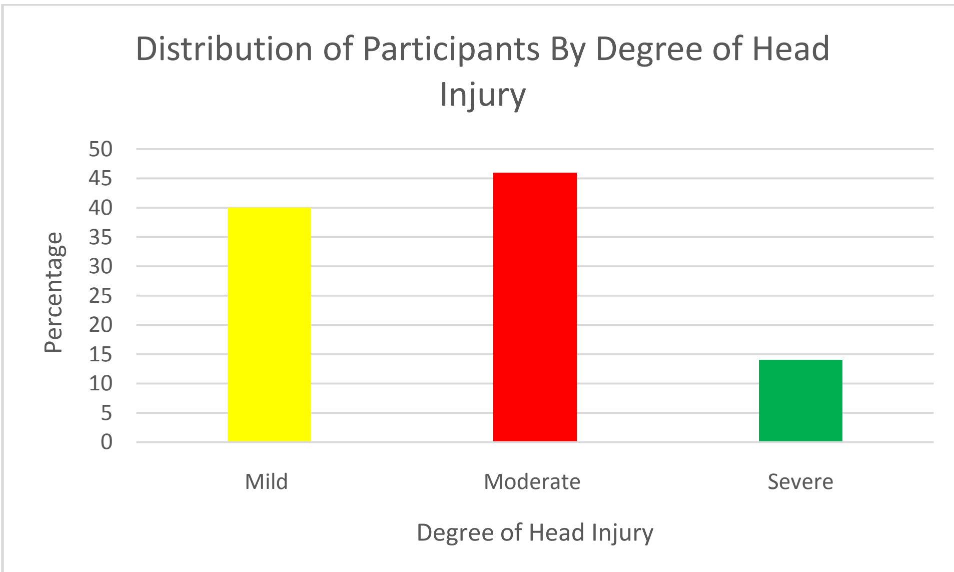
CHAPATER FOUR: RESULTS

A total of 57 participants who suffered head injury and underwent both computed tomography (CT) of the cervical spine with multiplanar reconstruction and 2-view cervical spine radiography for diagnosing cervical spine injuries met the inclusion criteria and were recruited into this study.

The median Glasgow Coma Scale (GCS) for the participants was 12 and the range was 7 and 14.

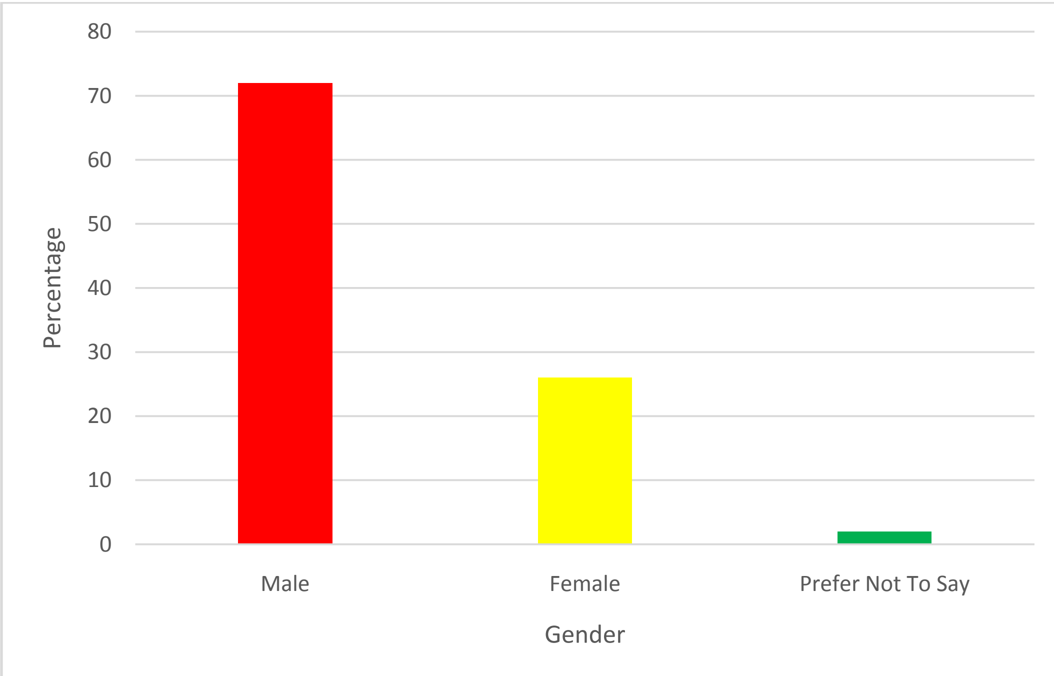
From the fifty-seven participants, 8 had severe head injury while 26 and 23 presented with moderate and mild degrees of head injury, respectively, as presented in the graph 3 below.

Figure 3 Represents Distribution of Participants by Degree of Head Injury



Out of the total number of participants, 39 individuals identified as male, accounting for approximately 72% of all participants. On the other hand, there were 15 female participants, making up approximately 26.3% of the total. It is worth noting that one participant chose not to disclose their gender of birth and preferred to be identified as gender neutral, as communicated by a relative.

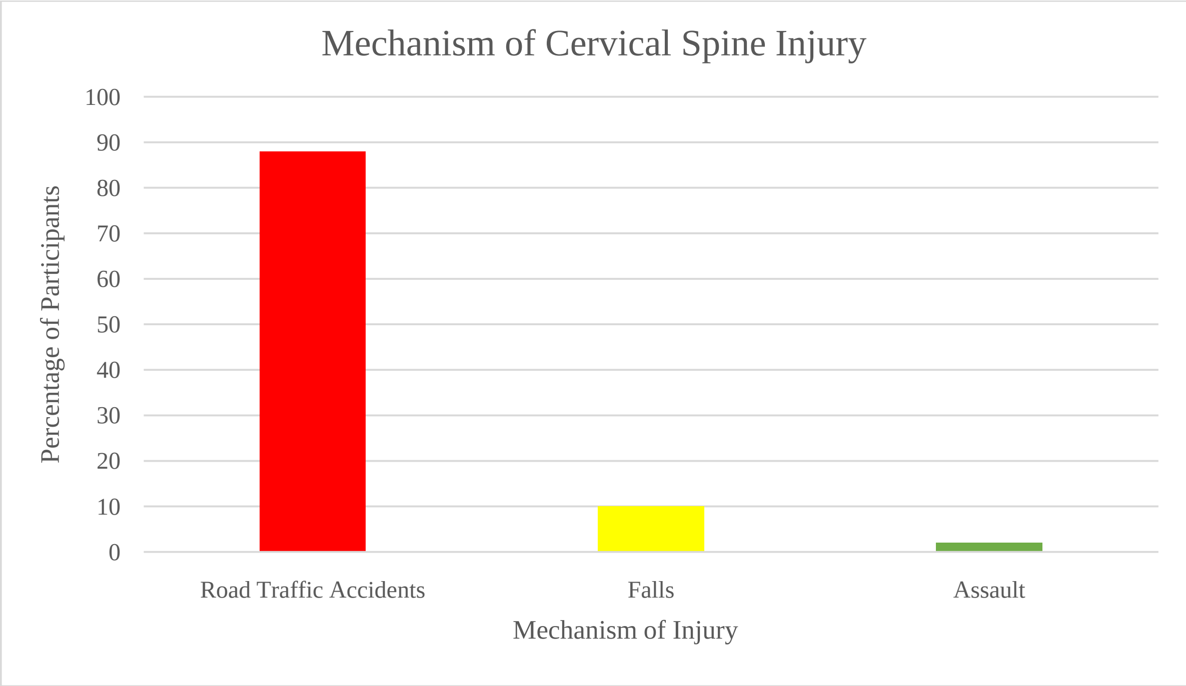
Figure 4 Depicts the Distribution of Participants by Gender



The mean age for the participants was thirty-nine years with the youngest participant being eighteen years of age while the oldest was seventy-three years.

It appears that road traffic accident was the dominant mechanism of injury of the cervical spine injury in patients with head injury. Of the fifty-seven patients, about 87.7 % sustained road traffic accidents while 10% and 2% suffered falls and assaults respectively. From the road traffic accident category, passengers and pedestrians of both vehicular and two-wheelers modules were the most impacted at 52% of all the accidents while motorcyclists were the second most affected group at 42%, and the remaining 6% were drivers of vehicular accidents.

Figure 5 Shows Distribution of Participants by the Mechanism of Injury



For the participants who sustained fall, a height range of between 10 and 30 meters was observed while the median approximate height was noted at 18.3 meters.

The study involved analyzing the clinical profiles of the participants, focusing on various parameters including focal neurological deficit, distracting injuries, and step-offs.

During the clinical examination of the cervical spine, a step-off was observed in only three out of the 57 patients upon palpation. This accounts for approximately 2% of the total injuries assessed. The presence of a step-off indicates a misalignment or discontinuity between adjacent vertebrae.

Close to half of the participants presented with neurological deficits, which predominantly manifested as tetraplegia as about 20 out of the 30 participants had both lower and upper limbs affected.

Regarding distracting injuries, out of the total 57 patients, seven individuals were identified to have distracting injuries. Among these patients, three had femur fractures, while the remaining four had injuries in the abdomino-pelvic and chest regions.

The proceeding table show some of the selected clinical profiles of the participants.

Table 4 Represents Selected Clinical Profiles for the Participants in the Study

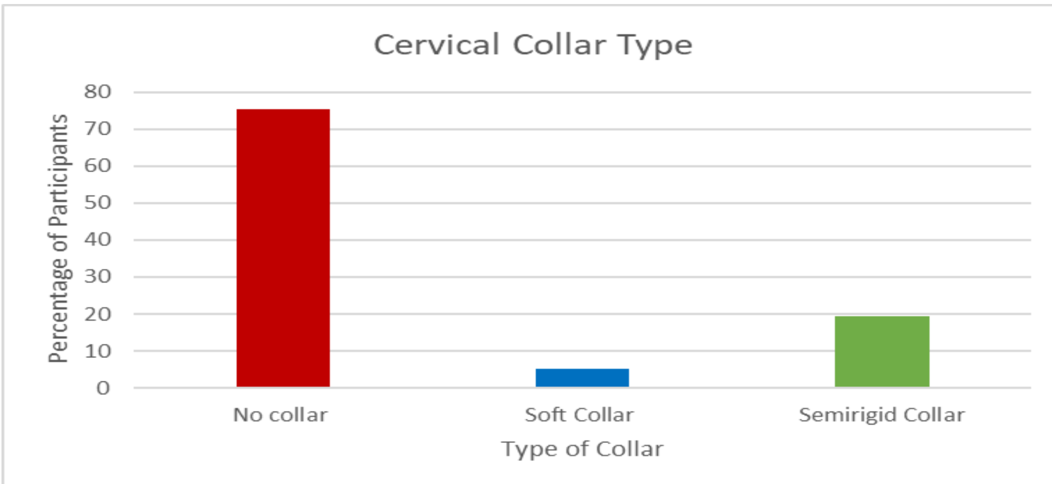
Variable	Total (n=57, %)
Focal Neurological Deficit, n (%)	
Absent	27(47)
Present	30(53)
Distracting Injuries, n (%)	
Absent	50 (94.3)
Present	7 (5.7)
Step Off, n (%)	
Absent	54 (98.2)
Present	3 (1.8)

The other important clinical feature from the results is that of cervical spine immobilization, which implies fitting of neck braces to avert possible fracture instability. Often, they are applied at the first point of clinical contact, usually at either the feeder hospital or by the emergency medical team during transportation to the hospital.

Overall, only 14 of the participants had some form of cervical spine immobilization. Of these, 11 participants had semi-rigid collars while the remaining 3 had soft cervical spine collars.

Regarding the fit of the cervical spine collars, about 6 were appropriately worn while the rest were fitted loosely. It was also observed that soft collars were likely to be properly worn than the semi-rigid collars.

Figure 6 Represents Cervical Spine Use and Type for the Participants



The most commonly injured cervical spine vertebra from this study was C6 at 6 (24%), which was closely followed by C3 and C5 at 4 (16.67%) of all the cervical spine injuries.

The fourth most injured cervical spine was C7 at 3(12.5%) while C2, C2 and C4 came at joint fifth position at 2(8.3%) each, representing close to a quarter of all cervical spine fractures.

The least injured cervical spine "vertebra" was the occipital condyles, representing 1 (4.15%) of all the cervical spine fractures.

Table 5 Shows the Common Level of Cervical Spine Injury and the Number of Patients

Variable	Axial	Sagittal	Coronal
Occipital Condyles	1	1	1
C1	2	2	2
C2	2	2	2
C3	4	4	4
C4	2	2	2
C5	4	4	4
C6	**6**	**6**	**1**
C7	3	3	3
Total	**24**	**24**	**24**

Among the 57 participants included in this study, a substantial proportion of 24 patients (42%) exhibited no pathologies on both the Clinical Spine Radiography (CSR) and Computed Tomography (CT) scan of the Cervical Spine. On the other hand, the prevalence of cervical spine injuries in patients with head injuries was 33 participants, accounting for about (58%).

It is worth mentioning that four of the participants had cervical spine hyperlordosis, on both CSR and CT scan of the cervical spine.

Among the 33 participants who did show cervical spine injuries, it was observed that 5 injuries were initially missed during the evaluation using cervical spine radiography, but were later identified through CT scans. In other words, these five injuries had been initially reported as "normal" on the radiography examination but were found to be abnormal on subsequent CT scans.

Table 6 Provides the Reported Results of the 57 participants with Emphasis on Injuries That Were Initially Missed on CSR but later Visualized on CT of the Cervical Spine

CT scan	Plain Radiograph	Number of patients
Normal Cervical Spine	Normal Cervical Spine	24
C7 Wedge Compression Fracture	C7 Wedge Compression Fracture	1
Anterolisthesis of C6 Over C7	Anterolisthesis of C6 Over C7	1
Retrolisthesis of C6	Retrolisthesis of C6	1
Anterolisthesis of C5 Over C6	Anterolisthesis of C5 Over C6	1
Undisplaced C2 Fracture Type III	**Normal Cervical Spine**	1
Anterolisthesis of C6 Over C7	Anterolisthesis of C6 Over C7	1
Bilateral Rami Fracture of C3	Bilateral Rami Fracture of C3	1
Complete retrolisthesis of C6 and C7; Upward Displacement of C7	Complete Retrolisthesis of C6 over C7; Upward Displacement of C7	1
Occipital Condyle Fracture	Normal Cervical Spine	1
Hangman's Fracture(Levine & Edwards II)	**Normal Cervical Spine**	1
Clay Shoveler's Fracture of C3	Clay Shoveler's Fracture of C3	1
Posterior Translation of C5 Over C6	Posterior Translation of C5 Over C6	1
Odontoid Type 2 Fracture	Odontoid Type 2 Fracture	1
Hyperlordosis of Cervical Spine	Hyperlordosis of Cervical Spine	1
Retrolisthesis of C5 Over C6	Retrolisthesis of C5 Over C6	1
Hyperlordosis of Cervical Spine	Hyperlordosis of Cervical Spine	1
Anterolisthesis of C6 over C7	Anterolisthesis of C6 Over C7	1
Undisplaced Fracture of C6	**Normal Cervical Spine**	1
Undisplaced Odontoid Type II Fracture	**Normal Cervical Spine**	1
Retrolisthesis of C5	Retrolisthesis of C5	1
Odontoid Type 3 Fracture	Odontoid Type 3 Fracture	1
Anterolisthesis of C5 Over c6	anterolisthesis of C5 Over c6	1
Odontoid Fracture Type 2	Odontoid Fracture Type 2	1
Retrolisthesis of C6 over C7	Retrolisthesis of C6 Over C7	1
Retrolisthesis of C5 over C6	Retrolisthesis of C5 Over C6	1
Hyperlordosis of Cervical Spine	Hyperlordosis of Cervical Spine	1
Anterolisthesis of C4 over C5	Anterolisthesis of C4 Over C5	1
Tear drop fracture of C3	Tear Drop fracture of C3	1
C3 Cervical Spine Fracture	C3 cervical Spine Fracture	1
Clay Shoveler's Fracture of C5	Clay Shoveler's Fracture of C5	1
Tear Drop Fracture of C4	Tear Drop Fracture of C4	1
Hyperlordosis of Cervical Spine	Hyperlordosis of Cervical Spine	1
Undisplaced C1 Fracture	**Undisplaced C1 Fracture**	1

The comparative analysis of two-view plain radiography of the cervical spine with computed tomography (CT) of the cervical spine revealed the following diagnostic accuracy results.

The sensitivity of cervical spine radiography was found to be 85%, indicating the proportion of patients with injuries who were correctly identified as positive on the examination using plain radiographs. The reported range for the sensitivity of CSR was observed to be between 68% and 94% at a 95% confidence interval. This suggests that in most cases, cervical spine injuries were successfully detected through this imaging modality.

Conversely, the specificity of plain radiography of the cervical spine, which denotes the proportion of patients without cervical spine injuries who were correctly identified as negative on plain radiographs, was observed to be 100%. The range for specificity was between 85% and 100% at a 95% confidence interval. This implies that the imaging technique had a high accuracy in ruling out cervical spine injuries.

The positive and negative predictive values for cervical spine radiography were 100% {87-100%, at 95% CI} and 83% {64-94%}, respectively.

Table 7 shows Test Performance (Sensitivity, Specificity, Positive and Negative Predictive Values) of Cervical Spine Radiography as Compared to Computed Tomography in Diagnosing Cervical Spine Injuries in Adult Patients with Head Injury.

CT scan	Radiographs(x ray) Pos.	Neg.	Total
Abnormal	28	5	33
Normal	0	24	24
Total	28	29	57

Pearson chi2(1) = 40.0251 Pr = 0.000
True abnormal diagnosis defined as CT = 1 (labelled Present)

			[95% Confidence	Interval]
Prevalence	Pr(A)	57.9%	44.1%	70.9%
Sensitivity	Pr(+|A)	84.8%	68.1%	94.9%
Specificity	Pr(-|N)	100.0%	85.8%	100.0%
ROC area	(Sens. + Spec.)/2	0.92	0.86	0.99
Likelihood ratio (+)	Pr(+|A)/Pr(+|N)	.	.	.
Likelihood ratio (-)	Pr(-|A)/Pr(-|N)	0.15	0.07	0.34
Odds ratio	LR(+)/LR(-)	.	29.50	.
Positive predictive value	Pr(A|+)	100.0%	87.7%	100.0%
Negative predictive value	Pr(N|-)	82.8%	64.2%	94.2%

Missing values or confidence intervals may be estimated using the -sf- or -sf0- options.

CHAPTER FIVE:DISCUSSION

The objective of this study was to evaluate the sensitivity of cervical spine radiography as compared to computed tomography (CT) of the cervical spine in diagnosing cervical spine injuries in patients with head injury. It is widely accepted within the spine community that head injury is closely associated with the occurrence of cervical spine injury.

The results of this study provide additional evidence for this association, revealing that among adult patients with head injury, there was a significant occurrence of cervical spine injuries at a rate of 58%. This closely matches the 53% figure discovered by P. Njoroge in a 2003 study conducted at Kenyatta National Hospital, which examined the prevalence of cervical spine injury in patients with head injury.

Importantly, this study did not observe an association between head injury severity and specific head injury sites as the most injured cervical vertebra was found to be C6. In contrast, previous studies have suggested that upper cervical spine injuries are likely associated with more severe head injuries.

Furthermore, the results of this study didn't stablish an association between the location of the cervical spine injury and the degree of head injury as measured by the Glasgow Coma Scale as the majority of patients in this study had moderate or mild head injuries, accounting for approximately 87% of cases.

While concurrent cervical spine and head injuries can happen across all age groups, they tend to be more prevalent in younger individuals, particularly those below the age of 55. Additionally, these injuries disproportionately afflict males. In this study, there was no significant deviation from this pattern, as the average age of the participants was 39 years, and approximately 72% of the victims were male.

In contrast to a study conducted by JG Kiboi et al at Kenyatta National Hospital, which indicated that cervical spine injuries primarily stem from falls rather than road traffic accidents, this study yielded different findings, which were that the road traffic accident represents the commonest mechanism at 85% followed by fall at 10%.

Among the various subcategories of road traffic accidents, the populations most affected were passengers and pedestrians, accounting for 52% of the cases. Motorcyclists closely followed at 42%, while drivers constituted only 6% of the cases. These findings are intriguing as they shed light on specific population groups and hold the potential for informing policy interventions.

One of the secondary objectives of the study was to assess the usage, type, and fitness of cervical collars. The study found that cervical collars were not commonly worn, with only 14 out of 57 patients (25%) utilizing them. However, there were positive aspects in terms of collar types, as approximately 79% of the cervical spine collars used were semi-rigid collars, specifically of the Philadelphia type, while the remaining collars were soft collars.

The study did not provide clear reasoning behind the selection of particular collar types and whether it was based on the stability of cervical spine fractures. Soft collars were utilized in cases where rigid immobilization seemed necessary, raising questions about the appropriateness of their use.

In addition to the low usage rate, the study identified a concerning issue with the fitness of the cervical spine collars. Approximately 70% of the collars were loosely fitted, which could compromise their effectiveness and undermine their intended purpose.

These findings highlight the need for improved adherence to wearing cervical collars and for better attention to proper fitting. The use of appropriate collar types based on the specific clinical needs, such as the stability of cervical spine fractures, should also be carefully considered to ensure optimal patient outcomes.

In recent decades, there has been a notable shift towards the widespread utilization of computed tomography (CT) for radiological assessment in high-risk patients with suspected cervical spine injury, particularly those with head injury. Conversely, clinical decision rules have remained the primary approach for evaluating the cervical spine in low-risk patients.

In this study, further evaluation with cervical spine CT revealed the identification of five fractures that had initially gone undetected on cervical spine radiography. These fractures primarily involved the upper cervical spine and consisted of an undisplaced C1 fracture, three fractures from C2 (including Hangman's fracture of Levine and Edward Type 2, Odontoid Type 2, and Odontoid Type 3), as well as an undisplaced C6 fracture.

These injuries held clinical significance as they necessitated specific interventions. The findings of this study indicate that cervical spine radiography misses approximately 15% of such injuries, underscoring the importance of employing more advanced imaging techniques like CT to enhance diagnostic accuracy.

Overall, this highlights the need for a comprehensive and meticulous approach in evaluating cervical spine injuries, particularly in cases where traditional radiography may not effectively identify all fractures. Incorporating CT imaging into the diagnostic process can aid in the detection of previously missed injuries, guiding appropriate interventions, and improving patient care.

CHAPTER SIX: CONCLUSION

Medical practitioners at the first point of clinical contact at the Kenyatta National Hospital commonly rely on cervical spine computed tomography (CT) for evaluating patients with head injury and suspected cervical spine injury. This widespread use of cervical spine CT in initial evaluations for patients with head injury and suspected cervical spine injury reflects the transition towards it as the standard of care. However, the use of cervical spine radiographs in this patient population has decreased.

In terms of identifying clinically significant cervical spine injuries in patients with head injury, CT scans generally outperformed plain radiography of the cervical spine. This conclusion is supported by the fact that the sensitivity of cervical spine radiography was 85%, while CT had a sensitivity of 100%.

Plain radiography of the cervical spine had limitations, particularly in visualizing upper cervical spine injuries. Four out of five cervical spine injuries involving the C1 and C2 vertebrae were missed by radiography.

Nonetheless, cervical spine radiography remains a useful imaging tool for evaluating the cervical spine in adults with head injury as it detects injuries in participants with varying degrees of head injuries and risk levels.

Combining both cervical spine radiography and CT of the cervical spine and even magnetic resonance imaging in this patient population would likely improve diagnostic accuracy compared to relying on a single imaging modality alone.

Another notable conclusion from the study is the limited utilization of cervical spine collars in patients with head injury and suspected cervical spine injury, and when they are used, their application is often inadequate, posing a jeopardy to their intended purpose.

Additionally, the choice of cervical spine collar type is poorly aligned with the stability of cervical spine fractures, and in certain instances, there were instances where obviously unstable cervical spine fractures, which would ideally necessitate rigid immobilization, were instead treated with soft collars.

CHAPTER SEVEN: RECOMMENDATIONS

Based on the aforementioned conclusions, several key recommendations emerge.

In adult patients with head injury and suspected cervical spine injuries, where upper cervical spine injuries are suspected, initial radiological evaluation of cervical spine should proceed with computed tomography of the cervical spine as this would greatly enhanced identification of injuries when compared to plain radiography of cervical spine. This recommendation has the potential for reducing delayed diagnosis and could potentially improve outcomes.

The findings recommend the development of comprehensive clinical protocols for radiological clearance of the cervical spine that go beyond the scope of head injury and suspicion of cervical spine injury. Such protocols should incorporate clear eligibility criteria for the use of both computed tomography (CT) and plain radiography. Developing and implementing such guidelines can establish a systematic approach that maximizes the visualization of cervical spine injuries while optimizing resource utilization.

These protocols would outline specific recommendations regarding the appropriate combination of CT and plain radiography to achieve the best possible outcomes. For instance, individuals who are more likely to have upper cervical spine injuries would be initially evaluated using CT, while those with suspicion for lower cervical spine injuries would undergo plain radiography first before further evaluation with CT.

By providing a roadmap for clinicians, these guidelines would ensure standardized and evidence-based practices, promoting consistency in evaluating cervical spine injuries. This approach would help minimize unnecessary imaging and reduce healthcare costs, while ensuring timely and accurate diagnoses.

Further, such clinical protocols hold immense potential for improving patient care and safety. It would provide a framework that enhances the visualization of cervical spine injuries, leading to more efficient and effective management strategies. Therefore, it is crucial to invest in further research and collaborative efforts to establish these guidelines, ultimately benefiting both healthcare providers and patients alike.

The study recommends further research to be conducted on cost-effectiveness analysis and risk assessment on the use of computed tomography (CT) for evaluating the cervical spine. This is particularly important because nearly half of the cervical spine CT scans in the study did not reveal any cervical spine injuries. By examining the cost-effectiveness and risk factors associated with cervical spine CT, a more comprehensive understanding can be gained to optimize its utilization and ensure appropriate allocation of resources.

There’s a need for implementation of a targeted awareness campaign aimed at populations with at high risk of cervical spine injuries, including passengers, pedestrians, and motorcyclists. This campaign should delve into root causes contributing to the heightened incidence of accidents among these specific groups.

Emphasizing factors such as maintaining proper lane discipline, avoiding tailgating, and discouraging over-speeding among motorists and motorcyclists can play a pivotal role in reducing the occurrence of accidents and associated cervical spine injuries.

Thisapproach has the potential to significantly decrease the incidence of cervical spine injuries and promote a culture of responsible and vigilant behavior among all road users, and ultimately reducing the burden of cervical spine injuries and enhancing public safety.

Finally, it is highly recommended to prioritize advocacy efforts targeting medical emergency teams and lower-level hospitals, noting the critical importance of ensuring the appropriate and timely application of cervical spine collars. Emphasis should be placed on the profound impact that proper cervical spine immobilization can have on improving outcomes for patients with cervical spine injuries.

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CHAPTER NINE: APPENDICES

9.1 STUDY TIMELINES

GANNT'S CHART

	Sept, 2022	Octob, 2022	November 2022	Dec, 2022	January-February 2023	March 2023	April 2023	May 2022	June to July 31, 2023
Proposal Development and Departmental Presentation and Approval									
Ethical Review and Approval									
Data Collection, Analysis and Report Development									
Final Review by Dissertations Advisors,									

Presentation and Submission									

9.2 STUDY BUDGET

Budget lines	Cost
Stationery	30,000
Research Associate	25,000
Biostatistician/Data Analyst 3	30,000
Ethics Research Committee Submission Fee	3,000
Miscellaneous and Study Contingencies	45,000
Total	133,000

9.3 CONSENT INFORMATION

8.3.1 Participants' information and Consent Form for Enrollment in the Study

Title of the Study

Test Performance of Cervical Spine Radiography as compared to Computed Tomography of Cervical Spine in Diagnosing Traumatic Cervical Spine Injuries in Adults with Head Injury at Kenyatta National Hospital

Principal Investigator: Dr. Nyuon, Deng Akoi

Affiliation: Orthopedics Surgery Resident, Department of Surgery, University of Nairobi

Introduction

My name is Dr.Nyuon Deng Akoi, I am a postgraduate student in the thematic unit of Orthopedics Surgery at the University of Nairobi. I am conducting a research study entitled: "Comparison of the Test Performance of Computed Tomography and Plain Radiography in Diagnosing Traumatic Cervical Spine Injuries in Adults with Head Injury at the Kenyatta National Hospital"

I would like to extend an invitation to participate in this study, and please take your time to decide if you would like to be part of it. If you have any questions or concerns, please don't hesitate to reach out to me or my research assistant.

Purpose of the Study

The purpose of this study is to compare the diagnostic accuracy of computed tomography and plain radiography of the cervical spine in adult patients who present with head injury, a clinical suspicion cervical spine injury at the Kenyatta National Hospital. Findings from this study will be valuable in improving the management of patients with head injury and suspected cervical spine injuries.

Study Procedures

The Principal Investigator and the research assistant will complete a data collection sheet by examining your next-of-kin, specifically conducting a physical examination including establishing their level of consciousness and reviewing their radiological images.

We will follow all COVID-19 protocols and maintain a safe distance while conducting the study. The patient information sheet should take approximately 10 minutes to complete, and there are no foreseeable risks associated with the study.You are welcome to ask any questions you may have about the research, its purpose, potential consequences of participating, your rights as a volunteer, and any other relevant information that needs clarification. This process is called 'informed consent'.

Once all your questions have been satisfactorily answered, you may decide whether or not to participate in the study. If you choose to participate, you will be asked to sign this form.

It is important to understand the general principles that apply to all participants in medical research:

I) Participation in the study is entirely voluntary.

II) You have the right to withdraw from the study at any time, without having to give a reason.

III) Refusing to participate in the study will not affect the medical care you receive at this or any other facility.

You will receive a copy of this form for your records.

Are you ready to continue? YES [ ] NO [ ]

Please note that this study has been approved by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Protocol No. ______________________________

Risks and benefits of participating in the study

All the information obtained from you and the patient will be treated with the utmost confidentiality.

Your name and that of your next-of-kin will not appear on the patient information sheet, as it will be de-identified and a study number will be assigned to it. You will be free to withdraw from the study or refuse to answer questions at any time.

9.3.2RESEARCH TEAM

For more information, contact the following:

PRINCIPAL INVESTIGATOR: DR. NYUON DENG AKOI

Orthopedics Surgery Resident, Department of Surgery

University of Nairobi

Email: ddengdiit@student.uonbi.ac.ke; Telephone number: 0724 625 600

LEAD SUPERVISOR:VINCENT STEPHEN MUOKI MUTISO

M.B.Ch., B, MMed (Surgery), FCS (ECSA Ortho), Tr. & Ortho (U.K)

Senior Lecturer and Head, Thematic Unit of Orthopedics Surgery, Department of Surgery, University of Nairobi.

P.O.BOX 3019—00100 GPO NAIROBI, KENYA Email: mutiso@uonbi.ac.ke

CO-SUPERVISOR: KIRSTEEN ONDIKO AWORI

M.B.Ch., B, MMed (Surgery), FCS (Ortho, ECSA), Dip SICOT

Senior Lecturer, Department of Human Anatomy and Physiology

Clinical Instructor, Thematic Unit of Orthopedics Surgery, Department of Surgery, University of Nairobi.

P.O.BOX 30197—00100 GPO NAIROBI, KENYA Emails: kawori@uonbi.ac.ke; OR

THE SECRETARY

KENYATTA NATIONAL HOSPITAL—UNIVERSITY OF NAIROBI EHTICS AND RESEARCH COMMITTEE

Telephone No. 2726300 Ext. 44102

Email: uonknh_erc@uonbi.ac.ke.

9.3.3Statement of Consent for the Next-of-Kin

I, ______________________Next-of-kin of_______________ do hereby freely and fully consent to take part in this research study titled:"Test Performance of Cervical Spine Radiography as compared to Computed Tomography of Cervical Spine in Diagnosing Traumatic Cervical Spine Injuries in Adults with Head Injury at Kenyatta National Hospital"

The Principal Researcher, Dr. D.A Nyuon, an Orthopedic Surgery Resident at the University of Nairobi's Department of Surgery has explained to me in full details the purpose of the study and that I have voluntarily chose to participate in the study.

I have agreed to the following:

1. To be interviewed regarding possible injuries to the head andthe cervical spine(neck) of my next-of-kin including being physically examined and reviewing of the radiological images, and that the findings will be recorded as part of the study.

2. I acknowledge that my participation in this study is voluntary, and I have the right to withdraw at any time,should I desire and will not suffer any adverse repercussion.

3. I understand my participation will not impact the treatment that my next-of-kin is receiving and that at any time or point in the study, I can withdraw from the study, should I desire and will not suffer any adverse repercussion.
4. I understand that any information accrued from the research interaction will be treated with confidentiality.
5. I acknowledge that my participation in this study may potentially improve the care of patients with head injury and suspected traumatic cervical spine injury in the future.
6. I have thoroughly read and comprehended the contents of this consent form, or it has been read to me and I fully understand.
7. I have been afforded the opportunity to inquire about any aspects of this research study that are unclear to me.
8. My queries have been satisfactorily addressed in a language that I comprehend.

I confirm that by signing this consent form, I am agreeing to participate in this research study as one of the 52 participants. And that I willingly agree to take part in this research study: Yes/No

I agree to provide my contact information for the purpose of follow-up: Yes/No

Participant/Next-of-kin: ________________________

Signed/Thumb print: ___________________________

Contact information/Telephone Number: ____________________

Date:______________________________

Consultant: _________________Signed: ___________________

Date: _________________

Principal Investigator/Researcher Statement

I, Dr. D.A. Nyuon, Telephone Number 0724625600, wish to acknowledge and confirm that I have clearly explained to the Next-of-Kin the purpose for this study, and that I have provided the participant with a thorough explanation of the relevant details of the research and believe that the participant has understood and given their consent freely and willingly.

Name of Researcher: Dr.Nyuon, Deng Akoi

Role in the study: Principal Investigator

Signed: _________________________ Date: ______________________

For more information, contact the following:

The Principal Investigator

Dr. Nyuon, Deng Akoi

Orthopedics Surgery Resident and Principal Researcher, Department of Surgery

University of Nairobi

Email: ddengdiit@student.uonbi.ac.ke

Telephone number: 0724 625 600

Lead Supervisor:

Vincent Muoki Mutiso

M.B.Ch., B, MMed (Surgery), FCS (ECSA Ortho), Tr. & Ortho (U.K)

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Or:

The Secretary

Kenyatta National Hospital-University of Nairobi Ethics and Research Committee

Telephone No. 2726300 Ext. 44102

Email: uonknh_erc@uonbi.ac.ke

KISWAHILI VERSION

MaelezoyaWashirikinaFomuyaIdhiniyaMgonjwakwaKujiandikishakatikaUtafiti

FomuyaIdhiniyaNduguwaKaribu

Kichwa cha Somo

UsahihiwautambuziwaRadiografiaya Spine yashingoyakizaziikilinganishwana Tomography yaKuhesabuyamgongowakizazikatikakugunduamajerahayautiwamgongowakizazikwawatuwazimawenyemajerahayakichwakatikaHospitaliyaKitaifaya Kenyatta

MpeleleziMkuu: Dk. Nyuon Deng Akoi

Washirika: MkaziwaUpasuajiwaMifupa, IdarayaUpasuaji, Chuo Kikuu cha Nairobi

Utangulizi

Jinalanguni Dk. D.A. Nyuon, miminimwanafunziwauzamilikatikakitengo cha mada cha UpasuajiwaMifupakatika Chuo Kikuu cha Nairobi. Ninafanyautafitiunaoitwa: "UlinganishowaUtendajiwaMtihaniwaTomografiayaKompyutanaRadiografiaisiyonakifanikatika KugunduaMajerahayaKiweweyaMgongowaKizazikwaWatuWazimawenyeJeraha la KichwakatikaHospitaliyaKitaifaya Kenyatta

Ningependakutoamwalikowakushirikikatikautafitihuu, natafadhalichukuamudawakokuamuakamaungependakuwasehemuyao. Ikiwa una maswali au wasiwasiwowote, tafadhaliusisitekuwasiliananami au msaidiziwanguwautafiti.

MadhumuniyaUtafiti

Madhumuniyautafitihuunikulinganishausahihiwauchunguziwatomografiailiyokokotwana radiography yawaziyautiwamgongowaseviksikwawagonjwawazimaambaowanamajerahayakichwa, jeraha la kliniki la tuhuma za utiwamgongowakizazikatikaHospitaliyaKitaifaya Kenyatta. Matokeokutokakwautafitihuuyatakuwamuhimukatikakuboreshausimamiziwawagonjwawalionaje raha la kichwanamajeruhiyanayoshukiwayautiwamgongowaseviksi.

Taratibu za Masomo

MchunguziMkuunamsaidiziwautafitiwatakamilishakaratasiyakukusanya data kwakuchunguzajamaayakowakaribu, hasakufanyauchunguziwakimwiliikiwanipamojanakutambuakiwango chao cha fahamunakuhakikipichazao za radiolojia.

Tutafuataitifakizote za COVID-19 nakudumishaumbalisalamatunapofanyautafiti. Karatasiyamaelezoyamgonjwainapaswakuchukuatakribandakika 10 kukamilika, na hakuna hatarizinazoonekanazinazohusiananautafiti. Unakaribishwakuulizamaswaliyoyoteambayounawezakuwanayokuhusuutafiti, madhumuniyake, matokeoyanayowezakutokeayakushiriki, hakizakokamamtuwakujitolea, nataarifanyingineyoyotemuhimuinayohitajiufafanuzi. mchakato wake unaitwa 'ridhaayataarifa'.

Mara tumaswaliyako yote yamejibiwakwanjiayakuridhisha, unawezakuamuakushiriki au kutoshirikikatikautafiti. Ukichaguakushiriki, utaombwakutiasahihikwenyefomuhii.

Ni muhimukuelewakanuni za jumlazinazotumikakwawashirikiwotekatikautafitiwamatibabu:

i) Kushirikikatikautafitinikwahiarikabisa.

ii) Una hakiyakujiondoakwenyeutafitiwakatiwowote, bilakulazimikakutoasababu.

iii) Kukataakushirikikatikautafitihakutaathirihudumayamatibabuunayopokeakatikakituohiki au kituokinginechochote.

Utapokeanakalayafomuhiikwarekodizako.

Je, ukotayarikuendelea? Ndio[ ] La [ ]

TafadhalikumbukakuwautafitihuuumeidhinishwanaItifakiyaKamatiyaMaadilinaUtafitiya Chuo Kikuu cha Kitaifa cha Kenyatta-Chuo Kikuu cha Nairobi Namba.

Hatarinafaida za kushirikikatikautafiti

Taarifazotezilizopatikanakutokakwakonakwamgonjwazitashughulikiwakwausiriwahaliyajuu.

Jinalakona la jamaayakowakaribuhalitaonekanakwenyekaratasiyamaelezoyamgonjwa, kwakuwahalitatambuliwananambariyautafitiitapewa. Utakuwahurukujiondoakwenyeutafiti au kukataakujibumaswaliwakatiwowote.

MawasilianoMuhimu

Kwa maelezozaidi, wasiliananawafuatao:

MpeleleziMkuu:

Dk.Nyuon Deng Akoi

MkaziwaUpasuajiwaMifupa, IdarayaUpasuaji

Chuo Kikuu cha NairobiBarua pepe: ddengdiit@student.uonbi.ac.ke; Nambariyasimu: 0724 625 600

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KirsteenOndikoAwori

M.B.Ch., B, MMed (Upasuaji), FCS (Ortho, ECSA), Dip SICOT

MhadhiriMkuu, IdarayaAnatomiayaBinadamunaFiziolojia

MkufunziwaKliniki, Kitengo cha MadayaUpasuajiwaMifupa, IdarayaUpasuaji, Chuo Kikuu cha Nairobi.

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Au:

Katibu,

HospitaliyaKitaifaya Kenyatta-KamatiyaMaadilinaUtafitiya Chuo Kikuu cha Nairobi

Nambariyasimu 2726300 Ext. 44102

Barua pepe: uonknh_erc@uonbi.ac.ke.

TaarifayaIdhinikwaNduguwaKaribu

Mimi, ____________________Jamaawa pili wa ______________ nakubalikwahiarinakikamilifukushirikikatikautafitihuuwautafitiunaoitwa: "UlinganishowaRadiografiaisiyonakifaninaTomografiayaKompyutakatikaKugunduaMajerahaya UtiwaKizazikwaWagonjwawenyeMajerahayaKichwanaMajerahayanayoshukiwayaMgongowaKizazi" katika Kenyatta. HospitaliyaTaifa.

MtafitiMkuu, Dk. Nyuon Deng Akoi, Mkaazi

waUpasuajiwaMifupakatikaIdarayaUpasuajiya Chuo Kikuu cha Nairobi amenielezakwaundanikamilimadhumuniyautafitinakwambanimechaguakwahiarikushirikikatikautafiti.

Nimekubaliyafuatayo:

1. Kuhojiwakuhusumajerahayanayowezakutokeakwakichwanautiwamgongowaseviksi (shingo) yajamaayanguwakaribuikiwanipamojanakuchunguzwakimwilinakuhakikipicha za radiolojia, nakwambamatokeoyatarekodiwakamasehemuyautafiti.

2. Ninakubalikwambaushirikiwangukatikautafitihuuniwahiari, naninahakiyakujiondoawakatiwowote, iwaponitatamaninasitapatwanaathariyoyotembaya.

3. Ninaelewakuwaushirikiwanguhautaathirimatibabuambayojamaayanguwakaribuanapokeanakwa mbawakatiwowote au hatuayoyotekatikautafiti, ninawezakujiondoakwenyeutafiti, iwaponitatamaninasitapataathariyoyotembaya.

4. Ninaelewakuwamaelezoyoyoteyatakayotokananamwingilianowautafitiyatashughulikiwakwausiri.

5. Ninakubalikwambaushirikiwangukatikautafitihuuunawezakuboreshautunzajiwawagonjwawalion ajeraha la kichwanajerahalinaloshukiwakuwakiwewe la utiwamgongowaseviksikatikasikuzijazo.

6. Nimesomakwa kina nakuelewayaliyomokatikafomuhiiyaidhini, au imesomwakwangunaninaelewakikamilifu.

7. Nimepewafursayakuulizakuhusuvipengelevyovyotevyautafitihuuambavyosivielewi.

8. Maswaliyanguyameshughulikiwakwanjiayakuridhishakatikalughaambayoninaielewa.

Ninathibitishakwambakwakutiasainifomuhiiyaidhini, ninakubalikushirikikatikautafitihuukamammojawawashiriki 52. Na kwambaninakubalikwahiarikushirikikatikautafitihuu: Ndiyo/Hapana

Ninakubalikutoamaelezoyanguyamawasilianokwamadhumuniyaufuatiliaji: Ndiyo/Hapana

Mshiriki/Nduguwakaribu: ________________________

Imetiwasaini/kidolegumba: ____________________________________

Maelezoyamawasiliano/Nambariyasimu: _____________________

Tarehe: _______________________________

Mshauri: _______________________________ Amesaini: _______________________________

Tarehe: _________________

MchunguziMkuu/Mtafiti

Mimi, Dkt. Nyuon Deng Akoi, Nambariya Simu 0724625600, anapendakukirinakuthibitishakwambanimeelezawaziwazimadhumuniyautafitihuu, nakwambanimempamshirikimaelezoya kina yamaelezomuhimuyautafitihuunaninaaminikwamba. mshirikiameelewanakutoaridhaayaokwauhurunakwahiari.

Jina la Mtafiti: Dk. Nyuon Deng Akoi

Jukumukatikautafiti: MpeleleziMkuu

Imetiwasaini: ____________________________________ Tarehe: _______________________

Kwa maelezozaidi, wasiliananawafuatao:

MpeleleziMkuu:

Dk. Nyuon Deng Akoi

MkaziwaUpasuajiwaMifupa, IdarayaUpasuaji

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MhadhiriMkuu, IdarayaAnatomiayaBinadamunaFiziolojia

MkufunziwaKliniki, Kitengo cha MadayaUpasuajiwaMifupa, IdarayaUpasuaji, Chuo Kikuu cha Nairobi.

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Au:

Katibu,

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9.3.4Patient InformationCollection Sheet

Clinical Evaluation

1. Demographic Information

Patient's Special Identifier:………………………………………………

Age: …………………………………………….

Sex: Male [ ] Female [ ] Prefer not to say [ ]

Patient Date & Time of Presentation: _____/_____

Date and time of Accident: _____/______

2. Mechanism of Injury

Road Traffic Accident [ ]

If Road Traffic Accident (select one)

Cyclist [ ] Pedestrian [ ] Passenger [ ] Driver [ ]

If a Fall; [ ]Approximate the height in meters : ________

If Assault: Yes [ ] No [ ]

Any other detail for the assault.

3. Physical Examination

Focal Neurological Deficit: Present [ ] Absent [ ]

Distracting Injuries: Present [ ] Absent [ ]

If present; what they are? ________________________________

Neurological Level of Injury

Sensory level: ……………………………………

Step-off: Present [ ] Absent [ ]

Loss of sphincter tone on Digital Rectal Examination (DRE): Present [ ] Absent [ ]

Cervical Spine Collar: Semi-rigid Collar [ ] Soft Collar [ ] No Collar [ ]

Severity of Head Injury as Demonstrated by the Glasgow Coma Scale

Eye Opening Response: 1 [ ] 2 [ ] 3 [ ] 4 [ ]

Verbal Response: 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]

Motor Response: 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ]

Total GCS: Mild [ ] Moderate [ ] Severe [ ]

Radiological Evaluation

1. Cervical Spine Radiography

Fracture Base of the skull

Occipital Condyle; [ ] Other [ ]

If other (Specify): ____

Upper Cervical Spine/Atlanto-axial Spine

Pre-Dens Interval [ ] Basion-Dens Interval [ ]

Jefferson's Fracture: Present [ ] Absent [ ]

Fracture Dens: Type I [ ] Type II [ ] Type III [ ]

Hangman's Fracture: present [ ] Absent [ ]

Subaxial Cervical Spine Vertebral Injuries

Vertebral Level of Injury: C3 [ ] C4 [ ] C5 [   ] C6 [ ] C7 [ ]

If more than one [ ], Indicate______________

Fracture Pattern

Wedge compression [ ]

Loss of vertebral height [ ]

Spinous process space widening [   ]

Intervertebral disc space widening [ ]

Retropharyngeal soft tissue swelling: Present [ ] C2 [ ]   C6/7 [ ]   Absent [ ]

Loss of Cervical Spine lordosis: Present [ ] Absent [ ]

Subluxation/Dislocation: Less than or equal 50% [ ] More than or equal 50% [ ]

Non-contiguous injury: ____

SCIWORA: ____

2. Cervical Spine CT scan

Occipital Condyles: Axial [ ] Sagittal [ ] Coronal [ ]

C1: Axial [ ] Sagittal [ ] Coronal [ ]

C2: Axial [ ] Sagittal [ ] Coronal [ ]

C3: Axial [ ] Sagittal [ ] Coronal [ ]

C4: Axial [ ] Sagittal [ ] Coronal [ ]

C5: Axial [ ] Sagittal [ ] Coronal [ ]

C6: Axial [ ] Sagittal [ ] Coronal [ ]

C7: Axial [ ] Sagittal [ ] Coronal [ ]

Other CT findings: ____

Radiologist's Report

CT scan: ____

Plain Radiograph: ____

IMPRESSION: _________________________

9.3.5 Institutional Consent

I, Nyuon Deng Akoi, an OrthopedicSurgery registrar in the Department of Surgery, University, would like to seek approval from the administrative and research sections of the Kenyatta National Hospital, for the conduct of a research studycoroneted: "Comparison of Computed Tomography and Plain Radiography in Adults with Head Injury and Suspected Cervical Spine Injuries". I also wish to state that patient data will be appropriately de-identified and that the results of this study will be shared with the hospital and hopefully inform institutional protocol and guidelines for the acute care of adult patients with cervical spine trauma.

9.3.6 Study Correspondences

The Principal Investigator

NYUON, DENG AKOI

H58/7944/2017

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