RETROSPECTIVE CHART REVIEW OF SURGICAL MANAGEMENT OF COMPOUND ELEVATED SKULL FRACTURES

By

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for the degree of Master of Medicine in Neurosurgery
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As the candidate's supervisor, I have approved this thesis for submission.

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I Prashanth Maharaj declare that

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Dedication

I would like to dedicate this thesis to my understanding wife, Ramona, my parents, Parkash and Usha, and my son Pranav.

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Thanks to Basil Enicker for the assistance and supervision in developing the research idea, conducting the research and composing the manuscript.

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Overview of the thesis

Abstract

Background: Traumatic skull fractures have been traditionally classified into those that involve the base or vault with distinct entities linear or depressed. Compound elevated skull fracture is a newer entity with scanty reports in the literature.

Objective: To describe the clinical presentation, neuro-radiology findings by development of a classification system, medical and surgical management, and complications of patients with compound elevated skull fractures at a busy Neurosurgical Department in Durban, South Africa.

Methods: Medical records of consecutive patients admitted from January 2005 to December 2018 with compound elevated skull fractures at Inkosi Albert Luthuli Central Hospital were retrospectively evaluated. Data was analysed for demographics, clinical presentation, mechanisms of injury, neuro-radiology findings, management and outcomes. Neuro-radiological images were used to develop a classification system.

Results: Eighteen patients were included in this series with a median age of 28 years, median admission Glasgow Coma Scale was 12. Ten patients presented with focal neurological deficits which included hemiparesis [n=8, 44%] and unilateral afferent pupil deficit [n=2, 11%]. Intra-cerebral haematoma was the most common associated neuro-radiological finding [n=10, 55%] followed by acute extradural haematoma [n=4, 22%]. Three distinct neuro-radiological subtypes were identified. All patients underwent surgical debridement and of which 11 [61%] required duroplasty and 10[55%] re-placement of elevated bone flap. Septic complications included meningitis [n=5, 27%], brain abscess [2, 11%] and surgical site infection [n=1, 5%]. Seventeen patients had favourable outcomes at discharge (Glasgow Outcome Scale 4 or 5).

Conclusion: Compound elevated skull fracture is an additional subtype of skull vault fracture. Use of the originally developed classification system is important and infrequently described type of skull fracture. We recommend early surgical intervention which includes careful management of dura and elevated bone fragment reduces morbidity from septic complications.

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Part 1: The Review of Literature

The entity of compound elevated skull fracture is an unusual type of fracture involving the cranial vault which has been described inadequately in the current literature.[1]

Post-traumatic skull fractures are traditionally classified into fractures of vault or base with skull vault fractures being further sub-divided into linear, comminuted or depressed. Compound elevated skull fracture involves the fractured portion of bone being elevated above level of the intact skull bone.[2]

It has been suggested to include compound elevated skull fracture as subtype into the classification of skull fractures although the current literature only encompasses isolated case reports and short case series.[1-6]

Different mechanisms of injury have been noted in these studies to result in compound elevated skull fractures. The proposed mechanism underlying the development of compound elevated skull fracture in the case of blunt force trauma comprises of a tangential force applied to skull bone which then elevates fractured fragment of bone due to lateral force of the object or rotation of the head.[2] This combination of forces may imitate a formal craniotomy.[4]

Local experience has shown that penetrating injury (like those caused by a machete) may cause an elevated compound skull fracture.[7,8] The mechanism of injury resulting in compound elevated

skull fracture may occur during the assault with a sharp heavy weapon or upon retrieval. This mechanism may mimic a craniotomy flap. [1] The presenting clinical features depends on site, extent and severity of the underlying brain injury. Computed Tomography (CT) of brain is the investigation of choice for diagnosis in addition to assessing intracranial injury.[5]

Management principles correspond to those of other compound skull fractures which are early wound debridement with removal of loose bone fragments, evacuation of haematoma (if present), duroplasty and broad spectrum antimicrobial therapy. Complications of compound elevated skull fracture include meningitis, abscess formation or cerebrospinal fluid fistula.[4,6,9] Timeous neurosurgical management may prevent these complications reducing morbidity and mortality. [1-6,10,11] Treatment of elevated bone flap has been inconsistently dealt with in the literature as some authors discarded all free or elevated bones whilst others kept the bone flaps in the bone bank. Delayed cranioplasty was advocated either with the autologous bone or synthetic cranioplasty products.[2] An intact dura was less common but not infrequent[2,4], whilst duroplasty (primarily with or without pericranial augmentation) was performed on primary surgery in all reported cases of dural injury. [1,3,5,6]

In conclusion, compound elevated skull fracture is a rare injury which should be included in the classification of skull fractures. Early detection and prompt neurosurgical management should improve morbidity and mortality however underlying brain injury also plays a significant role in the overall prognosis.

References:

1. Sharma R, Saligouda P, Bhat DI, Devi BI. Compound elevated skull fracture mimicking a frontotemporoorbitozygomatic craniotomy flap. Neurol India. 2012;60(4):448-9.

2. Borkar SA, Prasad GL, Gupta DK, Sinha S, Mahapatra AK. Compound elevated skull fracture: a clinical series of three patients with a review of the literature. Turk Neurosurg. 2013;23(4):514-7.

3. Adeolu AA, Shokunbi MT, Malomo AO, Komolafe EO, Olateju SO, Amusa YB. Compound elevated skull fracture: a forgotten type of skull fracture. Surg Neurol. 2006;65(5):503-5.

4. Borkar SA, Sinha S, Sharma BS. Post- traumatic compound elevated fracture of skull simulating a formal craniotomy. Turk Neurosurg. 2009;19(1):103-5.

5. Agrawal A, Kumar SS, Reddy UV, Hegde KV, Subrahmanyan BV. Compound elevated skull fracture: Should we incorporate in skull fracture classification? Int J Crit Illn Inj Sci. 2015;5(4):227-9.

6. Abu Talha K, Selvapandian S, Asaduzzaman K, Selina F, Rahman M, Riad M. Compound elevated skull fracture with occlusion of the superior sagittal sinus. A case report. Kobe J Med Sci. 2009;54(5):E260-3.

7. Enicker B, Gonya S, Hardcastle TC. Spinal stab injury with retained knife blades: 51 Consecutive patients managed at a regional referral unit. Injury. 2015;46(9):1726-33.

8. Enicker B, Madiba TE. Cranial injuries secondary to assault with a machete. Injury. 2014;45(9):1355-8.

9. Ralston BL. Compound elevated fractures of the skull. J Neurosurg. 1976;44(1):77-9.

10. Verdura J, White RJ. Letter: Compound elevated skull fractures. J Neurosurg. 1976;45(2):245.

Part 2: A submission ready manuscript.

Compound Elevated Skull Fractures: A Retrospective Descriptive Study

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Conclusion: Compound elevated skull fracture is an additional subtype of skull vault fracture. Use of the originally developed classification system is important and infrequently described type of skull fracture. We recommend early surgical intervention which includes careful management of dura and elevated bone fragment reduces morbidity from septic complications.

Introduction

Compound elevated skull fracture involves the fractured portion of bone being elevated above level of the intact skull bone.[2]Post-traumatic skull fractures are traditionally classified into fractures of the vault or base with skull vault fractures being further sub-divided into linear or depressed.[12,13] Compound elevated skull fractures are rare injuries and are not classified in the traditional skull fracture classification.[5] We report a series of this rare type of post-traumatic skull vault fracture which represents the largest study of compound elevated skull fractures, to date, from the Neurosurgical unit at Inkosi Albert Luthuli Central Hospital in Durban, South Africa.

Methods

We undertook a retrospective analysis of data collected from electronic charts of all patients with a diagnosis of open skull vault fracture (ICD code S02.0) resulting from head injuries treated by the Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital, Durban, South Africa from 1st January 2005 to 31st December 2018. This facility is the single provincial neurosurgical referral center for a population of 11 million people in KwaZulu-Natal. [14] We included all patients with clinical and radiological features documented as compound elevated skull fracture or autocraniotomy, and excluded patients with compound depressed or linear skull fractures.

Once the patients were identified, the following data was obtained from the hospital records: neuroradiology images, clinical progress notes, surgical operative notes and outcomes. Demographic details (age, gender) were studied together with the reported circumstances of mechanism of injury, Glasgow Coma Scale (GCS) on admission and neurological examination.

The current unit policy for management of compound skull fractures includes: prompt administration of prophylactic antimicrobials, anti-tetanus toxoid and prophylactic antiepileptic drugs with early surgical debridement and repair of dura when breached.

Classification

The neuro-radiological images were analysed to develop a classification system which would enable accurate description allowing better operative planning.

Details of neurosurgical operation performed with regards to dural and bone management were examined, additionally the baseline neuroimaging (computed tomography) were reviewed noting pattern of injury to the skull vault as well as presence of intracranial haematoma.

Medical management with regards to administration of antimicrobial therapy (therapeutic and prophylaxis) and seizure prophylaxis were noted. The data related to septic complications (post-traumatic meningitis, abscess formation and surgical site infection) and Glasgow Outcome Scale (GOS) on discharge were also captured.

Results

There were 783 patients with open fractures of the skull identified during the study period. Eighteen (2.2%) of these patients were selected with compound elevated skull fracture (also documented as "autocraniotomy"). The details of the patients are summarised in Tables 1A and 1B.

Table 1A. Demographics, Clinical details, and Management of 18 patients with Compound Elevated Skull Fractures

Patient	1	2	3	4	5	6	7	8	9
Age	36	13	25	28	25	49	40	31	52
Gender	Male	Male	Male	Male	Male	Male	Male	Male	Female
Admission GCS	7	11	15	14	14	15	10	11	11
Focal Neurological Deficit	Right pupil deficit	No	Left hemiplegia	Left hemiplegia	Left hemiplegia	No	Right hemiplegia	Right hemiplegia	Right hemiplegia
Mechanism	Machete	PVC	Axe	Axe	Machete	Machete	Machete	Machete	PVC
Location on CT Scan	Frontal	Occipital	Frontal	Parietal	Parietal	Frontal	Parietal	Parietal	Parietal
Fracture Type	Type 1	Type 3	Type 1	Type 2	Type 1	Type 1	Type 2	Type 2	Type 2
Dural Injury	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Surgical Management of fractured elevated bone	Debrided only	Replaced	Replaced	Debrided only	Replaced	Replaced	Debrided only	Debrided only	Debrided only
Antimicrobial	Yes	Y	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anti-epileptics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post-traumatic meningitis	Yes	No	No	No	No	No	No	Yes	Yes
SSI/Abscess	No	No	No	No	No	No	No	Abscess	SSI
Associated intracranial haematoma	ICH	ICH	ICH	ICH	ICH	AEDH	ICH	No	No
GOS on Discharge	1	5	5	4	4	5	4	4	4

Table 1B. Demographics, Clinical details, and Management of 18 patients with Compound Elevated Skull Fractures

Patient	10	11	12	13	14	15	16	17	18
Age	12	41	18	22	22	23	29	22	32
Gender	Male	Male	Male	Male	Male	Male	Male	Male	Male
Admission GCS	7	15	14	9	9	14	15	15	15
Focal Neurological Deficit	Right hemiplegia	No	Right hemiparesis	No	Left pupil deficit	No	No	No	No
Mechanism	Fall from bicycle	Machete	Axe	Driver MVC	Driver MVC	PVC	Blunt assault	Machete	Axe
Location on CT Scan	Frontal	Parietal	Frontal	Frontal	Frontal	Temporal & Parietal	Parietal	Parietal	Frontal
Fracture Type	Type 2	Type 2	Type 3	Type 3	Type 3	Type 2	Type 2	Type 2	Type 2
Dural Injury	Yes	Yes	Yes	No	No	No	No	No	No
Surgical Management of fractured elevated bone	Replaced	Replaced	Debrided only	Debrided only	Debrided only	Replaced	Replaced	Replaced	Replaced
Antimicrobial	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anti-epileptics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Post-traumatic meningitis	No	No	Yes	No	Yes	No	No	No	No
SSI/Abscess	No	No	Abscess	No	No	No	No	No	No
Associated intracranial haematoma	ICH	ICH	ICH	ICH	No	AEDH	AEDH	AEDH	No
GOS on Discharge	4	5	5	5	5	5	5	5	5

Legend: GCS – Glasgow Coma Scale, CT – Computed Tomography, SSI – Surgical Site Infection, GOS – Glasgow Outcome Scale, PVC – Pedestrian Vehicle Collision, MVC – Motor Vehicle Collision, ICH – Intracerebral Haematoma, AEDH – Acute Extradural Haematoma.

The majority of the patients were male (94%), with a median age of 28 years. The most common mechanism of injury was that of assault with machete (n=7), followed by blunt cranial injury from motor vehicle collision (n=5), and assault with an axe (n=4). Fall from a bicycle and blunt assault each occurred in one patient. The median GCS was 12 with only two patients in coma (GCS <9). Only 10 of the 18 patients presented with focal neurological deficits, 8 with a hemiparesis and 2 with afferent pupil defect.

Upon review of neuro-radiology imaging, fractures were located in the parietal [n=9], frontal [n=8] and occipital [n=1] regions.

Three distinct types were identified: Type 1 – fractured segment with minimal loss of contact with rest of the cranial vault, Type 2 – fractured segment with complete loss of contact with rest of the cranial vault but retained attachment with scalp tissues, Type 3 – fractured segment with complete loss of contact with rest of the cranial vault and scalp tissues. The compound elevated fracture subtypes are shown in Table 2 and Figures 1,2 and 3.

Table 2. Results of Subtypes of Compound Elevated Skull Fractures

Type 1 (Figure 1)	Fractured segment with minimal loss of contact with rest of cranial vault	22.2% (n=4)
Type 2 (Figure 2)	Fractured segment with complete loss of contact with cranial vault but retained attachment with scalp	55.6% (n=10)
Type 3 (Figure 3)	Fractured segment with complete loss of contact with cranial vault and scalp	22.2% (n=4)

Figure 1 – Type 1 with elevated fractured segment (arrow) with minimal loss of contact with cranial vault

Figure 2 –Type 2 with elevated fractured segment (arrow) with complete loss of contact with cranial vault but retained attachment to scalp

Figure 3 – Type 3 with elevated fractured segment which has complete loss of contact with cranial vault and scalp

Regarding underlying brain injury, most patients had associated underlying intracranial haemorrhage (55% intracerebral, 22% extradural). Surgical intervention was undertaken in all patients with the majority (n=11) requiring duroplasty. The bone flap was debrided and re-placed in 55% (n=10) of cases whilst discarded in the rest due comminution or extensive contamination.

With regards to sepsis, two patients developed post-traumatic brain abscesses and one patient who was assaulted with a machete developed wound sepsis. Post-traumatic meningitis occurred in 5 patients. Post-traumatic meningitis occurred in 36% with dural injury versus 14% without. Time from injury to surgery were all within 24 hours. Bone replacement did not result in any acute sepsis or long-term osteitis.

Two patients had an injury to the superior sagittal sinus (anterior third). Ninety-four percent (n=17) of the patients in the series had favourable outcomes, Glasgow Outcome Scale 4-5.

The single patient who died in the series, was assaulted with a machete presenting with a GCS 7/15 and right dilated non-reactive pupil. The patient was intubated on arrival. He was taken to theatre and found intra-operatively to have an injury to the superior sagittal sinus with an associated acute extradural hematoma. Post-operatively, the patient was managed in the neurosurgical intensive care unit for assisted ventilation and monitoring of ICP. He developed an early ventilator associated pneumonia and cerebrospinal fluid confirmed post-traumatic meningitis (*Enterococcus faecalis*). Despite ventilation and appropriate antimicrobial therapy, he developed septic shock refractory to therapy.

Discussion

The entity of compound elevated skull fracture is an unusual type of fracture involving the cranial vault, the current literature has been limited to case reports and small case series.[1-6,10,11] We present the largest series, to date, of compound elevated skull fractures as well as provide a descriptive analysis regarding aspects of clinical presentation, mechanisms of injury, neuro-imaging and management.

Clinical Presentation

The presenting clinical features which include GCS and focal neurological deficit are dependent on site, extent and severity of the underlying brain injury, in addition to the mechanism of injury.

Mechanism of Injury

The mechanisms of injury have not been consistent in the current literature, both blunt as well as penetrating force have been shown to be responsible which is confirmed by the presented series of patients.[2,3,5,12,13] The proposed mechanism underlying the development of compound elevated skull fracture in the case of blunt force trauma comprises of a tangential force applied to skull bone which then elevates fractured fragment of bone due to lateral force of the object or rotation of the head.[2] This combination of forces may imitate a formal craniotomy as in Figure 4 and Figure 5.[4]

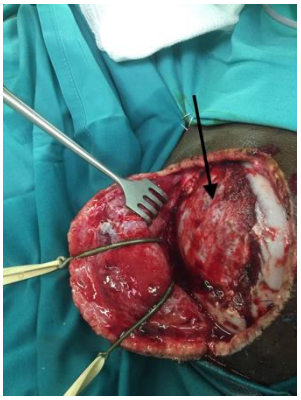

Figure 4 – Intra-operative picture showing Type 3 compound elevated skull fracture with intact dura (arrow) as a result of blunt force trauma due to involvement in a motor vehicle collision

Figure 5 – Elevated fracture segment (arrow) from patient in Figure 4 brought to emergency department in saline soaked gauze for re-placement in operating theatre

With regards to our experience, penetrating neurosurgical trauma comprises a significant portion of the local case load. [7,8] This may occur when a sharp heavy weapon is used in an assault or upon retrieval of the weapon elevating the fractured segment. The outcome may mimic a craniotomy flap. [1]

Neuroimaging

Computed Tomography (CT) scan of the brain is the investigation of choice for diagnosis in addition to assessing extent of injury to underlying parenchyma and intracranial haematomas.[5] Performing coronal, sagittal and three-dimensional reconstructions will be of value (see Figure 6) in evaluating the grade. The proposed grading system is important in consistently providing an accurate description of the extent of elevated skull fracture. Contrasted CT Brain scan is recommended when post-traumatic sepsis or brain abscess formation is suspected. Management is in accordance with standard Surviving Sepsis guidelines. [15]

Figure 6 – Coronal CT Brain scan showing elevated fractured segment

Surgery

Surgical principles include early wound debridement with removal of loose bone fragments, evacuation of haematoma (if present), duroplasty and broad spectrum antimicrobial therapy. Management of the elevated bone flap is dependent on intra-operative assessment of the elevated bone fragment for possible contamination. Treatment of elevated bone flap was inconsistently dealt with in the literature; some authors discarded the elevated bone flap [6,16] whilst others kept the bone flap in the bone bank[2,4] or performed immediate re-placement[1,3,12,13,16] as in Figure 7. In our unit, we favour immediate re-placement of bone flap for protection of the underlying brain and for cosmesis. In the scenario where the bone flap is severely comminuted or contaminated we discard it. In these cases, we prefer a delayed cranioplasty with synthetic cranioplasty products. [2]

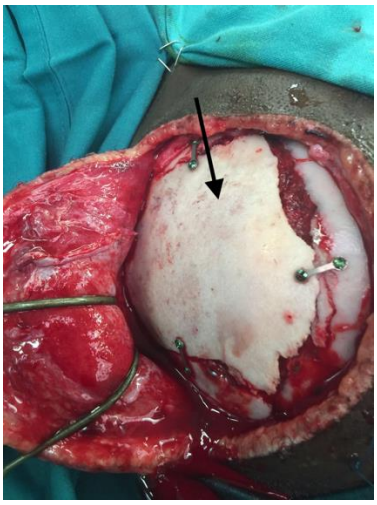

Figure 7 – Intra-operative picture showing re-placement of elevated fractured segment from Figures 4 and 5

Dural penetration

An intact dura was less common but not infrequent[2,4]. In our unit, we prefer primary dural closure or augmentation with peri-cranium.

Morbidity and Mortality

Complications of compound elevated skull fracture include surgical site infection, meningitis, brain abscess formation or cerebrospinal fluid (CSF) fistula. In comparison to compound depressed skull fractures where infection rates have been reported from 1.9 - 10.6%[17], the infection rate with compound elevated skull fractures are significantly higher (44%). This is thought to be as a result of the large surface area exposure following elevation of bone fragment with exposure or injury to underlying dura. Timeous neurosurgical management as seen in Figure 8 may prevent these complications thus reducing morbidity and mortality. [1-6,10,11]

Figure 8 – Intra-operative picture from Figure 6 showing elevated fractured segment (arrow) at risk for secondary septic complications.

The majority of authors describe favorable outcomes [1-6] in congruence with our study. The few case reports with poor outcome are due to development of post-traumatic brain abscess, primary brain injury or associated intracranial haematoma. [2,3]

Neurological morbidity compared to compared to depressed skull fractures (11%)[17] were significantly higher (55%). Association with intracranial haematoma was also much higher (77%) when compared to compound depressed skull fractures (23.6%)[18].

Conclusion

Compound elevated skull fracture represents an additional subtype of skull vault fracture which is rarely reported in the literature. This study builds on the 40 years of literature with the largest series of patients with compound elevated skull fractures to date describing this clinico-pathological entity. Surgical principles and medical management remain standard of care in line with current practice. The novel neuro-radiology classification the authors propose provide a consistent method of description of compound elevates skull fractures.

Disclosure statement

The authors report that they have no conflicts of interest.

References

1. Sharma R, Saligouda P, Bhat DI, Devi BI. Compound elevated skull fracture mimicking a frontotemporoorbitozygomatic craniotomy flap. *Neurol India.* 2012;60(4):448-449.
2. Borkar SA, Prasad GL, Gupta DK, Sinha S, Mahapatra AK. Compound elevated skull fracture: a clinical series of three patients with a review of the literature. *Turk Neurosurg.* 2013;23(4):514-517.
3. Adeolu AA, Shokunbi MT, Malomo AO, Komolafe EO, Olateju SO, Amusa YB. Compound elevated skull fracture: a forgotten type of skull fracture. *Surg Neurol.* 2006;65(5):503-505.
4. Borkar SA, Sinha S, Sharma BS. Post- traumatic compound elevated fracture of skull simulating a formal craniotomy. *Turk Neurosurg.* 2009;19(1):103-105.
5. Agrawal A, Kumar SS, Reddy UV, Hegde KV, Subrahmanyan BV. Compound elevated skull fracture: Should we incorporate in skull fracture classification? *Int J Crit Illn Inj Sci.* 2015;5(4):227-229.
6. Abu Talha K, Selvapandian S, Asaduzzaman K, Selina F, Rahman M, Riad M. Compound elevated skull fracture with occlusion of the superior sagittal sinus. A case report. *Kobe J Med Sci.* 2009;54(5):E260-263.
7. Enicker B, Gonya S, Hardcastle TC. Spinal stab injury with retained knife blades: 51 Consecutive patients managed at a regional referral unit. *Injury.* 2015;46(9):1726-1733.
8. Enicker B, Madiba TE. Cranial injuries secondary to assault with a machete. *Injury.* 2014;45(9):1355-1358.

9. Kumar A, Kankane VK, Jaiswal G, Kumar P, Gupta TK. Compound Elevated Skull Fracture Presented as a New Variety of Fracture with Inimitable Entity: Single Institution Experience of 10 Cases. *Asian J Neurosurg.* 2019;14(2):410-414.
10. Ralston BL. Compound elevated fractures of the skull. *J Neurosurg.* 1976;44(1):77-79.
11. Verdura J, White RJ. Letter: Compound elevated skull fractures. *Journal of neurosurgery.* 1976;45(2):245.
12. Balasubramaniam S, Tyagi DK, Savant HV. Everted skull fracture. *World Neurosurg.* 2011;76(5):479 e471-473.
13. Ferrer E, de Notaris M. Contemporary skull fractures: unusual everted fracture. *World Neurosurg.* 2011;76(5):417-418.
14. Mid-year population estimates, 2018 (PDF) (Report). Statistics South Africa. 31 July 2018. p. 3. Retrieved 30 July 2019
15. Levy MM, Dellinger RP, Townsend SR, et al. The Surviving Sepsis Campaign: results of an international guideline-based performance improvement program targeting severe sepsis. *Intensive Care Med.* 2010;36(2):222-231.
16. Kumar J, Prakash A, Harsh V, Kumar A. Elevated fracture of skull in pediatric age group: A series of five patients with review of literature. *Asian J Neurosurg.* 2016;11(1):75.
17. Bullock MR, Chesnut R, Ghajar J, et al. Surgical management of depressed cranial fractures. *Neurosurgery.* 2006;58(3 Suppl):S56-60; discussion Si-iv.
18. Manne S, Musali SR, Gollapudi PR, et al. Surgical Outcomes in Depressed Skull Fractures: An Institutional Experience. *Asian J Neurosurg.* 2019;14(3):815-820.

Appendix 1: The final Study Protocol

Retrospective Chart Review of surgical management of compound elevated skull fractures

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Contents:

1. Introduction

Post-traumatic skull fractures are traditionally classified into fractures of vault or base with skull vault fractures being sub-divided into linear, comminuted or depressed. Compound elevated skull fracture involves the fractured portion of bone being elevated above level of the intact skull bone. It has been suggested to include compound elevated skull fracture as subtype into the classification of skull fractures although the current literature only encompasses isolated case reports and short case series. This rare type of post-traumatic skull vault fracture has yet to be studied in South Africa.

2. Research Questions

    a. What are the outcomes of patients with compound elevated skull fractures at the Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital (IALCH) situated in the province of Kwa Zulu Natal (KZN), South Africa?
    b. What mechanisms of injuries are associated with compound elevated skull fractures?
    c. What surgical management options are used to treat patients with compound elevated skull fractures?

3. Aim of study

To review the presentations, complications, management strategies and outcomes of patients who present following head injuries with compound elevated skull fractures by the Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital.

4. Objectives

    a. To review the total admissions of all patients with head injuries treated at the Department of Neurosurgery at IALCH from 1st January 2005 to 31st December 2018, so as to select those with compound elevated skull fractures.

    b. To review the medical records for information on demographics, clinical presentation, and medical/surgical treatment.

    c. To review neuroradiology reports/images.

    d. To review medical records of hospital-stay, complications, Glasgow Outcome Scale and mortality.

5. Literature review

The entity of compound elevated skull fracture is an unusual type of fracture involving the cranial vault which has been described inadequately in the current literature.[1]

Post-traumatic skull fractures are traditionally classified into fractures of vault or base with skull vault fractures being sub-divided into linear, comminuted or depressed. Compound elevated skull fracture involves the fractured portion of bone being elevated above level of the intact skull bone.[2]

It has been suggested to include compound elevated skull fracture as subtype into the classification of skull fractures although the current literature only encompasses isolated case reports and short case series.[1-6]

The mechanisms of injury have not been consistent in these studies involving both blunt as well as penetrating force. The proposed mechanism underlying the development of compound elevated skull fracture in the case of blunt force trauma comprises of a tangential force applied to skull bone which then elevates fractured fragment of bone due to lateral force of the object or rotation of the head.[2] This combination of forces may imitate a formal craniotomy.[4]

With regards to local experience, penetrating neurosurgical trauma comprise of a significant portion of the case load. [7,8] However, a penetrating mechanism may also result in compound elevated skull fracture where a sharp heavy object which elevates the fractured portion of skull bone or the elevation may occur upon retrieval of the object in question (which may be a weapon). This mechanism may mimic a craniotomy flap. [1]

The presenting clinical features is heavily dependent on site, extent and severity of the underlying brain injury. Computed Tomography (CT) of brain is the investigation of choice for diagnosis in addition to assessing extent of injury to underlying parenchyma and intracranial haematomas.[5]

Management principles correspond to those of other compound skull fractures which are early wound debridement with removal of loose bone fragments, evacuation of haematoma (if present), duroplasty and broad spectrum antimicrobial therapy. Complications of compound elevated skull fracture include meningitis, abscess formation or cerebrospinal fluid fistula. Timeous neurosurgical management may prevent these complications reducing morbidity and mortality. [1-6,10,11] Treatment of elevated bone flap was inconsistently dealt with in the literature as some authors discarded all free or elevated bone whilst others kept the flap in the bone bank. Delayed cranioplasty was advocated either with the autologous bone or synthetic cranioplasty products.[2] An intact dura was less common but not infrequent[2,4], whilst duroplasty (primarily with or without pericranial augmentation) being performed on primary surgery in all reported cases of dural injury. [1,3,5,6]

In conclusion, compound elevated skull fracture is a rare injury which should be included in the classification of skull fractures. Early detection and prompt neurosurgical management should improve morbidity and mortality however underlying brain injury also plays a significant role in the overall prognosis.

6. Rationale for study

Evidence and description of surgical management of compound elevated skull fractures is limited to case reports and small case series. Despite the large caseload of patients with traumatic brain injury at our institution, the entity of compound elevated skull fracture has presented rarely with no clearly defined

surgical management strategy. The development of surgical site infection, post-traumatic abscess formation is known complications of compound skull fractures in general and may worsen outcomes. The presence of intracerebral haematoma may also be a contributing factor to poorer neurological outcome.

7. References

1. Sharma R, Saligouda P, Bhat DI, Devi BI. Compound elevated skull fracture mimicking a frontotemporoorbitozygomatic craniotomy flap. *Neurol India.* 2012;60(4):448-449.
2. Borkar SA, Prasad GL, Gupta DK, Sinha S, Mahapatra AK. Compound elevated skull fracture: a clinical series of three patients with a review of the literature. *Turk Neurosurg.* 2013;23(4):514-517.
3. Adeolu AA, Shokunbi MT, Malomo AO, Komolafe EO, Olateju SO, Amusa YB. Compound elevated skull fracture: a forgotten type of skull fracture. *Surg Neurol.* 2006;65(5):503-505.
4. Borkar SA, Sinha S, Sharma BS. Post- traumatic compound elevated fracture of skull simulating a formal craniotomy. *Turk Neurosurg.* 2009;19(1):103-105.
5. Agrawal A, Kumar SS, Reddy UV, Hegde KV, Subrahmanyan BV. Compound elevated skull fracture: Should we incorporate in skull fracture classification? *Int J Crit Illn Inj Sci.* 2015;5(4):227-229.
6. Abu Talha K, Selvapandian S, Asaduzzaman K, Selina F, Rahman M, Riad M. Compound elevated skull fracture with occlusion of the superior sagittal sinus. A case report. *Kobe J Med Sci.* 2009;54(5):E260-263.
7. Enicker B, Gonya S, Hardcastle TC. Spinal stab injury with retained knife blades: 51 Consecutive patients managed at a regional referral unit. *Injury.* 2015;46(9):1726-1733.
8. Enicker B, Madiba TE. Cranial injuries secondary to assault with a machete. *Injury.* 2014;45(9):1355-1358.
9. Kumar A, Kankane VK, Jaiswal G, Kumar P, Gupta TK. Compound Elevated Skull Fracture Presented as a New Variety of Fracture with Inimitable Entity: Single Institution Experience of 10 Cases. *Asian J Neurosurg.* 2019;14(2):410-414.
10. Ralston BL. Compound elevated fractures of the skull. *J Neurosurg.* 1976;44(1):77-79.
11. Verdura J, White RJ. Letter: Compound elevated skull fractures. *Journal of neurosurgery.* 1976;45(2):245.
12. Balasubramaniam S, Tyagi DK, Savant HV. Everted skull fracture. *World Neurosurg.* 2011;76(5):479 e471-473.
13. Ferrer E, de Notaris M. Contemporary skull fractures: unusual everted fracture. *World Neurosurg.* 2011;76(5):417-418.
14. Mid-year population estimates, 2018 (PDF) (Report). Statistics South Africa. 31 July 2018. p. 3. Retrieved 30 July 2019
15. Levy MM, Dellinger RP, Townsend SR, et al. The Surviving Sepsis Campaign: results of an international guideline-based performance improvement program targeting severe sepsis. *Intensive Care Med.* 2010;36(2):222-231.

16. Kumar J, Prakash A, Harsh V, Kumar A. Elevated fracture of skull in pediatric age group: A series of five patients with review of literature. *Asian J Neurosurg.* 2016;11(1):75.
17. Bullock MR, Chesnut R, Ghajar J, et al. Surgical management of depressed cranial fractures. *Neurosurgery.* 2006;58(3 Suppl):S56-60; discussion Si-iv.
18. Manne S, Musali SR, Gollapudi PR, et al. Surgical Outcomes in Depressed Skull Fractures: An Institutional Experience. *Asian J Neurosurg.* 2019;14(3):815-820.

8. Study methodology

The study with be a retrospective analysis of data collected from electronic charts of all patients with a diagnosis of compound elevated skull fracture resulting from head injuries treated by the Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital from 1st January 2005 to 31st December 2018.

9. Study location

This study will be performed in a single center which is the Department of Neurosurgery unit at Inkosi Albert Luthuli Central Hospital situated in Durban, South Africa.

10. Inclusion criteria

All patients with the diagnosis of compound elevated skull fracture diagnosed by clinically and CT Brain scans, which were referred and treated at the Department of Neurosurgery at IALCH from 1st January 2005 to 31st December 2018.

11. Exclusion criteria

Patients with head injuries referred to IALCH Department of Neurosurgery with no radiological features of compound elevated skull fracture will be excluded.

12. Data collection methods and tools.

Data will be collected from electronic charts of all patients with a diagnosis of compound elevated skull fracture resulting from head injuries treated by the Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital from 1st January 2005 to 31st December 2018. Due to the unusual nature of compound elevated skull fractures, cases will be selected within the bank of patients with traumatic brain injury. Clinical details including clinical presentation, operative notes and discharge outcomes will be extracted from electronic note keeping system at Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital. Neuro-radiology findings will be reviewed on PACS systems (Plaza Web®). Data will be collected using Microsoft® Excel®.

13. Statistical analysis

Statistical analysis will be performed with the assistance of the biostatistician Yuesentha Balakrishna (SAMRC). Data will be analysed using Stata version 14 (StataCorp®, 2015). Frequencies and medians/means will be used to describe the data.

14. Study limitations

Study will not include patients with diagnosis of compound elevated skull fracture who are not referred to Department of Neurosurgery at Inkosi Albert Luthuli Central Hospital will be included in study (e.g. those who attend private healthcare facilities in the province of Kwa Zulu Natal).

15. Ethical approval

Ethical approval will be sought from the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal.

16. Ethical considerations

The study will be conducted in full accordance with the principles of the Declaration of Helsinki, good clinical practice and regulations of BREC of the University of KwaZulu-Natal. This is a retrospective study and there will be no direct contact with patients. The details of patients will be kept confidential in a password protected computer program.

17. Outcomes and significance

The data gathered will be analysed and will be the subject of a publication in a peer reviewed journal. The information will help us better understand this rare type of skull fracture and describe surgical methods used for management.

18. Data collection sheet

Data collection sheet

Numerical identifier: ……..

1. **Age**

2. **Gender**	**I.**	**Male**
	II.	**Female**
3. **Mechanism of injury**	**I.**	**Fall**
	II.	**Motor vehicle accident as passenger**
	III.	**Pedestrian vehicle accident**
	IV.	**Bicycle accidents**
	V.	**Assault with blunt object**
	VI.	**Assault with Machette**
	VII.	**Assault with knife or axe**
4. **Signs on clinical examination**	**I.**	**Hemiparesis / hemiplegia**
	II.	**Pupil defect**
5. **GCS on admission**	**I.**	**13- 15**
	II.	**9-12**
	III.	**3-8**
6. **CT scan findings**: Location of Fracture and underlying injury	**I.**	**Frontal**
	II.	**Parietal**
	III.	**Temporal**
	IV.	**Occipital**

	V. Does extradural cross suture line	
	VI. ASDH	
	VII. ICH	
	VIII. AEDH	
7. **Surgical management**		
8. **Medical management**		
9. **ICU stay**		
10. **ICU complications**		
11. **Length of ICU stay** 12.		
13. **Surgical complications**		
14. **Length of stay in hospital**		
15. **Mortality**		
16. **GOS at discharge**		

Appendix 2: The Guidelines for Authorship for the Journal selected for submission of the manuscript-

British Journal of Neurosurgery

(as adapted https://www.tandfonline.com/action/authorSubmission?journalCode=ibjn20&page=instructions#style)

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Your paper should be compiled in the following order: title page; abstract; keywords; main text introduction, materials and methods, results, discussion; acknowledgments; declaration of interest statement; references; appendices (as appropriate); table(s) with caption(s) (on individual pages); figures; figure captions (as a list).

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Please use British (-ise) spelling style consistently throughout your manuscript.

Please use single quotation marks, except where ‘a quotation is “within” a quotation’. Please note that long quotations should be indented without quotation marks.

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2. Should contain a structured abstract of 300 words. A structured abstract should cover (in the following order): the purpose of the article, its materials and methods (the experimental system and procedures used), the results and conclusions.
3. **Graphical abstract** (optional). This is an image to give readers a clear idea of the content of your article. It should be a maximum width of 525 pixels. If your image is narrower than 525 pixels, please place it on a white background 525 pixels wide to ensure the dimensions are maintained. Save the graphical abstract as a .jpg, .png, or .gif. Please do not embed it in the manuscript file but save it as a separate file, labelled GraphicalAbstract1.
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Appendix 3: Ethical approvals

Included hospital and provincial approvals as well as the BREC approval (or waiver if appropriate).

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

Inkosi Albert Luthuli Central Hospital
Ethekwini Health District

DEPARTMENT OF NEUROSURGERY
Private Bag X03, Mayville, 4058
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To:

Professor J. Tsoka-Gwegweni
Biomedical Research Ethics Committee
University of KwaZulu-Natal
Westville Campus
Govan Mbeki Building
Private Bag X54001
Durban
4000

07 February 2017

Re: Ethical approval for study titled: "Retrospective Chart Review of surgical management of compound elevated skull fractures" for degree purposes (Master of Medicine in Neurosurgery) under class approval BREC reference number: BCA 219/15.

Dear Professor J. Tsoka-Gwegweni

Dr. Prashanth Maharaj, a registrar in the Department of Neurosurgery is currently registered for a MMed. (Neurosurgery) with the University of KwaZulu-Natal. The title of his study is "**Retrospective Chart Review of surgical management of compound elevated skull fractures"** and is for higher degree purpose.

The Department of Neurosurgery has BREC class approval to maintain a database of admissions and procedures performed in this unit for research purposes (**BREC reference number: BCA 219/15**).

We request permission to perform this study under the existing class approval using the database in our unit.

Yours Sincerely

Dr. Basil Enicker (Class approval / database primary administrator)
Consultant Neurosurgeon
Department of Neurosurgery
Inkosi Albert Luthuli Central Hospital (IALCH)
800 Bellair Road
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Durban, South Africa
4091
Telephone: +27 31 240 1135
Cell: 079 892 6711
E-mail: basilenicker@yahoo.com

- KINDLY RETURN **ALL DOCUMENTATION** WHEN REPLYING

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

26 April 2017

Dr P Maharaj (205501695)
Discipline of Neurosurgery
School of Clinical Medicine
drpmaharaj@gmail.com

Dear Dr Maharaj

Protocol: Retrospective chart review for surgical management of compound elevated skull fractures.
Degree: MMed
BREC reference number: BE088/17

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 28 February 2017.

The study was provisionally approved pending appropriate responses to queries raised. Your response received on 18 April 2017 to BREC letter dated 10 April 2017 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given **full ethics approval** and may begin as from 26 April 2017.

This approval is valid for one year from **26 April 2017.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **RATIFIED** by a full Committee at its next meeting taking place on **09 May 2017.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor Joyce Tsoka-Gwegweni
Chair: Biomedical Research Ethics Committee

cc supervisor: basilenicker@yahoo.com
cc postgraduate administrator: jantjies@ukzn.ac.za

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Appendix 4: Glasgow Outcome Scale

Glasgow Outcome Scale	Interpretation
1 – Dead	Dead
2 – Vegetative State	Absence of awareness of self and environment
3 – Severe Disability	Needs assistance with activities of daily living
4 – Moderate Disability	Independent, can partially resume work/school/social activities
5 – Good Recovery	Full recovery or minor symptoms which do not affect daily life

As adapted from Jennett B, Snoek J, Bond MR, Brooks N. Disability after severe head injury: observations on the use of the Glasgow Outcome Scale. Journal of Neurology, Neurosurgery & Psychiatry. 1981 Apr 1;44(4):285-93