Depressed Fracture Over Superior Sagittal Sinus: Management Outcome In Qena University Hospitals

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Abstract

Background: Depressed skull fractures that lie over dural venous sinuses have the potential to lacerate or compress these sinuses resulting in massive bleeding or intracranial hypertension, non-surgical management may allow sinus thrombosis or stenosis and subsequent venous infarction or intracranial hypertension to occur. Surgical management with sinus reconstruction or repair is now advocated.

Objectives: to assess the outcome of management of patients with skull depressed fractures over superior sagittal sinus in Qena university hospitals.

Patients and methods: hospital-based Cohort study conducted on 30 patients admitted with depressed skull fractures over superior sagittal sinus to Neurosurgery Department, Qena University Hospital. The patients data were collected including demographic data, mode of trauma, vital signs, they were subjected to neurological evaluation of the conscious level and the motor power preoperatively using Glasgow coma scale and Muscle power scale respectively .Radiological assessment was done using CT scan to evaluate the pattern of the fracture ,the site and its relation to the sagittal sinus. Magnetic resonance imaging (MRI) and Magnetic resonance venograohy(MRV) were ordered only for patients who developed signs of superior sagittal sinus thrombosis. Patients were managed either conservative or surgical including evaluation elvation of the fracture, sinuorraphy or hitch stiches to control the sinus bleeding. Postoperatively the outcome was evaluated using the Glasgow coma scale, the Motor power scale and Extended Glasgow outcome scale.

Results: Out of 30 patients with depressed skull fractures related to the superior sagittal sinus we found that there were significant male predominance about 93.3%, assault was the most common mode of trauma 70%. Surgical intervention was chosen for 90% of patients while 10% of patients were managed conservatively. As regard Glasgow coma score (GCS)80% of patients showed improvement post operatively. While 87.5% of patients showed significant improvement in their motor power, and as regard Glasgow outcome score Extended (GOS-E) 74.1% of patients who had undergone surgery had upper good recovery while only one patient 3.7%had upper moderate disability.

Conclusion: In conclusion, surgical management of depressed fractures overlying the superior sagittal sinus should be strongly considered especially when there are venous sinus compression, neurological deficit or scalp wound over the fracture site. Venous sinus thrombosis must be taken into account when evaluating patients with simple depressed fracture over or near the superior sagittal sinus.

Keywords: Traumatic brain injury; Depressed fracture; Superior sagittal sinus.

DOI: 10.21608/SVUIJM.2023.233465.1681

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Received: 20 August,2023.

Revised: 20 September, 2023.

Accepted: 24 September, 2023.

Published: 24 April, 2025

Cite this article as Radwan Nouby Mahmoud, Ali Rabee Kamel, Eslam Esayed Hassan, Mohamed Ahmed Abdulaziz. (2025). Depressed Fracture Over Superior Sagittal Sinus: Management Outcome In Qena University Hospitals. *SVU-International Journal of Medical Sciences*. Vol.8, Issue 1, pp: 938-948.

Introduction

Depressed skull fracture is one of the common conditions that need urgent surgical intervention. Open (compound) depressed fractures represent an emergency due to the potential of fatal bacterial infection (**Stein, 2019**).

Treatment of depressed skull fracture has been described in some of the oldest recorded medical literature, and there is even evidence of surgery for depressed skull fractures in prehistoric times (**Kushner et al., 2018**).

Depressed skull fractures that lie over dural venous sinuses have the potential to lacerate or compress these sinuses resulting in massive bleeding or intracranial hypertension. Due to these risks, conservative management was initially advocated for these fractures. However, non-surgical management may facilitate sinus thrombosis or stenosis and subsequent venous infarction or intracranial hypertension. The patient -in these cases- may present with progressive neurological deterioration, deep coma and intracranial hypertension caused by venous stasis without collateral circulation (**RAGAEE et al., 2019**).

Superior sagittal sinus thrombosis is still an unusual complication of traumatic brain injury and its pathogenesis is still not fully understood (**Tamimi et al., 2005**).

Early definitive diagnosis and management of depressed skull fracture decreases both morbidities and mortalities (**Marshall, 2000**). Surgical elevation of these fractures should only be performed if indicated by experienced surgeons in a well-prepared facility aiming for sinus reconstruction or repair if needed **(Pramantara et al., 2022)**.

Behera et al. 2015 described operative techniques for management of superior sagittal sinus injury including Gelfoam compression only, hitch stitches over gelfoam, bilateral hitch stitches over gelfoam and sinoraphy.

The goal of our research is to assess the clinical outcome of management of patients with skull depressed fractures over superior sagittal sinus in Qena university hospitals.

Patients and methods

Thirty patients admitted to our department with traumatic brain injury who showed depressed skull fracture over the superior sagittal sinus in their CT head from April 2022 to April 2023.

Inclusion criteria included: All patients with depressed skull fracture over the superior sagittal sinus.

Exclusion criteria included:

1. Depressed fractures away from the superior sagittal sinus.
2. Fissure fracture.

Data of the patients were collected including demographic data, age , gender,residancy ,and the mode of trauma. All patients were subjected to

1. **Clinical evaluation:**
   a) Complete history taking including demographic data, age , gender,residancy ,and the mode of trauma .
   b) General examination including pulse,blood pressure,respiratory rate
   c) neurological examination including conscious level and motor power using Glasgow coma scale and Medical Research Council Scale For Power Of Muscle(MMRC) (**Table.1**) respectivly .
2. **Routine laboratory work up:** especially complete blood count, prothrombin concentration, prothrombin time and INR .
3. **Radiological** evaluation via computed tomography (CT) to diagnose the fracture, its type and site in relation to the affected part of the superior sagittal sinus(anterior-middle or posterior third) as well as any associated intracranial findings.

Management

a) Non-surgical management was considered in patients that were fully conscious with no neurological deficit having simple depressed fractures on their CT scan (**Stein, 2019**). These patients were admitted to the ward for 1 week follow up and were observed for any signs of increased intracranial tension ,then MRV was done to exclude any venous sinus affection, then discharged to home and follow up for further 3 weeks at outpatient clinic . As long as no signs of increased intracranial pressure appeared. Follow up period was extended in patients with signs of increased intracranial pressure.
b) Surgical management was chosen in all patients with abnormal neurological examination, have compound depressed fractures or associated surgical lesion **(Pramantara et al., 2022**).

Surgical elevation of the depressed fracture was done according to the standard technique and if a dural sinus tear was found, repair was done by sinorrhaphy or hitch sutures over gelfoam as described by **Behera et al. 2015**. Patients were transferred to the department after the operation and followed up in the ward until discharge was done.

Patients were followed up for 1 month after discharge from hospital.

Outcome evaluation

- Postoperatively, all patients were evaluated clinically according to the following:

a) Conscious level according to Glasgow coma scale.
b) Motor power using MMRC (**Table.1**).
c) Vital signs including heart rate, temperature, O_2 saturation, systolic and diastolic blood pressure.
d) Fundus examination was done to assess presence of papilledema in patients with signs of increased ICP.
e) Extended Glasgow outcome scale (GOS-E) (**Table.2**) was assessed at the end of the follow up period **(Wilson et al., 2021)**.

- Radiographic evaluation by CT, and MRV was ordered only in patients with signs of increased intracranial tension.

Table 1. Medical Research Council Scale For Power Of Muscle (James, 2007)

	Medical Research Council Scale For Power Of Muscle
0	No response\no contraction visible
1	Flicker of contraction,but no movement
2	Joint movement when gravity effect is eliminated
3	Movements against the gravity but not against examiner's resistance
4	Movements against resistance but weaker than normal
5	Normal power

Table 2. Extended Glasgow outcome score(GOSE). (Wilson et al., 2021).

GOS-E score.	**Performance level**
1	Dead
2	Vegetative state
3	Lower severe disability
4	Upper severe disability

5	Lower moderate disability
6	Upper moderate disability
7	Lower good recovery
8	Upper good recovery

All patients signed a written informed consent prior to their inclusion in this study and the institutional ethical committee of the Faculty of Medicine, Qena, approved the study (IRB NO; SVUMED-NES014-1-22-4-389).

Statistical analysis

Data was collected, coded then entered as a spread sheet using Microsoft Excel 2016 for Windows, of the Microsoft Office bundle; 2016 of Microsoft Corporation, United States. Data was analyzed using IBM Statistical Package for Social Sciences software (SPSS), 21st edition, IBM, United States. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Continuous data was expressed as mean ± standard deviation, median & IQR while categorical data as numbers and percentage.Data was presented as tables and graphs. Continuous data were compared using the Chi square test. Categorical data was compared using the t-test. Results was considered statistically significant at a p-value of less than or equal 0.05 and highly statistically significant at a p-value of less than or equal 0.001.

Results

Our study was conducted on 30 cases who presented to our department with depressed fracture over the superior sagittal sinus. As regard demographic data 28 patients (93.3%) were males while two patients (6.7%) were females with male to female ratio was 14:1 .Their age ranged from three years to 75 years with mean age was 27.33± 19.82 years as shown in (**Table.3**).

Table 3. Distribution of patients regarding demographic data.

Parameters		**Studied patients (n= 30)**	
		N	**%**
Sex	**Male**	28	93.3%
	Female	2	6.7%
Age (years)	**Mean± SD**	27.33± 19.82	
	Median	22.0	
	Range	3.0 – 75.0	

The most common mode of trauma was assault reported in 70% of the cases followed by fall from height that was seen in 26.7% of the studied cases. One patient presented with electric saw injury as shown in (**Table.4**).

Table 4. Distribution of patients regarding mode of trauma.

Parameters		**Studied patients (n= 30)**	
		N	**%**
Mode of trauma	**Assault**	21	70%
	Fall From Height	8	26.7%
	Electric saw	1	3.3%
	Total	30	100.0%

As regard management patients were divded into 2 subgroups , the first group was managed surgically 90%, and the second group was managed conservatively 10% who were fully conscious from the start, neurologically intact and with simple depressed fracture . Regarding general examination, the mean systolic and diastolic blood pressure were 134.00± 17.34 and 79.33± 13.37 mm/Hg respectively. The mean heart rate was 91.07± 14.99 beats/min. Temperature ranged from 37 ^{O}C to 38.5 ^{O}C with mean of 37.72± 0.47 . The mean conscious level on admission was 14.23± 2.14 as shown in (**Table .5**).

Table 5. Distribution of patients regarding preoperative general examination findings.

Variables	Studied patients (n= 30)				
	Mean	±SD	Median	Range	
Systolic Blood Pressure (mm/Hg)	134.00	17.34	130.00	110.00	200.00
Diastolic Blood Pressure (mm/Hg)	79.33	13.37	80.00	60.00	110.00
SPO2 (%)	98.10	1.81	99.00	90.00	100.00
Heart rate (beats/min.)	91.07	14.99	90.00	60.00	120.00
Temp (^{O}C)	37.72	0.47	37.85	37.00	38.50
GCS	14.23	2.14	15.00	4.00	15.00

On neurological examination of the studied cases, 22 patients (73.3%) were neurologically intact, while 8 patients showed motor deficit(Table 9) as follow: Two cases had weakness (grade 2), four cases had weakness (grade 4), one case had weakness (grade 3), one case had weakness (grade 0) . Initial CT brain done on presentation showed that The most common fracture site reported was the anterior parietal area that occurred in 12 patients (40%) followed by the middle parietal area in 11 (36.7%) patients then the posterior parietal area in 7 patients (23.3%) (**Table 6, Fig.1**)

Table 6. Distribution of studied cases according to fracture site in relation to the superior sagittal sinus:

Parameters		Studied patients (n= 30)	
		N	%
Fracture site	**Over anterior third**	12	40%
	Over middle third	11	36.7%
	Over posterior third	7	23.3%

There was no associated intracranial findings in 70% of the cases, epidural rim of hematoma was seen in 10% of cases, both epidural hemorrhage and subarachnoid hemorrhage were seen in 6.7% and subarachnoid hemorrhage was

seen in 6.7%. Brain contusion was found in one case and both epidural hematoma & brain contusion was found in one case.

The mortality rate among the studied patients was 3.3% as one case out of 30 cases died on postoperative day one. 27 out of 30 patients (90%) were managed surgically while conservative management was opted for in three cases, one case out of the these 27 patients passed away 1 day post-operative (who had multiple organs trauma hemo-pneumo thorax and fracture pelvis). Regarding vital signs at follow up, systolic blood pressure among the 29 survived cases ranged from 110 mm/Hg to 160 mm/Hg with mean ±SD was 127.24± 11.69 mm/Hg. Diastolic blood pressure among the 29 survived cases ranged from 60 mm/Hg to 90 mm/Hg with mean ±SD was 74.66± 8.23 mm/Hg. heart rate among the 29 survived cases ranged from 60 beats/min. to 100 beats/min. with mean ± SD was 72.93± 9.44 beats/min.

Regarding conscious level, all patients who survived had post-operative GCS of 15. The motor power at follow up improved in six cases to full motor power and only two patients improved but still had residual affection, one patient improved from G0 to G4, one patient improved from G2 to G4+ (**Table .7**).

Table 7. Neurological examination at follow up:

Parameters		**Studied patients (n= 29)**	
		N	**%**
Neurological Examination at follow up	**Normal**	24	93.1%
	weakness G4+	1	3.4%
	weakness G4	1	3.4%

Regarding postoperative MR venography, two out of 12 cases who had depressed over anterior parital third had affected anterior third of the superior sagittal sinus, one case out of 11 who had depressed over middle parital third had affected middle third of the superior sagittal sinus (SSS) and one case out of 6 who had depressed over posterior parital third had affected posterior third of superior sagittal sinus (**Table.8**). None of these affected cases belongs to the conservative group .

Table 8. Distribution of cases according to MRV findings

Parameters		**Studied patients (n= 4)**	
		N	**%**
	Affected ant. 1/3 SSS (stenosis)	2	50%
	Affected middle. 1/3 SSS (stenosis)	1	25%
	Affected post. 1/3 SSS (stenosis)	1	25%

The studied cases were assessed using Extended Glasgow outcome scale (GOSE) (**Table.2**). Most cases (76.7%) had upper good recovery. Five cases (16.7%) had lower moderate disability. One case had upper moderate disability. One case died(**Table .9**).

Table 9. Distribution of cases according to management, demographic, clinical data and outcome

Management	Surgical			Conservative			
Age Range Mean SD IQR	3-67 years Mean 27.15 SD 17.7 13-37.5			5-75 years Mean 29 SD 39.85 -		P value =0.88	
Sex	Number		Percentage	Number		Percentage	*P Value = 0.001*
	Male	26	96.3%	Male	1	33.3%	
	Female	1	3.7%	Female	2	66.7%	
Residence in Qena	Number		Percentage	Number		Percentage	P value >0.99
	27		100%	3		100%	
Glasgow coma scale	Fully conscious N: 22 81.4%		Disturbed conscious level N: 5 18.5%	Fully conscious N:3 100%		Disturbed conscious level N:0 0%	*P Value =0.06*
Neurological Deficit	Number		Percentage	Number		Percentage	*P Value =0.85*
	8		29.7%	0		0 %	
Superior sagittal sinus integrity	Intact N:23 85.2%	Affected N:4 14.8%		Intact N:3 100%	Affected +N:0 0%		*P Value =0.61*
Glasgow outcome Score-E		Number	Percentage		Number	Percentage	*P Value =0.37*
	Upper good recovery	20	74.1%	Upper good recovery	3	100%	
	Lower good recovery	5	18.5%				
	Upper moderate disability	1	3.7%				
	Dead	1	3.7%				

N:number , %: percentage. P value<0.05 is significant, P value <0.01 is highly significant, SD: Standard deviation.

The mean age in the surgical group was 27± 17.77 with range of 3-67 years compared to 29± 39.85 with range of 5-75 years in the conservative group. There was

non-significant difference between the 2 group regarding age (P-value = 0.88). Of the surgical treatment group, 26 (96.3%) cases were male, and 1 (3.7%) case was female compared to 1 (33.3%) male case and 2 (66.7%) female cases in the conservative treatment group. There was significant difference between the 2 groups regarding sex distribution (P-value = 0.001). All the participants of both groups were from Qena. Of the surgical group 22 (81.4%) were fully conscious and 5 (18.5%) had disturbed conscious levels while all the participants in the conservative group were fully conscious. There was non-significant difference between the 2 group (P-value = 0.06). 8 (29.75%) patients in the surgical group had neurological deficit while non of the conservative group had neurological deficit with non-significant difference between the 2 group (P-value = 0.85). From the surgical group 23 (85.2%) had intact Superior sagittal sinus integrity and 4 (14.85) had affected Superior sagittal sinus integrity from which 2 cases were managed by Sinoraphy and 2 cases were managed by Hitching sutures. In the conservative group, all the patients had Intact Superior sagittal sinus integrity. There was non-significant difference between the 2 group (P-value = 0.61). As regard the extended Glasgow outcome Score, in the surgical group 20 (74.1%) had upper good recovery, 5 (18.5%) had lower good recovery, 1 (3.75%) had Upper moderate disability and 1 (3.75%) died. In the conservative group, all the patients had upper good recovery.

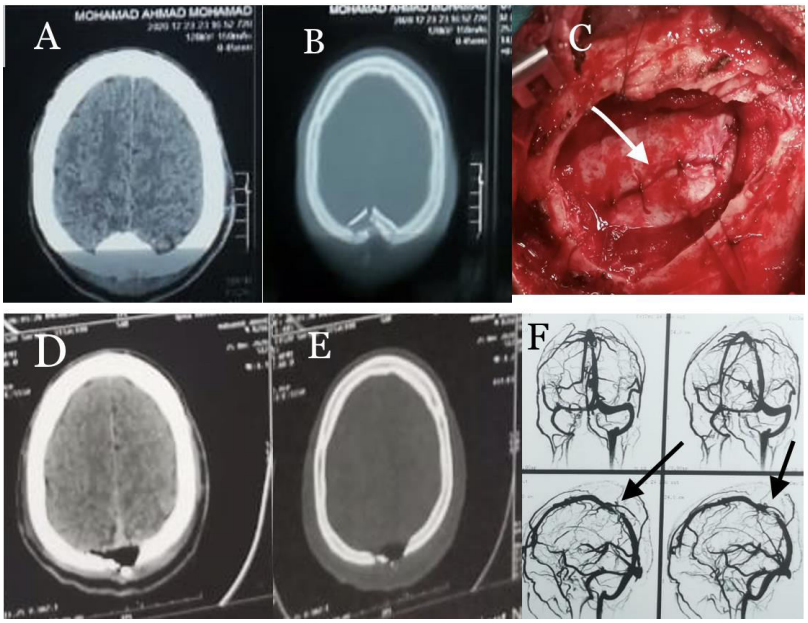

Fig.1: Initial CT brain showing midline occipital depressed fracture(A and B) and intra-operative view after sinoraphy(C) (white arrow). Postoperative CT scan(D and E) & MRV(F) showing occlusion of the posterior third of the superior sagittal sinus (black arrows). The management was in the form of anticoagulant administration and follow up with fundus examination.

Discussion

Depressed fracture of the skull usually occurs due to high-energy trauma to the head where the outer and inner tables of the skull break concurrently and it is one of the most common conditions that need urgent surgical intervention especially compound fractures to prevent fatal infections (**Ozor et al., 2019**).

Depressed fractures overlying the dural venous sinuses are considered a challenge as they can cause lacerations or

compress the underlying sinus leading to massive bleeding or intracranial hypertension (**RAGAEE et al., 2019**).

In 1946, Ecker described the first case of head injury associated with dural venous sinus thrombosis. Since then, a few cases of posttraumatic sagittal sinus thrombosis have been reported.

Our study was conducted on 30 patients with depressed fracture overlying the superior sagittal sinus.

In our study, the 28 patients (93.3%) were males while two patients (6.7%) were females with male to female ratio was 14: 1. The age of cases ranged from three years to 75 years with mean age was 27.33± 19.82 years. Similarly, the study of **Aziz et al., 2019** showed similar results regarding age and gender, as their patients comprised of 94.12% males and 5.9% females with mean age of 20.8 ± 11.5 years.

Similar to the study of **Aziz et al., 2019,** Assault was found to be the most common mode of trauma in our study. However, **Behera et al., 2015** identified road traffic accident as the major causative mode of trauma in their study.

Regarding conscious level, the mean GCS on admission was 14.23± 2.14. **Mohammad et al., 2007** and **Behera et al., 2015** showed similar data regarding admission GCS. Neurological examination of our cases revealed that 22 patients (73.3%) had no neurological deficits, however, 8 patients (26.7%) had motor deficits where 4 patients had weakness G4, 2 patients had weakness G2 , one patient had weakness G3 and one patient had weakness G0. These findings were in accordance with the study of **Aziz et al., 2019** where 82.5%of the patients showed no neurological deficit.

Radiographic evaluation showed that the most common fracture site reported was the anterior parietal area that occurred in 12 patients (40%) followed by the middle parietal area in 11 patients (36.7%) then the posterior parietal area in 7 patients (23.3%). **Özer et al., 2005** found that the majority of depressed fractures were localized over the superior sagittal sinus, and half were over the middle one-third of the sinus. However, **Hersh et al., 2018** established that the posterior third of the superior sagittal sinus was the most affected in their study. 70% of the cases had no associated intracranial findings on CT. This was not the same case in the study of **Mostafa Elkatatny et al., 2019** who found that 65% of their cases to have associated hematoma on their initial CT.

27 patients (90%) were managed surgically while conservative management was opted for in 3 cases as they were fully conscious with no neurological deficit on examination and they had simple depressed fractures. **Behera et al., 2015** operated on 100% of their patients. However, **Hersh et al., 2018** only operated on 3 patients (7.3%).

The mortality rate among the studied patients was 3.3% as, unfortunately, one patient -who was GCS 4 on admission and had associated hemo-pneumo thorax with bilateral chest tubes inserted in the emergency department before transfer to the operative theatre - died one day postoperatively. Concurrently, **Özer et al., 2005** had mortality rate of 11.8%.

There was no significant difference between pre and postoperative systolic and diastolic blood pressure ($p = 0.076$ and 0.176 respectively). However, there was a significant decrease in heart rate postoperatively compared to preoperative values ($p<0.001$).

Fundus examination was done for patients who showed manifestations of increased ICP and it showed papilledema in 2 patients (6.8%) who also complained of having headache and blurred vision.

There was a significant improvement in GCS postoperatively compared to preoperative findings ($p=0.026$). Concurrently, **Harris et al., 2021** presented similar results regarding

GCS at discharge as 50% had a GCS of 15 and 29% had GCS of 14.

The patients who had neurological deficit on admission showed improvement on follow up as 6 patients had no deficit and 2 patients had improved motor power in comparison to admission grade. This was also seen in the study of **Aziz et al., 2019** who found improvement of motor weakness in 4 out of 6 patients on follow up.

The extended Glasgow outcome scale (GOSE) was used to assess disability at the end of follow up period and it showed that 23 cases (76.7%) had upper good recovery. Five cases (16.7%) had lower moderate disability. One case had upper moderate disability and one patient died. No significant relation was found between GOSE and management decision ($p>0.05$). Similar results were achieved in the case series conducted by **Grangeon et al., 2017.** In the study of **Mostafa Elkatatny et al., 2019**, they found that moderate disability occurred in 5% and good recovery occurred in 80% of the cases with 15% mortality rate.

MR venography was done for patients who showed manifestations of increased intracranial pressure and it was positive in 4 cases, two had affected anterior third of the superior sagittal sinus, one case had affected middle third of the superior sagittal sinus and one case had affected posterior third of superior sagittal sinus. **Mostafa Elkatatny et al., 2019** showed that the middle part was the most affected part of the superior sagittal sinus. **Harris et al., 2021** found superior sagittal sinus thrombosis in 46% of the cases (23% anterior, 27% middle and 36% posterior, with 14% involving the whole sinus).

Conclusion

Despite the controversy around the management of depressed skull fractures involving the dural venous sinuses, surgical management of depressed fractures overlying the superior sagittal sinus should be strongly considered especially when there are venous sinus compression, neurological deficit or scalp wound over the fracture site. Venous sinus thrombosis must be taken into account when evaluating patients with simple depressed fracture over or near the superior sagittal sinus.

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