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Management of Compound Depressed Fractures Over Major Cranial Venous Sinuses

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ABSTRACT

Background: Incidence of trauma increased both in developing and developed countries especially in congested cities because of high traffic flow. This makes it a worldwide health and social issue. Furthermore, depressed skull fractures occur over venous sinuses in 11% –18% of cases, representing a fairly large proportion of these cases.

Objective: To characterize the demographic, clinical and radiological findings of patients with depressed fractures overlying cranial dural sinuses that we have faced in our institute at Sohag University Hospital.

Patients and Methods: This retrospective and prospective study was conducted on 50 patients with compound depressed fracture over venous sinuses, which were treated either surgically or conservative at Sohag University Hospitals.

Results: Despite surgical group included patients with neurological deficit and impaired level of consciousness compared to conservative group; surgical group had the same outcome as the conservative group. CNS infection was not recorded in both groups and the superficial infection was significantly higher in the conservative group. Mortality related to the treatment modality was not recorded in our study.

Conclusion: Both surgical and conservative treatment of compound depressed fracture over major cranial venous sinuses had a good outcome as regards morbidity and mortality. Risk of CNS infection is not high but surgical treatment can significantly decrease the risk of infection compared to the conservative treatment.

Keywords: Depressed fractures overlying cranial dural sinuses, Sohag University.

INTRODUCTION

Depressed skull fracture usually occurs following high-speed impact with sharp object. The outer and inner tables of skull typically break concurrently [(1)]. Depressed skull fracture over superior sagittal sinus (SSS) is the commonest type of dural venous sinus injury with significant morbidity and mortality. Significant dural sinus injury occurs in 1.5 to 5% of all head injury cases [(2)]. Depressed skull fracture as one of the most common conditions needs urgent surgical intervention. An open depressed fracture represents an emergency due to potential of bacterial infection. Early definitive diagnosis and management of skull fracture decreases both morbidities and mortalities. Among all open depressed fractures, only those showing a close relationship with one of the venous sinuses is life-threatening. Regarding the degree of injury in the dural sinus, massive blood loss could occur at the time of trauma or at the time of elevation of fragments in the operating room [(3)].

The classical teaching in depressed skull fracture over venous sinuses is conservative management. This may be true in view of expected blood loss and skills required to handle the sinus bleed. However conservative approach in such cases exposes the patient to the risk of cerebral venous thrombosis and consequent venous infarct or elevated intracranial pressure [(4)]. Neurosurgeons have always been wary about operating on compound depressed skull fractures overlying a venous sinus. Conservative treatment of such lesions, however, must be weighed against the benefits of surgery including reduced sepsis, mass effect, and improving cosmetic appearance. Nonetheless, very few cases of intracranial hypertension due to venous sinus compression have been reported [(5)]. Traditionally, conservative management of depressed skull fractures that lie over venous sinuses has been preferred over surgical treatment because of the risk of hemorrhage associated with operating over a venous sinus. However, in cases in which neurological deficits are reported with elevated ICP, surgical treatment is preferred [(5)].

The recent experimental studies by **Fuentes *et al.*** [(5)] on acute thrombosis of the superior longitudinal sinus in rabbits, cats and dogs have shown rather surprising results. To occlude the sinus they used ligation, irritant coagulants, thrombin, muscle and cotton wool, but in 11 cases, they failed to produce compete thrombosis. These attempts of obliteration of the superior sagittal sinus were followed by varying degrees of organization and recanalization, and most surprising, no functional disturbances [(6)]. The most likely explanation for the different response got that in the animals there are not nearly as many cerebral veins emptying into the superior longitudinal sinus and that collateral circulations are adequate to compensate rapidly for such venous interference [(3)].

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The aim of this study was to characterize the demographic, clinical and radiological findings of patients with depressed fractures overlying cranial dural sinuses that we have faced in our institute at Sohag University Hospital.

PATIENTS AND METHODS

This retrospective and prospective study was conducted on 50 patients with compound depressed fracture over venous sinuses, which were treated either surgically or conservative at Sohag University Hospitals.

Inclusion criteria: All patients presenting with a compound depressed skull fracture over a venous sinus were undertaken in Sohag University Hospitals.

Exclusion Criteria: Patients with depressed fracture away from the venous sinuses, patients with compound depressed fracture associated with other pathology away from the fracture and patients with simple depressed fractures.

All patients included in the study were subjected to:

1) Clinical assessment: Taking medical history, general examination and neurological examination.

2) Investigations:

A- **Radiological:** X-ray skull, CT brain, 3D CT skull and MRV when indicated.

B- **Laboratory:** Preoperative routine investigation i.e. CBC, coagulation profile, renal function and random blood sugar. Also, blood grouping and cross matching were done preoperatively.

3) Treatment:

Treatment of compound depressed fracture over the major venous sinuses is still a clinical dilemma, due to the risk of bleeding from the sinus associated with surgical management. The majority of compound fracture overlying dural sinuses can be managed safely without major surgical intervention with a low risk of infection. Conservation should be favored when the sinus is patent, dura intact, and bone displacement is insignificant in neurologically intact patients with an apparently clean wound. Otherwise, surgery should be considered. So the decision usually was taken according to the physician in duty, for patients with neurological deficit directly related to the fracture or showed the manifestation of increase intracranial pressure or sinus thrombosis, surgical intervention was indicated. The CT, 3D skull scans were assessed for the position of the fracture and the underlying pathology and the surgical approach will be selected accordingly, opening the overlying wound, careful elevation of the depressed bone fragment and inspection of the venous sinus were done and be ready to control bleeding if present.

For patients treated conservatively, prophylactic antibiotics were prescribed.

For both group, prophylactic antiepileptic drugs were prescribed for 3 to 6 weeks.

4) Follow up:

All patients included in the study were followed up during the hospital stay and during regular visits at our outpatient clinic for at least 3 to 6 months for:

- Clinical and neurological assessment.
- CT brain recorded for all patients before discharge and after 6 to 8 weeks later if not indicated before that time.
- Glasco Outcome Scale (GOS) was applied to the patient at the discharge time and 3 to 6 months later.

Table (1): Glasco Outcome Scale

GCS 1 Death	Severe injury or death without recovery of consciousness
GCS 2 Persistent vegetative state	Severe damage with prolonged state of unresponsiveness and a lack of higher mental functions
GCS 3. Severe disability	Severe injury with permanent need for help with daily living
GCS 4. Moderate disability	No need for assistance in everyday life, employment is possible but may require special equipment.
GCS 5. Low disability	Light damage with minor neurological and psychological deficits.

Ethical approval and written informed consent:

An approval of the study was obtained from Sohag University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Independent-samples t-test of significance was used when comparing between two means. Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%. P values ≤ 0.05 was considered significant.

RESULTS

A total of 50 patients were included in our study; 43 males (86%) and 7 females (14%). The highest incidence was in the second decade, the mean age was 18.86 (range 1-52 years), and there was slight statistically difference between patients in the surgical (mean = 20.9 range 4-52 years) and non-surgical (mean = 13.5 range 1- 48 years) treatment groups. Twenty five patients (50%) were of the pediatric age group (age ≤ 18 years) (Table 2).

Table (2): Age and sex distribution of the studied groups

	Total	Group (A) (Surgical =36)	Group (B) (Conservative=14)	P-value
Age (years)				
Mean	18.86	20.9	13.6	0.480
(range)	(1-52)	(4-52)	(1.48)	
Gender:				
Male	43	34	9	
Female	7	2	5	

The most common cause was, direct trauma (direct hit, animal kick, assault from others or object falling on head) (n = 35, 70%) was the most common mode of injury, followed by road traffic accidents (n = 11, 22%), particularly in patients involved in motor vehicle accidents. None of the motor cyclists wore protective helmet. Falling from a height came last in frequency (n = 3, 6%) followed by firearm injury (n = 1 2%). The mean time from trauma until arrival to the hospital was 3.8 ± 1.5 hours (Table 3).

Table (3): Mechanism of trauma in the studied groups

Mode of trauma	Total	Group (A) (Surgical =36)	Group (B) (Conservative=14)
RTA Number of cases (%)	11(22%)	8(22%)	3(21%)
Assault Number of cases (%)	14(28%)	13(36%)	1 (7%)
Hard object Number of cases (%)	20(40%)	12(33%)	8(57%)
FFH Number of cases (%)	3(6%)	1(3%)	2(14%)
Animal kick Number of cases (%)	1(2%)	1(3%)	0(0%)
Firearm Number of cases (%)	1(2%)	1(3%)	0(0%)

The mean admission Glasgow Coma Score (GCS) was 13.9, with a range between 10 and 15. The mean GCS in surgical group was 13.6. The non-surgical group had a better GCS at the presentation, the mean GCS was 14.9. Thirty eight (76%) patients were neurologically intact on admission and 12 (24%) had motor deficits; all of them were in the surgical group (33.3%), where 8 patients had hemiparesis (4 patients grade 2, 3 patients grade 3 and one patient grade 4), 3 patients had paraparesis (2 patients were grade 3 and one patient grade 2) and one patient had monoparesis grade 3 (Table 4).

Table (4): Clinical presentation of the studied groups.

	Total	Group (A) (Surgical =36)	Group (B) (Conservative=14)	P-value
CO MORBID DISEASE number of cases (%)	2(4%)	2(6%)	0(0%)	0.065
GCS mean	13.9	13.5	14.9	<0.001
NEUROLOGICAL DEFICIT Number of cases (%)	12(26%)	13(33.3%)	0(0%)	<0.001
OTHER BODY TRAUMA Number of cases (%)	6(12%)	6(17%)	0(0%)	<0.001
OTHER BRAIN INSULT Number of cases (%)	12(24%)	11(31%)	1(7%)	<0.001

Forty two patients (84%) had the fracture overlying the superior sagittal sinus (SSS), of which 18 (36%) were anterior and in 24 were mid third SSS. In 3 patients (6%) the fracture overlaid the torcular herophili and 5 patients (10%) had fractures on the transverse sinus The middle third SSS was the commonest site of fracture which accounted for 24 (48%) patients, where the torcular herophili was the least affect site in 3 patients (6%) (Table 5).

Table (5): The distribution of fracture by site involvement in each group

Site of fracture	Total (N=50)	Surgical group (N=36)	Conservative group (N=14)
Ant third SSS	18 (36%)	11 (30.6%)	7 (50%)
Mid third SSS	24 (48%)	19 (52.8%)	5 (35.8%)
Torcular herophili	3 (6%)	2 (5.6%)	1 (7.1%)
Transvers sinus	5 (10%)	4 (11%)	1(7.1%)

Work up: All patients had a CT scan and 3D reconstruction on admission. MRI and MRV were performed in 18 patients (36%), in most of them the sinus was patent and were managed non- surgically.

Treatment and outcome: Prophylactic antibiotic initiated once the patient arrived to the hospital, prophylaxis against tetanus was not routine in our institute. Surgery was favored when the fracture segment was compressing on the brain or displaced fragment, that was manifested clinically by neurological deficit if the fragment compress eloquent area of the brain (motor strip around the SSS) or compressing the flow of venous sinuses or showed the manifestation of increased intracranial pressure. When the decision to treat the patient surgically was established, intervention was done within 6.5 ± 1.5 hr. For non-surgical patients, good sterilization and cleaning of the wound then suturing was done, parenteral broad spectrum antibiotic for 3-5 days then shifting to oral antibiotics till suture removed. The mean length of hospital stay was 5.06 ± 2.22 days (minimum 3, maximum 10 days).

1st group: surgical group: This group included 36 patients (72%), the most common indication for surgical intervention was the presence of neurological deficit directly related to the fracture segment in 12 patients (33.3%), followed by large segment depressed bone and increased intracranial pressure clinically then surgeon preference for fear of the risk of infection. Intact venous sinus was encountered in 32 cases (88.9%), while sinus injury was encountered in 4 cases (11.1%); two cases were managed by gel foam and saline irrigation over cottonwood, one case was managed by sinus repair with simple suture and one case was managed by periosteal flab repair. All patients showed uneventful post-operative course. All patients showed improvement of the neurological deficit apart from one case in which CT brain showed undelaying contusion. Post-operative wound infection was recorded in one case (2.8%) that was managed by broad spectrum antibiotic.

2nd group: conservative group: This group included 14 patients (28%), all patients were treated with broad spectrum antibiotics. Post-operative wound infection was recorded in two cases (14.3%); both cases were treated by wound revision and under antibiotics umbrella.

DISCUSSION

The mean age of our study was 18.86 years, the second decade is the most active and adventurous age group for head trauma, with 25 patients (50%) in the pediatric age group (≤18 years). Our results are similar to those of the study by **Taghyan *et al.*** [7] and similar to reports from other studies [8, 9, and 10]. **Annegers *et al.*** [11] **and Mackenzie *et al.*** [12] described 15 to 24 years as the most adventurous age group carrying higher risk of head injury in the United States.

43 (86%) of our patients were male, and there were only seven females (14%), a finding that has been corroborated in many studies, and probably related to environmental, occupational and cultural factors. This reflects male preponderance for exposure to head injury compared to females. The sociodemographic characteristics were directly related to the incidence of head injury (HI).

Direct trauma (direct hit or object falling on head) [n=35 (70%)] was by far the most common mode of injury, explained by the fact that assailants often face each other, and falls consisted mostly of either a brick or metal object striking the head from a height. Road traffic injury was the 2nd most common cause accounting for (22%). This agrees with reports from the developing countries, as there is poor knowledge and practice of road safety measures by the general population. While use of seat belt and crash helmet is not mandatory, high speed driving is very common. Licensing authorities and the mechanisms of checking road worthiness of vehicles are ineffective. These in part, accounted for high incidence of road traffic accidents (RTA), which frequently results in head injuries. Recent trends in developed countries indicate a reducing incidence of vehicular-related severe head injury. This is attributed to improved traffic control, compliance with road safety measures and public prevention campaign. In addition, there have been improvements in vehicle design to make them safer for occupants in the event of a collision. These include automatic air bags, head restrain and automatic roll bars for vehicles that overturn in a collision [13, 14].

The mean time from trauma until arrival to hospital was 3.8 1.5 hours and there was no statistically significant difference between patients managed surgically and conservatively.

The mean admission GCS was 13.9, findings were similar to previously published series (Choni SC). Cases with low GCS were compound depressed fractures with underlying brain injury. 38 patients (76%) had no neurologic deficit on initial clinical

examination. The 12 (24 %) cases with deficits were cases of compound depressed fractures around the middle part of superior sagittal sinus.

Depressed skull fracture may cause dural venous sinus occlusion either by penetration or compression against the outer wall. The clinical picture of early venous sinus occlusion is nonspecific, may occur late, and may not be associated with the parenchymal abnormalities related to venous insufficiency on either CT and/or MRI. However, brain MRV can provide good anatomical details of the deep and superficial intracranial venous system, and can be used to demonstrate filling defects. However, common variants of the venous sinuses system should not be mistaken for sinus thrombosis.

Venous hypertension and increased intracranial pressure from venous sinus narrowing or sinus thrombosis, is a late complication associated with depressed fractures overlying venous sinus [4, 5, 15].

In our 50 patients series, the SSS was the most involved dural sinus (n=42, 84%), most of which were the middle third (n=24, 48%), while the rest were in the anterior and posterior third of superior sagittal sinus. Five cases (10%) involved the transverse sinus compared to those in the series by **Ozer *et al.*** [1] where the majority of cases of depressed fracture were localized over the SSS, and half were over the middle one-third sinus. These results are similar to those of other reported series [1]. This could be explained by the previously explained mechanism of injury in the majority of our patients (a direct hit or a falling object striking the head).

Raised intracranial pressure resulting from depressed skull fracture occluding the sagittal sinus has been described [16, 17]. A preoperative angiography with venous flow phase has been recommended by some authors **Richard** [18] **and Yuan *et al.*** [19]. This provides information regarding the position and extent of occlusion and transverse sinus dominance, but this was not done in our patients. All of our patients were treated based on clinical and CT brain findings alone.

MRI and MRV were done in 15 cases. Two cases had abnormality in MRV in the form of sinus attenuation but not occluded. These were treated by surgical elevation of the depressed segment in addition to supportive treatment in the form of hydration anticoagulants (low molecular weight heparin subcutaneous injection twice daily) and anticonvulsants in the acute phase followed by oral therapy in the next three months. The decision to operate is based on the neurological status of the patient, the location of the sinus involved and the extent of venous flow compromise and increase intracranial pressure or associated with injury to the brain. Elevating depressed skull fractures overlying a cranial venous sinus is hazardous [5]. The fracture should be carefully elevated, attempting to gain the best control of the venous sinus as soon as possible, preparing for the possibility of significant transfusion requirements. Sinus bleeding is a known common complication rendering this operation difficult [20], a hazard that might even lead to aborting the operation [16]. Primary bone fragment replacement of large bony fragments was performed in all cases, as none of our cases had an apparent wound infection at the time of surgery. Several studies have recorded that the rate of postoperative infection is not increased by primary bone fragment replacement.

All of our patients received their surgery or local debridement within 12 hours of arrival to the hospital. There was no recorded difference in the rate of postoperative infection between patients with skull fractures undergoing surgical repair within eight hours and those treated after that time.

Anticonvulsant drugs were administered prophylactically to patients with a breached dura during the early post-operative period or cerebral lesion.

A few additional points; the sagittal sinus can be safely transected in its anterior third, if this become necessary. This was carried out in two of our patients with orbital and anterior skull base fracture. The sagittal sinus can be repaired in its middle and posterior third.

Sometimes, depressed fractures overlying major venous sinuses are associated with intracranial hematomas. Posterior fossa extradural hematomas, which usually extend above and below the tentorium, account for approximately 5% to 10% of these lesions. In our study, our two patients with fractures involving the transverse sinus had no associated hematoma compared to other studies [21].

All management protocols for compound depressed fractures (CDFs) should include antibiotics [1, 17]. All our patients with CDFs started parenteral triple antibiotics: a penicillin + second generation cephalosporins + metronidazole during the first week. In addition, parenteral paracetamol as analgesic, anticonvulsant (if breaching of dura or underlying brain lesion) and ranitidine was started. Mannitol and frusemide were given if features of raised intracranial pressure were detected on imaging studies. All patients were hospitalized until day three to five post-trauma, during which GCS and vital data were recorded, including follow-up CT brain scans for detection of early complications.

All patients were discharged on broad-spectrum oral antibiotics for a further week, then followed up for any appearance of new neurological deficit or delayed complications. GOS was used to assess the functional outcome in our patients. Follow-up visits were scheduled at one week, then one, two to three, six and twelve months, according to our departmental protocol, during which CT scans of the brain and/or fundus examination were conducted, depending on the complaint of the patient.

The mean length of hospital stay was 5.1 ± 2.2 days and the follow-up duration was 6.8 ± 2.7 months. In our cohort, the minimum follow-up for CDFs over

venous sinus was 8.3 ± 1.6 months. **Antunes *et al.* [22]** reported that patients with contaminated compound depressed skull fractures treated surgically have to be monitored with repeated CT scans a few times over the next two to three months to search for delayed abscess formation. **Geisler and Manson [23]** recommended follow-up by repeated CT scans for at least a year for any signs of brain abscess formation. Follow-up is also needed to look for the complications associated with skull fractures, for example, seizures, and infections, but in our study follow up was for three to six months by using CT scans and/or fundus examination according to patient complaints [22].

Thirty-two (94.12%) patients had a moderate to good outcome using GOS (n=28, 82.35%) with good recovery and four (11.76%) with mild disability-grade 4 weakness. Only two patients had severe disability. The pre-treatment motor power for these patients was grade 3. All the patients were discharged with a GCS of 15, being fully conscious. There were no cases of infection on follow-up and no cases of mortality.

CONCLUSION

Both surgical and conservative treatments of compound depressed fracture over major cranial venous sinuses had a good outcome as regards morbidity and mortality. The solid indication for surgical treatment is depressed fracture on eloquent area (mostly over middle third of the superior sagittal sinus) causing relevant neurological deficit; and depressed fractures causing manifestations of increased intracranial tension. Fear of intraoperative sinus injury management is not a reality but it is almost an intraoperative cause that must be taken seriously and carefully. Risk of CNS infection is not high but surgical treatment can significantly decrease the risk of infection compared to the conservative treatment.

REFERENCES

1. **Ozer F, Yurt A, Sucu H *et al.* (2005):** Depressed fractures over cranial venous sinus. J Emerg Med., 29: 137-139.
2. **Holmes G, Sargent P (2015):** Injuries to the superior longitudinal sinus. Brit M J., 2: 493-98.
3. **Han-Song S, Fang S, Jian L *et al.* (2017):** Traumatic open depressed cranial fracture causing occlusion of posterior superior sagittal sinus: Case report. World Neurosurg., 93: 489-93.
4. **Aarabi B, Hesdorffer D, Ahn E *et al.* (2006):** Outcome following decompressive craniectomy for malignant swelling due to severe head injury. J Neurosurg., 104: 469-479.
5. **Fuentes S, Metellus P, Levrier O *et al.* (2005):** Depressed skull fracture overlying the superior sagittal sinus causing benign intracranial hypertension. Description of two cases and review of the literature. No shinkei Geka. Br J Neurosurg., 19: 438–42.
6. **Miyake S, Yamamura K, Abe H (2016):** A Case of Depressed Skull Fracture Involving only the Inner Table. Neurol Surg., 44 (7): 599-603.
7. **Taghyan M, Moussa A, Nouby R (2008):** Compound depressed skull fractures overlying dural venous sinuses. Pan Arab Jornal of Neurosurgery, 12 (2): 51-55.
8. **Muhammad I (1990):** Management of head injuries at the ABU hospital, Zaria. East Afr Med J., 67: 447-451.
9. **Adeloye A, Olumide A (1976):** Pattern of skull fractures in Nigerians. Medicine d'Afrique Noire, 23: 109-113.
10. **Flesha S, Daramola A (2002):** Fatal head injuries: The Lagos University Teaching Hospital experience (1993-1997). Nig Postgrad Med J., 9: 38-42.
11. **Annegers J, Grabow H, Kurland L *et al.* (1980):** The incidence causes and secular trends in head injury in Olmsted County, Minnesota, 1935-1974. Neurology, 30: 912-919.
12. **Mackenzie E, Edelstein S, Flynn J (1989):** Hospitalized head injured patients in Maryland: incidence and severity of injuries. Md Med J., 38: 725-732.
13. **Ross A, Bagunley C, Hills B *et al.* (1991):** Towards safer roads in developing countries. A guide for planners and engineers. Transport Research Laboratory, Crowthorne UK., Pp: 856.
14. **Odero W, Garner P, Zwi A (1997):** Road traffic injuries in developing countries-a comprehensive review of epidemiological studies. Trop Med Int Health, 2: 445-460.
15. **Aran F (2014):** Research on fractures of the base of the skull. Arch Div Med., 3: 309-315.
16. **Dalgic A, Secer M, Ergungor F *et al.* (2008):** Dural sinus thrombosis following head injury: Report of two cases and review of the literature. Turkish Neurosurg., 18: 70-77.
17. **Fuentes S, Metellus P, Levrier O *et al.* (2005):** Depressed skull fracture overlying the superior saggital sinus causing benign intracranial hypertension. Description of two cases and review of the literature. Br. J. Neurosurg., 5: 438-442.
18. **Richard H (2013):** Youmans Neurosurgical Surgery, Pediatric head injury. In: Winn HR. Editor. Ed 5. Vol 3. Philadelphia: Saunders, Pp: 3473–80.
19. **Yuan Q, Liu H, Wu X *et al.* (2012):** Characteristics of acute treatment costs of traumatic brain injury in Eastern China--a multi-center prospective observational study. Injury, 43 (12): 2094-9.
20. **Choni S, Muizelaar J, Barnes T *et al.* (2008):** prediction tree for severly head injured patients. I Neurosurgery, 75: 251-255.
21. **Kelly D, Nikas D, Becker D (1996):** Diagnosis and treatment of moderate and severe head injuries in adults; in Youmans JR (ed): Neurological Surgery, ed 4. Philadelphia, Saunders, Pp: 1618–1718.
22. **Antunes A, Franciscatto A, Modkovski R *et al.* (2009):** Depressed skull fracture. In: Kalangu KKN, Kato Y, Dechambenoit G (eds). Essential Practice of Neurosurgery, 1st ed. Nagoya: Access Publishing Co., Ltd., Pp: 720-721.
23. **Geisler F, Manson P (2005):** Traumatic skull and facial fractures. In: Rengachary SS, Ellenbogen RG (eds). Wilkins Principles of Neurosurgery. 2nd ed. Elsevier Limited, Pp: 333.