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Original Investigation

Management of Dropped Skull Flaps

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ABSTRACT

AIM: Dropping a skull flap on the floor is an uncommon and avoidable mistake in the neurosurgical operating theater.

MATERIAL and METHODS: This study retrospectively reviewed all incidents of dropped skull flaps in Ain-Shams University hospitals during a 10-year period to show how to manage this problem and its outcome.

RESULTS: Thirty-one incidents of dropped skull flaps occurred from January 2004 to January 2014 out of more than 10,000 craniotomies. Follow-up period varied from 20 to 44 months. The bone flap was dropped while elevating the bone ($n = 16$), while drilling the bone on the operating table ($n = 5$), and during insertion of the bone flap ($n = 10$). Treatment included re-insertion of the skull flap after soaking it in povidone iodine and antibiotic solution ($n = 17$) or after autoclaving ($n = 11$), or discarding the skull flap and replacing it with a mesh cranioplasty in the same operation ($n = 3$). No bone or wound infection was noted during the follow-up period.

CONCLUSION: Management of dropped skull flap is its prevention. Replacement of the skull flap, after decontamination, is an option that avoids the expense and time of cranioplasty.

KEYWORDS: Dropped skull flap, Craniotomy, Autoclave, Cranioplasty, Povidone iodine

INTRODUCTION

There are many complications from craniotomy operation that neurosurgeons inform their patients and relatives about them as infection, bleeding and seizures. Dropping a skull flap on the floor during craniotomy operation is a grave mistake and fortunately is uncommon.

Ideally when a bone flap is raised in craniotomy, it has to be replaced at the end of the operation, but when it is dropped on the floor, it cannot be replaced due to the risk of infection.

Treatment of this disaster is difficult as it seems risky to the patient if we put the flap again after a trial of decontamination, and also it is costly to put a mesh cranioplasty in place of the flap. This study discusses the causes, methods of prevention, and management of this disaster.

MATERIAL and METHODS

This is a retrospective study from Ain-Shams University hospitals, Cairo, Egypt, that reviewed all incidents of dropped skull flaps during craniotomy operations from January 2004 to January 2014 to show how to manage this problem and its outcome.

Thirty-one incidents of dropped skull flaps occurred in a 10 year-period out of more than 10,000 craniotomies. The cause of dropping the skull flap, the intraoperative and postoperative treatments, and the outcome are stated. Clinical examination was done weekly after discharge in the outpatient clinic in the first month then every two weeks for 2 months then monthly thereafter.

Erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) titre and computed tomography (CT) skull were done for the patients who had their skull flap re-inserted in the first postoperative day as a baseline. Follow-up ESR and CRP titre were done at 4 weeks of surgery.



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Follow-up CT scan was done for all patients after 2 months of surgery and was done after 5 months of surgery for the patients in whom the skull flaps were re-inserted.

■ RESULTS

During the 10 year-period from January 2004 to January 2014, more than 10,000 craniotomies were done in the Neurosurgical operating rooms in Ain-Shams University hospitals in Cairo, Egypt. Thirty-one incidents of dropped skull flaps occurred in this time period (i.e. it occurred in about 0.3% of the craniotomy operations). The number of craniotomies that were operated at night after 1 am in this 10 year-period was 773.

The patients were 17 men and 14 women. The mean age of the patients was 34 years (ranged from 2 to 70 years). Eight patients were known hypertensive and six patients were known diabetic. Eighteen craniotomies (58%) were emergency operations and 72.2% of these emergency operations (13 cases) were done late at night after 1 am. Four elective cases were done in the second run order of the list and six cases

were done in the third run order. Four cases were recurrent craniotomies with a mean time after the first operation of 2 years (ranging from 6 months to 5 years) (Tables I, II).

The bone flap was dropped while elevating the bone (16 cases), while drilling the bone on the operating table (5 cases), and during insertion of the bone flap (10 cases). None of the patients had scalp or skull infection before the operation.

In 17 cases, the dropped bone flaps were mechanically decontaminated by bulb syringe irrigation with 0.9% normal saline solution then soaked in 10% povidone-iodine solution for 5 minutes followed by a ten-minute drying period then were put in gentamycin solution (two ampoules 80 mg in 100 ml saline) for two minutes then re-inserted. In 11 cases, the dropped skull flaps were put in saline then autoclaved for 20 minutes at 121°C then re-inserted. In 28 cases (who had their skull flaps re-inserted), the dropped skull flaps were initially put in saline solution, and the saline was sent for culture. All patients had good recovery, and the patients who had preoperative disturbed conscious level were obeying commands within 2 weeks of surgery.

Table I: Emergency Operations

Number	Diagnosis	Location	Management	Pathological examination
1	EDH	Left temporo-parietal	Chemical decontamination	-
2	EDH	Left parietal	Autoclaving	-
3	EDH	Right frontal	Chemical decontamination	-
4	EDH	Right temporo-parietal	Autoclaving	-
5	EDH	Right temporo-parietal	Chemical decontamination	-
6	EDH	Left temporo-parietal	Chemical decontamination	-
7	EDH	Left temporo-parietal	Chemical decontamination	-
8	EDH	Left frontal	Chemical decontamination	-
9	Hematoma in tumor bed	Left falcine (middle third)	Chemical decontamination	Angiomatous meningioma WHO grade I
10	Hematoma in tumor bed	Left posterior frontal	Autoclaving	Oligoastrocytoma WHO grade II
11	Hematoma in tumor bed	Left parietal (convexity)	Autoclaving	Meningioma WHO grade I
12	Hematoma in tumor bed	Right parietal-occipital (convexity)	Chemical decontamination	Meningioma WHO grade II
13	Hematoma in tumor bed	Suprasellar	Chemical decontamination	Craniopharyngioma
14	Spontaneous ICH	Right parietal	Autoclaving	AVM
15	Spontaneous ICH	Left parietal	Chemical decontamination	-
16	Spontaneous ICH	Right parietal	Chemical decontamination	-
17	Spontaneous ICH	Right frontal	Chemical decontamination	-
18	Brain tumor with disturbed LOC	Left posterior frontal	Autoclaving	Glioblastoma WHO grade IV

EDH: Extradural hematoma, **ICH:** Intracerebral hematoma, **AVM:** Arteriovenous malformation, **LOC:** Level of consciousness, **WHO:** World Health Organization.

All saline cultures were negative, except in 3 cases (i.e. 10.7% of the cultures were positive) which revealed *Coagulase-negative Staphylococcus*, and the postoperative antibiotics were shifted according to culture in these cases.

In 3 cases, the bone flaps were discarded and replaced with a mesh cranioplasty in the same operation (the mesh was available in our hospital at that time for another operation).

The mean time of delay in the operation to manage this disaster was 39 minutes, 37 minutes, 22 minutes for the cranioplasty, the autoclaving and for chemical decontamination of the dropped skull flap respectively.

Eight patients received steroids in preoperative and postoperative periods for their brain tumor. There was no recommendation to delay any further treatment by radiotherapy or chemotherapy. The patients were not discharged from hospital except after at least 10 days of surgery for close observation and intravenous antibiotics. Sutures were removed ten days after surgery.

The patients and their relatives were informed after the operation about this big mistake and the management that was taken. Postoperative hemoglobin less than 9 gm/dl was corrected by packed red blood cells (RBCs) transfusion. Clinical examination after discharge in the outpatient clinic

showed neither symptoms nor signs of skull or wound infection. The follow-up ESR and CRP titre were done at 4 weeks after surgery and these were lower than those done as a baseline in the first postoperative day. Follow-up CT scan 2 months after surgery showed normal position of the bone flaps with no signs of osteonecrosis and good position of the mesh. CT scan was done 5 months after surgery (for the patients who had their own skull flaps re-inserted) and showed no abnormality in position of all the skull flaps, and without any radiological signs of osteomyelitis. Partial resorption in thickness of only three autoclaved skull flaps (27% of autoclaved skull flaps) becomes evident after 5 months, but the external aspect of these flaps remained unchanged.

The results of the clinical and radiological follow-up of all patients for at least 20 months were satisfactory from the standpoint of brain protection, cosmetic reconstruction, and absence of infection. The long-term infection rate in this study is 0%.

■ DISCUSSION

This study includes thirty-one incidents of dropped skull flaps on the floor during craniotomy operations in Ain-Shams University hospitals from January 2004 to January 2014 out of more than 10,000 craniotomies, i.e. it occurred in about

Table II: Elective Operations

Number	Provisional Diagnosis	Location	Management of the dropped skull flap	Pathological examination
1	Convexity meningioma	Left parietal	Chemical decontamination	Meningothelial meningioma WHO Grade I
2	Convexity meningioma	Left occipital	Autoclaving	Angiomatous meningioma WHO Grade I
3	Low grade glioma	Right frontal	Mesh cranioplasty	Oligodendroglioma WHO grade II
4	Low grade glioma	Left frontal	Autoclaving	Oligoastrocytoma WHO grade II
5	Low grade glioma	Right parietal	Mesh cranioplasty	Diffuse astrocytoma WHO grade II
6	Parasagittal meningioma	Left parietal (middle third)	Chemical decontamination	Meningioma WHO grade II
7	High grade glioma	Right posterior frontal	Mesh cranioplasty	Anaplastic astrocytoma WHO grade III
8	Suprasellar lesion	Suprasellar	Autoclaving	Craniopharyngioma
9	Olfactory groove meningioma	Anterior skull base	Chemical decontamination	Atypical meningioma WHO Grade II
10	High grade glioma	Right frontal	Autoclaving	Glioblastoma WHO grade IV
11	Arachnoid cyst	Right temporal	Chemical decontamination	Arachnoid cyst
12	Convexity meningioma	Right frontal	Autoclaving	Psmammomatous meningioma WHO grade I
13	Sphenoidal ridge meningioma	Left fronto-temporal	Chemical decontamination	Fibrous meningioma WHO grade I and Hyperostosis

WHO: World Health Organization.

3/1000 of the craniotomy operations, so it is an uncommon complication (<1/100 -- >1/1000) and it is not written in the usual informed consent for craniotomy operations.

Dropped skull flap on the floor of the operating room and its management is discussed in only few studies (2,6,9). In this study, 13 cases were emergency operations done late at night after 1 am. These 13 cases constitute 1.68% of the craniotomies that were operated at night after 1 am in this 10 year-period (total: 773 cases), so this means that this complication in late night craniotomy becomes common (<10/100 -- >1/100) and should be written in the informed consent and extra-care have to be taken to avoid this big mistake of dropping the skull flap on the floor.

Also it should be kept in mind that the rate of complications in craniotomy operations will differ according to many factors including the timing of the operation in the day, mostly because of exhaustion of the team and/or lack of the well-trained personnel late at night.

The risk of bone flap resorption after re-insertion of an autoclaved skull has always been of concern (11). It is known that revitalization of autoclaved bone flaps following implantation occurs through re-vascularization, resorption, and new bone formation which gradually replace the devitalized bone (5). Vanaclocha et al. stated that autoclaved skull bone, if implanted with direct contact with living bone, is gradually re-populated with osteocytes (10). In this study, partial loss of thickness occurred in 27% of autoclaved skull flaps, but still the external aspect of these flaps remained unchanged. None of the cases in this study have shown significant bone resorption, that might compromise the integrity of the flap, nor did they require a second corrective surgical procedure as the cosmetic results were acceptable.

Bauer et al. concluded that mechanical agitation and serial washes of bone graft in povidone-iodine that is allowed to dry offers effective sterilization while preserving some cell viability (1). Presnal and Kimbrough studied the amount of contamination incurred when a bone graft is dropped on the floor of the operating room, and they found that no positive cultures were obtained from all dropped bone grafts and concluded that extensive sterilization of a dropped bone graft is not essential (8). In contrast, Bruce et al. stated that the contamination rate in dropped bone fragments was 70%, but found that cleansing with a 10% povidone-iodine solution followed by a normal saline solution rinse provide effective decontamination (3). In this study, the cultures from the saline wash of the dropped skull were positive in 3 cases out of 28 (i.e. 10.7% of the cultures were positive) and they revealed *Coagulase-negative Staphylococcus*.

Management of a dropped skull flap on the floor is variable among countries. In Japan, discarding the dropped skull flap and immediate cranioplasty by artificial bones or mesh is the rule. In Egypt, it is acceptable to re-use the dropped skull flap after it is decontaminated. In this study, the dropped skull flap was discarded in three cases and replaced with a mesh cranioplasty in the same operation, (the mesh was available in the hospital at that time for another operation), and this of

course increased the cost of the operation. Mesh cranioplasty in another operation as a management of dropped skull flap was not recommended as it increases the cost, infection rate, complications of anaesthesia, and a second operation constitutes a psychological trauma to the patient and their relatives.

The mean time of delay in the operation to solve the problem of the dropped flap was 39 minutes, 37 minutes and 22 minutes for the cranioplasty, the autoclaving and for chemical decontamination of the dropped skull flap respectively. Chemical decontamination of the dropped flap is a rapid, simple, and cheap procedure. The autoclaving of the skull bone is also a simple procedure if a well-functioning and ready autoclave is available. Wester emphasized the low complication rate met with re-implanting autoclaved bone flaps (11). Osawa et al. concluded that the rate of bone resorption after implantation is highly increased if cryopreservation was combined with autoclaving due to marked destruction of the bone structure and significant reduction of its osteogenic properties (7). Chernov stated that the re-insertion of the autoclaved skull flap can be accompanied by prolonged postoperative subgaleal collection (4). In this study, this complication was not seen in the eleven cases of autoclaving. In this study, all the three ways of management of this big mistake was effective and no complications occurred on the follow up.

Prevention of occurrence of this disaster is the rule and is much better than treatment. To prevent the dropping of the skull flap, I recommend the followings;

- During craniotomy, leave 3 mm of intact bone at one end (i.e. do not complete the craniotomy) then elevate the flap gently using dissector.
- Have an assistant to hold the flap during its elevation.
- Hold the skull flap with dry gauze.
- Have an assistant to hold the skull flap during drilling holes on the sterile table.
- Have an assistant to hold the flap during its reinsertion.
- The craniotomy operation is not a one man show. Have a well-trained assistant.
- Complications in general of the craniotomy operation and anaesthesia are much higher after midnight, so postpone the operation to the morning unless lifesaving.
- Dropping anything on the floor of the operating room during surgery denotes a careless act especially if repeated by the same person and needs re-evaluation of that person whether a nurse, assistant or even the main surgeon.

■ CONCLUSION

Dropping a skull flap is a careless mistake that must be prevented. Chemical decontamination of the dropped skull flap in povidone iodine and antibiotic solution is an option to solve this problem. Management of dropped skull flap is its prevention.

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