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Linear fractures of the cranium: follow-up and management results of 442 cases

Linear fractures of cranium

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Abstract

Aim: We aimed to evaluate the clinical and radiological follow-up of cases with isolated linear fractures detected in the cranium in the post-traumatic period, to determine on which cases and when to perform control radiological examinations and to suggest follow-up protocol. Material and Method: 442 cases with isolated linear cranium fracture were evaluated in the study. Imaging examinations and clinical findings of the cases at the time of admission were compared with radiological examinations and clinical findings at follow-up. Fracture localizations and trauma types were compared. Accompanying maxillofacial fractures depending on the localization of fractures detected in the cranium were determined. Results: In the follow-up CT examinations of 18 out of 442 cases, cerebral contusion in 12 cases and epidural hematoma in 1 case, not detected during initial admission were found. Post-traumatic epilepsy was observed in 4 cases without radiologic findings. In cases receiving follow-up radiological examinations, no significant difference was found between radiological examinations performed during 4-6 hours versus 12-24 hours after trauma. Discussion: Isolated linear fracture cases do not require neurosurgical intervention. The treatment protocol may change depending on findings during the follow-up period. Performing routine follow-up radiological examinations is not cost-effective in cases in which no additional finding is present, and symptoms do not persist.

Keywords

Linear Fractures; Cranial Fractures; Calvarium; Head Trauma; Mild Head Trauma

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Introduction

Linear fracture of the cranium is the most common neurosurgical diagnosis in the post-traumatic period in emergency departments. Surgical intervention is usually not required in cases with no additional findings [1]. However, cases should be kept under observation to determine whether additional pathologies have developed. There is no certainty about how long the follow-up period should be. A large number of factors, such as the type of trauma, patient age, and patient clinical and medical history can determine how long the follow-up period should be [2].

The data obtained by examinations performed at the time of admission do not always provide certainty regarding prognosis. Diffuse axonal injury and post-traumatic epilepsy cases cannot be detected during radiological examinations at the time of first admission.

Material and Method

442 cases diagnosed with linear fractures on the cranium and followed-up between 2013-2017 were evaluated. Case and computerized tomography (CT) databases were scanned for linear fracture diagnosis. The number and time of cranial CT imagings at first admission were recorded. The patient database of the detected cases was reviewed, and the follow-up treatment protocols and the number of hours between first admission and follow-up were recorded.

In radiological examinations of cases determined to have linear fracture, only the ones whose outer tabula of the cranium did not penetrate into the inner tabula were accepted into the study. Apart from isolated linear fracture cases, multi-trauma cases having findings of intracerebral hemorrhage, pneumocephalus, skull base fracture, a Glasgow Coma Scale (GCS) score lower than 13, and those who died due to other extracranial findings secondary to trauma were excluded from the study.

The fracture localizations and ratios determined to be associated with the trauma type are shown in Table 1. Other skull fractures accompanying the cranium fracture are shown in Table 2. The findings of the cases, obtained by follow-up CT, are reported by the number of hours before follow-up. Table 3 shows the distribution of cases with isolated fracture detected in the first CT and additional intracranial pathology detected after the follow-up CTs. Overall distribution and clinical findings of the cases are shown in Table 4.

Ethics Committee Approval was obtained from Ahi Evran University Clinical Research Ethics Committee on 08.08.2017 (2017-13/141).

Statistical Analysis

The data were analyzed using Statistical Package for the Social Sciences-Version 22.0 (2013; IBM Corp., Armonk, NY, USA). Standard deviation results were compared in each group.

Results

In the database review, 442 cases were diagnosed with linear fracture at first admission. The mean age of the cases was 36.9±25.61 (range: 0-94) and there were 290 males (mean age: 35.34±23.43 range: 0-93) and 152 females (mean age: 40.01±29.14; range: 0-93) in the cases evaluated. Of the cases, 181(40.9%) were asymptomatic and were evaluated with CT examination at first admission due to high-energy trauma. In 4 (0.9%) cases, post-traumatic epilepsy developed during the follow-up period. In 12 (2.7%) cases, cerebral contusions were detected in follow-up radiological examinations.

Table 1. Fracture ratios according to trauma types

	Traffic accident (n=140) %	Falling from a high place (n=238) %	Violence (n=37) %	Hit by object (n=27) %	Total
Frontal	53 (37.8%)	72 (30.0%)	14 (37.8%)	12 (44.4%)	151
Fronto-temporal	8 (5.7%)	6 (2.5%)	3 (8.1%)	4 (14.8%)	21
Fronto-parietal	7 (5.0%)	20 (8.4)	4 (10.8%)	4 (14.8%)	35
Temporal	25 (17,9%)	39 (16,4%)	8 (21,6%)	1 (3.7%)	73
Temporo-parietal	5 (3.6%)	11 (4.6%)	1 (2.7%)	1 (3,7%)	18
Parietal	39 (27.9%)	79 (33.2%)	6 (16.2%)	4 (14.8%)	128
Parieto-occipital	2 (1.4%)	1 (0.4%)	1 (2.7%)	1 (3.7%)	5
Occipital	1 (0.7%)	10 (4.2%)	0 (0.0%)	0 (0.0%)	11

Table 2. Maxillofacial fractures accompanying fracture localization

	Nasal	Orbital	Maxillar	Zygomatic
Frontal (n=151)	46 (30.5%)	26 (17.2%)	16 (10.6%)	2 (1.3%)
Fronto-temporal (n=21)	3 (14.3%)	4 (19.1%)	4 (19.1%)	4 (19.1%)
Fronto-parietal (n=35)	8 (22.9%)	4 (11.4%)	1 (2.9%)	3 (8.6%)
Temporal (n=73)	4 (5.4%)	14 (19.2%)	3 (4.1%)	21 (28.8%)
Temporo-parietal (n=18)	1 (5.6%)	1 (5.6%)	1 (5.6%)	0 (0.0%)
Parietal (n=128)	12 (9.4%)	4 (3.1%)	4 (3.1%)	5 (3.9%)
Parieto-occipital (n=5)	0 (0.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)
Occipital (n=11)	1 (9.7%)	0 (0.0%)	0 (0.0%)	1 (9.1%)

Table 3. Clinical and radiological findings obtained during the follow-up period

	<6 hours	6-12 hours	12-24 hours	> 24 hours
Contusion	12 (2.7%)	X	Edema around contusion (8 cases)	Edema around contusion (3 cases)
Epilepsy	4 (0.9%)	X	X	X
Epidural Bleeding	1 case with parietal fracture (0.2%)	X	X	X

The average length of hospitalization in follow-up cases was 1.34±0.47 days. A total of 785 cranial CT imaging examinations including follow-up CTs were performed in 442 cases (average: 1.78 per case). In the follow-up cranial CT examinations of 127 cases, additional pathology was detected in 2 (1.5%) cases. Additional intracranial pathology was detected in 13 (2.9%) cases having a continuous or an increasing headache, in 3 cases whose GCS was below 15, and in 10 cases with more than two vomiting episodes. According to fracture localization, additional traumatic intracranial pathology was detected in cases with the highest number of temporal zone fractures in the follow-up CT examination.

Table 4. Overall distribution and clinical findings of the cases

	0-3 years (n=46)	4-16 years (n=67)	17-50 years (n=183)	(50+ years) (n=146)
Maxillofacial fractures n= 158	4 (8.6%)	24 (35.8%)	83 (45.3%)	47 (32.2%)
Post-traumatic epilepsy n= 4	0 (0.0%)	2 (2.9%)	1 (0.5%)	1 (0.6%)
Vomitings (2+) n= 4	31 (67.4%)	5 (7.4%)	23 (12.5%)	8 (5.4%)
Continuous and/or increasing headache n= 89	X	18 (26.8%)	36 (19.6%)	35 (23.9%)
Commotio cerebri findings* n= 137	X	22 (32.8%)	51 (27.8%)	64 (43.8%)
Contusion detected on later CTs n= 12	2 (4.3%)	3 (4.4%)	4 (2.1%)	3 (2.0%)
Totally performed CTs. n=785	Total: 98 Mean: 2.13	Total: 140 Mean: 2.08	Total: 302 Mean: 1.65	Total: 245 Mean: 1.68

* One or more findings of post-traumatic amnesia, post-traumatic syncope, photophobia and agitation.

284 (64.2%) of the 442 cases who had a diagnosis of linear fracture revisited the neurosurgery clinics for complaints related to head trauma or for follow-up purposes; no evidence that required hospitalization or additional medication was found. A neurosurgical intervention was not required for any of the cases. However, in 11 cases, anti-epileptic treatment medication was started after their hospitalization because post-traumatic epilepsy or contusion was detected.

After detection of the linear fracture, an additional hemorrhagic finding was present in 13 cases of the 184 cases followed-up by cranial CT scan performed within the first 6-8 hours. No other hemorrhagic pathology was detected in any follow-up cranial CT scans after 8 hours, including cases who had additional hemorrhagic findings in the first 6-8 hours. However, in cases detected to have a contusion, it was observed that the contusion continued or its volume increased (Figure 1). One case was diagnosed with epidural hemorrhage on control CT, but it was thought to be of venous origin and did not require surgical intervention (Figure 2).

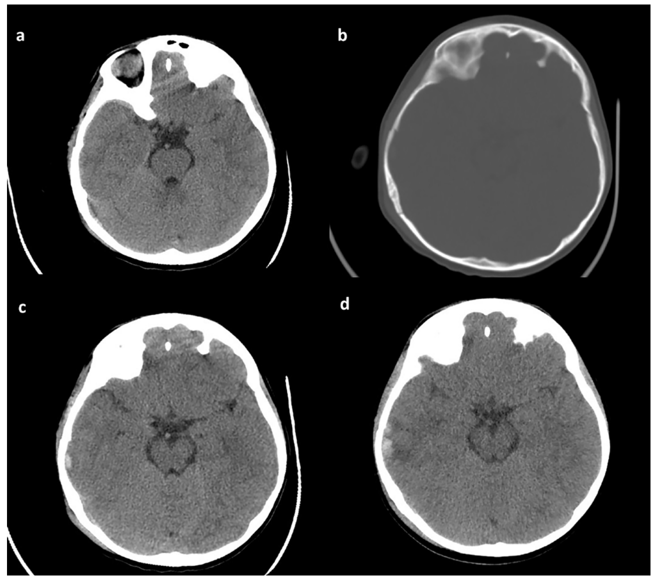

Figure 1. Right temporal linear fracture without parenchymal hemorrhage diagnosis at first admission (a,b). Cerebral contusion near the fracture was detected on control tomography at 6th hour(c). Additional cerebral edema and enhancement of contusion area on 3rd CT (d).

Figure 2. Linear fracture of parietal zone on x-ray(a). Left parietal linear fracture on initial CT (b). Epidural hemorrhage under fracture as a thin layer on control CT (c). Parietal epidural hematoma on sagittal section (d).

Discussion

Linear cranium fractures are one of the most common neurosurgical cases admitted to emergency services. Under normal conditions, isolated linear fractures do not require neurosurgical intervention. However, these cases may require medical or surgical treatment because of the additional pathologies that may develop in the follow-up period even though this is rare. There is no definitive procedure for follow-up of linear fracture cases. Different trauma centers perform different procedures for avoiding unnecessary hospitalizations, protecting from radioactive effects of CT scans, and for cost-effectiveness [3-5]. Different protocols for mild head trauma have been described in the literature [1,2,6].

In the pediatric age group cases, isolated linear fractures were reported in about 10% of radiological examinations performed in the post-head traumatic period [7]. However, it is controversial whether performing follow-ups of these cases by hospitalizing them is cost-effective [8-10]. It has been reported that the number of cases having isolated fractures that require neurosurgical intervention is very low and mortality is <0.1% [7,10]. After repeated radiological examinations, additional intracranial pathologies were detected in approximately 1% of cases, and none of them required surgical intervention [7]. In recent years, centers that deal with the pediatric age group have developed algorithms to determine which cases may need a CT scan [3-5]. With these algorithms, it is reported that the length of unnecessary hospitalization is reduced, the cases are not exposed to unnecessary radiation due to CT, and costs are reduced [7]. It is even argued that ambulatory follow-up care for the pediatric age group cases having isolated linear fracture, whose clinical findings are stable, should be sufficient [7].

In the pediatric age group cases, brain parenchyma has not completely developed volumetrically. However, in the elderly group, pathologies that may cause an increase in intracranial pressure (ICP) due to decreased parenchymal volume because of the frequent presence of cerebral atrophy may prevent early detection of ICP symptoms. For this reason, the cases in the elderly group should be evaluated separately from the adult age group. The cases of the elderly age group are those in which cardiovascular diseases are frequent and antiaggregant, and in which anticoagulant drugs are used more frequently [11-13]. Therefore, in head trauma cases, it should be remembered that this age group is at higher risk regarding intracranial hemorrhage. This age group may need to be evaluated before pathologies develop due to traumatic intracranial situations. For these reasons, the clinical follow-ups of pediatric and elderly age groups should be different from those of the adult age group [14].

It is clear that the adult age group is the most susceptible to an acute event that may cause an increase in ICP, considering that in these cases the brain parenchyma ratio is higher than intracranial volume ratio. In the elderly group, factors such as the presence of chronic illness and frequent use of anticoagulant drugs are risk factors for increased hemorrhage. In the pediatric age group, brain parenchyma has not yet completed its development, and is surrounded by cerebrospinal fluid (CSF), which probably buffers against trauma and protects the brain parenchyma.

In the pediatric and elderly age group as well as in adult cases, if an isolated fracture is detected in CT and there is no hemorrhage, follow-up cranial CT examination is not necessary as long as the clinical findings are stable. It is expected that any hematoma will appear in the first CT scan or the follow-up period. Epidural hemorrhages are the most common complications accompanying skull fractures, and since they originate from arteries, epidural hemorrhage is expected to be diagnosed during the initial CT scan. Even though acute subdural hematomas are also frequently of venous origin, they are expected to appear during the period between the trauma and the CT examination. These conditions do not apply to hemorrhagic contusions. In the initial CT scan, the contusions may not have developed and may not be radiologically evident. Also, if the clinical picture of the case is not very stable, if the case has agitation even if his/her GCS is 15, or if there is movement during the CT examination, depending on the motion artifact, other hemorrhagic findings—especially hemorrhagic contusions—may also be overlooked.

If any finding of hemorrhage is detected at the first CT, it should also be taken into account that, regardless of the initially detected bleeding volume, the bleeding can reach large volumes subsequently. The eventual volume cannot be predicted by the initially detected volume. It should also be kept in mind that edematous effects may occur, especially in intraparenchymal bleeding, contusions, and acute subdural hematomas, even if the hematoma volume does not increase.

The emergence of raised ICP findings in isolated fracture cases should be considered as a follow-up indication independent from radiological findings. Apart from these, deficits that occur in the parenchyma due to trauma exposures of particularly eloquent areas require clinical and radiological follow-up even if there is no ICP finding. The cases having these findings should be evaluated regarding morbidity, independent from linear fractures. In these cases, there is no protocol specifying the time required before a follow-up radiological examination; this time should be considered at the point when additional neurological symptoms and findings occur.

In cases where only linear fractures were detected and then follow-up CT examinations were performed, no new hemorrhagic findings were detected other than traumatic lesions detected within the first 6 hours. In cases having follow-up CT indications, it is concluded that traumatic additional pathologies can manifest within the first 6 hours, and in the subsequent follow-up CT examinations, additional hemorrhage findings will not be seen.

One of the most common symptoms of linear fracture is vomiting; therefore, it should be well investigated whether the vomiting is due to increased ICP. In these cases, vomiting in an eruptive manner is encountered, but this may not always be clearly distinguished from other kinds of vomiting that are not related to raised ICP. The vomiting center causes the symptom of vomiting due to increased sensitivity of the area postrema in the brain stem. Repeated vomiting may be due to affecting of the area postrema. Vomiting should not by itself be considered an ICP indicator.

Conclusions

Cases of isolated linear fractures in the cranium generally do not need to undergo radiological follow-up if they are asymptomatic after being diagnosed. However, staff should be alert to the possibility of hemorrhagic contusion, which can become symptomatic within a few hours after diagnosis. For this reason, it is necessary to keep these patients under observation for several hours after the diagnosis is made or to inform them or their relatives about the symptoms that may develop. Whereas in asymptomatic cases, there are no absolute follow-up CT indications. However, it should be kept in mind that cases such as grooving fractures or chronic subdural hematomas that become symptomatic in the late period have also been described in the literature. Although all factors such as hospitalization, medication, cost-effectiveness, and unnecessary radiation exposure should be considered, more clinically effective and financially cost-effective results will be obtained if the most important criterion is symptomatology.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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