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ORIGINAL ARTICLE

Treatment of Craniotomy-Related Bone Flap Osteomyelitis

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Abstract

Introduction: Cranial bone flap osteomyelitis (BFO) is rare. A few publications relating to postoperative osteomyelitis are available in the literature. In this study, we aim to share our experiences with the clinical management of BFO cases that developed secondary to surgery in the name of contributing to the literature.

Methods: Forty-four BFO cases that developed secondary to 4582 neurosurgical operations carried out in our clinic between 2011 and 2018 were evaluated. Patients were investigated in terms of demographic attributes, pathogen microorganisms, time that lapsed between the first surgery and development of osteomyelitis, and the cause of the primary surgery. Clinical procedures of patients who developed BFO and were treated by preserving or discarding the bone flap (BF) were studied retrospectively.

Results: A total of 44 patients were followed up due to BFO in our clinic between the years 2011 and 2018. Diagnoses before the first operation were tumor in 18 patients (40.9%), anterior circulation aneurysm in 11 patients (25%), epidural hematoma in 10 patients (22.7%), and chronic subdural haematoma in 5 patients. Regarding to the growth of the culture, microorganisms were grown in 31 cases (31/44) (70.4%) and it could not be grown in culture in 13 patients (13/44) (29.6%). Twenty patients (20/44) (45%) in the study group were treated by debridement+wound irrigation and preserving the BF with antibiotherapy. BF of the remaining 24 patients, on the other hand, were discarded.

Discussion and Conclusion: Surgery-associated osteomyelitis is one of the most undesired complications. BFs are discarded in nearly half of the patients, although the pathogen microorganism is isolated in a great majority of the cases and the appropriate antibiotherapy is applied. BFO treatment becomes more complicated especially due to the close anatomical relation between the frontal and pterional craniotomies and the sinuses.

Keywords: Bone flap osteomyelitis; craniotomy related; infection.

Infections that develop after cranial surgery are the leading problem for the clinicians. The incidence of postoperative surgical site infections varies between 0.8% and 7%[1,2]. Postneurosurgical bone flap osteomyelitis (BFO), on the other hand, is a serious complication that occurs in patients undergoing craniotomy. BFO is observed in the rates of incidence varying between 16% and 44% of all postoperative cranial infections[1,3,4].

BFO is a pathologic process, the diagnosis and treatment of which is complicated. Whether the infection has contaminated the bone flap (BF) is one of the controversial issues. The primary goal of the treatment is to grow the pathogenic microorganism and ensure recovery through antibiotherapy that is appropriate for the pathogen microorganism. The limits of surgical intervention required should also be questioned. The question on this matter is whether the

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surgical intervention should be carried out preserving the flap or removing it is another issue that the clinicians are most often in two minds about. In the case of recurrence of the infection in cases treated with BF preserved, the BF is removed and this leads to prolonged hospitalization duration due to reinitiation of antibiotic treatment which causes comorbidities[5]. There are authors arguing that the surgical intervention employed in cases, in which the BF is not preserved is too agressive and that a limited intervention is more suitable in cases of osteomyelitis[6,7].

In this study, we aimed to contribute to the literature by sharing our experiences with how BFO cases were managed in our clinic and to understand in which patients the BF was preserved or discarded.

Materials and Methods

This study had been carried out in accordance with the principles of Declaration of Helsinki and approved by Ethics Committee of Adana City Training and Research Hospital. 44 patients that developed wound site infection and were diagnosed with BFO for this reason following a total of 4582 neurosurgical operations carried out in our clinic between the years 2011 and 2018 were studied retrospectively. Of these 4582 craniotomy procedure, 2419 was tumour (52.7%), 1237 vascular surgery (26.9%), 791 trauma surgery (17.2%), 44 infectious surgery (0.9%) and 91 (1.9%) other. In addition to the demographic data of the patients; primary surgery that leads to infection, pathogen microorganisms, and whether the BF was preserved based on the microorganism reproduction results were studied.

BFO diagnosis was made based on detection of a suspicious lytic bone lesion in the computed tomography (CT) and/or appearance of the bone during debridement. Criteria for inclusion in the study was identified as being over 18, having undergone surgery with craniotomy and having been treated due to BFO after discharge (those patients who underwent surgical debridement). Pediatric age range and superficial infections that did not require debridement were not included in the study.

Primary surgeries were selected from among elective and traumatic neurosurgical surgeries. One gr of intravenous cefazolin sodium was administered to the patients 1 h before the primary surgery and no additional prophylaxis was carried out in the postoperative period. Their hair was cut with an electric shaver in the surgery room just before the incision. The wound site was dyed with Betadine solution for 5 min until it dried and the operative field was prepared using an Ioban (3M/USA) antibacterial film drape before incision.

Statistical Analysis

Statistical evaluation was carried out using the Statistical Package for the Social Sciences (SPSS) for Windows 20 (IBM SPSS Inc., Chicago, IL) program. Normal distribution of the data was evaluated with Kolmogorov–Smirnov test. Numeric variables displaying a normal distribution were shown with averages±standard deviation and numeric variables not displaying a normal distribution were shown as median (minimum, maximum). Categorical variables were indicated in numbers and percentages. Student t-test was employed in the comparison of numeric variables displaying a normal distribution between the two groups and Mann-Whitney U test was employed in the comparison of numerical variables not displaying a normal distribution between the two groups. The analysis of variance test (*post hoc*: Bonferroni correction) was used in the comparison of numeric variables displaying a normal distribution among three or more groups, and the Kruskall-Wallis H test (*post hoc*: Dunn's correction) was used in the comparison of numeric variables not displaying a normal distribution among three or more groups. The Chi-square test and Fisher's Exact Chi-square test were employed in the comparison of categorical data. Relationship between the numeric variables was evaluated with the Spearman's correlation analysis. $p<0.05$ (*) value was accepted to be significant in the statistical analyses.

Results

A total of 44 patients were followed up in our clinic due to BFO between the years 2011 and 2018. Among these patients, 26 were male (59%) and 18 were female (41%). Mean age of the group was found out to be 46.8±14.3. In addition to BFO; subcutaneous purulent collection (23 patients, 52.2%), epidural abscess (15 patients, 34%), parenchymal abscess (9 patients, 20.4%) and subdural empyema (2 patients, 4.5%) was most frequently observed among patients.

Diagnoses before the first operation were intracranial tumour in 18 patients (40.9%), anterior circulation aneurysm in 11 patients (25%), epidural hematoma in 10 patients (22.7%), and chronic subdural haematoma in 5 patients (Table 1). Time between the primary surgery and infection development was observed to be 74.5 days on average (between 30 and 301 days).

Regarding growth in the culture; pathogen microorganisms were grown in 31 cases (31/44)(70.4%). Microorganisms grown were *Staphylococcus aureus* in 20 patients

Table 1. Demographic and clinical findings related to microorganism development

Variables	All population n=44	Pathogen microorganism		Univariable Cox Regression		
		No, n=13	Yes, n=31	HR	95% CI	p
Age	46.8±14.3	50.1±11.8	45.2±15.1	0.98	0.96–1.01	0.210
Gender						
Female	20 (45.5)	7 (53.8)	13 (41.9)	ref		
Male	24 (54.5)	6 (46.2)	18 (58.1)	1.23	0.60–2.53	0.569
Primary surgery						
Tumor	18 (40.9)	5 (38.5)	13 (41.9)	ref		
ACA	11 (25.0)	4 (30.8)	7 (22.6)	0.77	0.30–1.97	0.590
EH	10 (22.7)	2 (15.4)	8 (25.8)	1.10	0.45–2.71	0.827
CSH	5 (11.4)	2 (15.4)	3 (9.7)	0.80	0.22–2.84	0.726

Categorical variables were shown in numbers and percentage, numerical variables were shown as mean±standard deviation or median (min-max). Ref: Referance; HR: Hazard Ratio; CI: Confidence interval; ACA: Ant. circulation aneurysm; EH: Epidural hematoma; CSH: Chronic subdural hematoma.

(20/44) (45.5%), *Staphylococcus epidermidis* in 6 patients (6/44) (13.6%), *Pseudomonas aeruginosa* in 2 patients (2/44) (4.5%), *Stenotrophomonas maltophilia* in 2 patients (2/44) (4.5%) and *Acinetobacter baumannii* in 1 patient (1/44) (2.2%). Microorganisms could not be grown in the culture in 13 patients (13/44) (29.6%). Distribution of microorganisms is shown in Figure 1. A significant relationship could not be observed between age, sex, type of surgery and pathogen microorganism growth (Table 1).

Reproduction of gram (-) bacteria among patients, whose BF were preserved, was identified in 2 patients and reproduction of gram (-) bacteria was observed in 3 patients, whose BF's were removed. This difference was not found out to be statistically significant (p=0.99). When considered in terms of reproduction of gram (+) bacteria, on the other hand, no significant difference was observed between patients, whose BF was preserved, and those, whose BF was sacrificed (p=0.99) (Table 2).

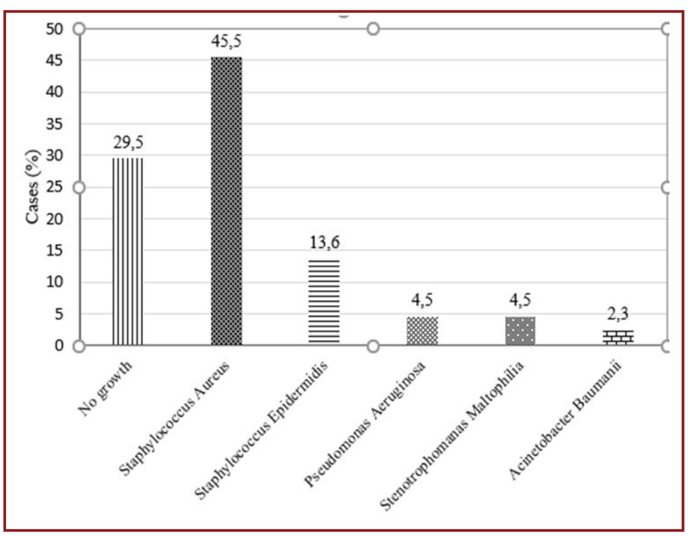

Figure 1. Distribution of microorganisms in bone flap osteomyelitis patients.

Table 2. Distribution of demographic and clinical findings by treatment groups

Variables	BFP n=20	BFR n=24	p
Age, years	48.7±15.5	45.2±13.1	0.422
Gender, n(%)			
Female	11 (55.0)	9 (37.5)	0.363
Male	9 (45.0)	15 (62.5)	
Time interval to infection	92.0 (37–301)	70.5 (30–187)	0.099
(days) primary surgery			
Tumor	9 (45.0)	9 (37.5)	0.706
ACA	5 (25.0)	6 (25.0)	
EH	3 (15.0)	7 (29.2)	
CSH	3 (15.0)	2 (8.3)	
Pathogen microorganism			
No growth	6 (30.0)	7 (29.2)	0.909
Staphylococcus aureus	8 (40.0)	12 (50.0)	
Staphylococcus epidermidis	4 (20.0)	2 (8.3)	
Acinetobacter baumanii	-	1 (4.2)	
Pseudomonas aeruginosa	1 (5.0)	1 (4.2)	
Stenotrophomanas maltophilia	1 (5.0)	1 (4.2)	
Pathogen microorganism			
No growth	6 (30.0)	7 (29.2)	0.999
Gram -	2 (10.0)	3 (12.5)	
Gram +	12 (60.0)	14 (58.3)	

Categorical variables were shown in numbers and percentage, numerical variables were shown as mean±standard deviation or median (min-max). BFP: Bone flap preserved; BFR: Bone flap removed; ACA: Ant. circulation aneurysm; EH: Epidural hematoma; CSH: Chronic subdural hematoma.

In the study group, 30 patients were first treated with debridement+wound irrigation and antibiotherapy preserving the BF. The remaining 14 patients, on the other hand, were treated discarding the BF upon observation of a lytic lesion in the CT (Fig. 2 a-d). However, upon recurrence of infection in 10 out of 30 patients treated preserving the BF, debridement+wound irrigation was performed for the second time and the BF were discarded. Finally, 20 (20/44, 45%) patients were treated preserving the BF. BF of the remaining 24 patients (55%) were removed. According to primary etiology; 9 (37.5%) of the cases, in which the BF was discarded, were patients operated due to intracranial tumour, 6 (25%) were those operated due to anterior circulation aneurysm, 7 (29.2%) were those operated due to epidural haematoma and 2 (8.3%) were those operated due to chronic subdural haematoma.

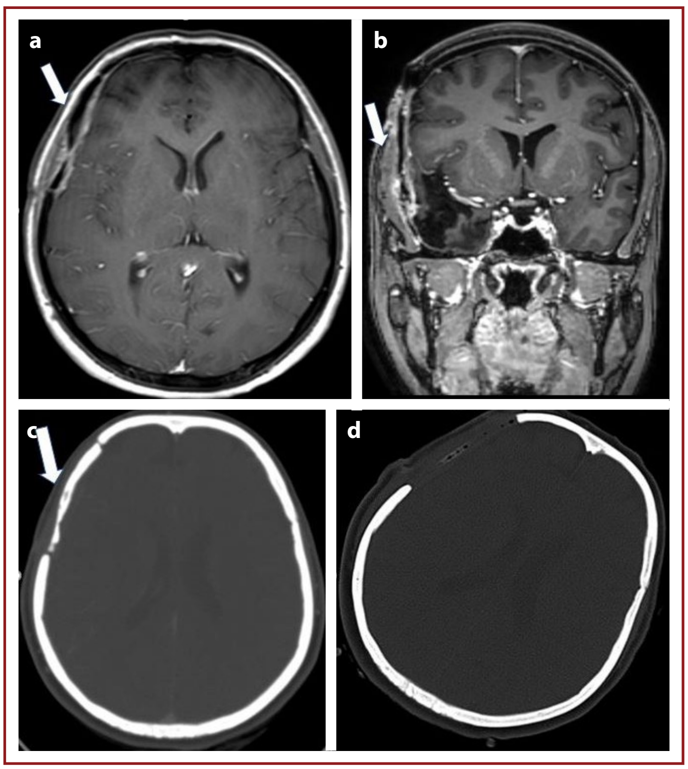

Figure 2. A female patient aged 36 years admitted due to purulent discharge from the flap forming a fistula on the skin and swelling in the wound site 2.5 months after the surgery for meningioma that is located in the temporal fossa. Magnetic resonance imaging with contrast demonstrated: **(a)** linear contrast enhancement in the epidural space in the right temporal lobe indicated with a white arrow stands out. **(b)** Image of the coronal section shows extensive contrast involvement in the bone flap and swelling in the temporal muscle implicates of bone flap osteomyelitis, **(c)** In the computed tomography scan given before the debridement, irregularities in the bone flap in the right temporal lobe shown with the white arrow stand out. **(d)** Early postoperative computed imaging after bone flap removal

Discussion

Although surgical strategies that prevent infection have been developed, wound site infection is one of the severe causes of morbidity and mortality today[8]. In addition to the systemic effects of infection after craniotomy, the bacterial colonization caused thereby in the BF locally, if not treated, might lead to bone loss[5,6,9,10]. This situation which causes tissue loss both prolongs hospitalization duration and necessitates cranioplasty[6,10].

Blood perfusion in the BF decreases and the defence mechanism of the BF weakens due to the devascularization of the free bone excised during craniotomy[5] Such findings as purulent discharge, erythema, local swelling are observed in patients with BFO[1,11]. These are nonspecific infectious findings and it is often difficult to understand whether the BF has been infected without a surgical exploration in the case of development of a severe wound site infection. Although articles arguing that scintigraphic studies, the number of which has increased recently, are diagnostically accurate studies and successful in predicting bone infection; rapid performance of such examinations are not always possible[4,8].

In our study, the number of patients whose BF's were discarded was 24 (54.5%). When we search the literature, the fewness of publications on this matter attracts the attention immediately. In the study carried out by Dashti et al.,[1] infections after craniotomy were researched and such infections were treated by removing the BF in 22 patients (44%). In another study, 117 patients that developed infection after craniotomy were investigated and the infections were grouped as superficial and deep infections. BFO was classified under the superficial infections group and the incidence was observed to be 37.6%. However, information as to whether the BF was preserved or not was not provided[12]. In the light of the aforementioned information, our series shows parallelism with the literature.

When results of culture reproduction in the wound site are examined in our study, the most frequent agents are gram (+) bacteria. The most frequent gram (+) bacteria is *S. aureus* (45.5%) followed by *S. epidermidis* (13.6%). Gram (-) reproduction was observed in 5 patients (11.4%). Staphylococci were found out to be the most frequent wound site agents in many studies[2,12,13]. In our study, a significant difference could not be found between patients, whose BF's were preserved and those, whose BFs were removed, in terms of reproduction of pathogenic microorganisms (p=0.909). In the study they carried out, Dashti et al.[1] could not find a relationship between the microorganisms that reproduced in the wound site and BF, either.

Postop infections were investigated in the literature as infections after elective surgery and infections after trauma surgery according to primary etiology[2,3,6,12,14]. Operations due to tumors are in the lead among elective surgeries. This is because the long term use of steroids, radiotherapy, and use of immunosuppressive and chemotherapeutic agents lead to infection[8]. In our study, osteomyelitis following intracranial tumour operation was observed in 18 patients and the BF's of 9 patients were discarded. 11 patients underwent an operation due to anterior circulation aneurysm and the BF's of 6 patients were discarded. 10 patients underwent an operation due to epidural haematoma and the BF's of 7 patients were discarded. 5 patients underwent an operation due to chronic subdural haematoma and the BF's of 2 patients were discarded. In our series, incidence of BF removal was slightly higher in trauma patients than in elective cases. However, such incidence was not found out to be statistically significant (p=0.709). We believe that the reason for this is the contamination caused by the damage in the scalp that occurred during the trauma[8,15]. We further believe that the fact that application of the preoperative antibiotic treatment was impossible in trauma cases was another cause of higher incidence of BF removals in trauma patients. One study comparing cranial osteomyelitides as trauma cases and elective cases is available[1]. In this study, no significant difference was found in terms of postoperative infection when the patients were divided into two groups as traumatic and nontraumatic. We attribute the high incidence of BF removals in the elective surgeries in our study to relatively more frequent incidence of frontal and pterional cranotomies. Unintentional violation, although rare, of the integrity of the frontal sinuses in these two craniotomies might lead to the exposure of the bone tissue to more pathogenic microorganisms. In the comprehensive review study they carried out, Mortavazi et al.[8] divided cranial osteomyelitides into two categories as sinus-related or non-sinus-related, and emphasized that contact with the sinus was significant in the bone-related infections of the anterior cranial fossa and the frontal bone. Again in line with our findings, the study carried out by Bruce et al.[6] reported that the BF might be sacrificed in patients that underwent craniofacial surgery and in case of contact with the paranasal sinuses.

Some limitations are present in our study. The first one of these limitations is the fewness of the patients included in the study and the study's retrospective design. Second, the fact that reproduction did not occur through the culture in a small part of our patients prevented us from achieving more eligible results. Moreover, existence of numerous variables associated with the surgery poses a significant challenge in evaluating the study. Our strength, on the other hand, is that our study evaluates a rare clinical process like BFO in relation to surgery.

Conclusion

Surgery-associated osteomyelitis is one of the most undesired complications. BF is discarded in nearly half of the patients, although the pathogen microorganism is isolated in and the suitable antibiotherapy is given to a great majority of the cases. Treatment of BFO becomes more complicated due to the close anatomical relation between the sinuses and the frontal and pterional craniotomies in particular.

Ethics Committee Approval: This study had been carried out in accordance with principles of Declaration of Helsinki and approved by Ethics Committee of Adana City Training and Research Hospital.

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Conflict of Interest: All the authors declare that they have no conflict of interest.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

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