



Single-Stage Reconstruction with Titanium Mesh for Compound Comminuted Depressed Skull Fracture

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Objective : Traditionally, staged surgery has been preferred in the treatment of compound comminuted depressed fracture (FCCD) after traumatic brain injury (TBI) and involves the removal of primarily damaged bone and subsequent cranioplasty. The main reason for delayed cranioplasty was to reduce the risk of infection-related complications. Here, the author performed immediate reconstruction using a titanium mesh in consecutive patients with FCCD after TBI, reported the surgical results, and reviewed previous studies.

Methods : Nineteen consecutive patients who underwent single-stage reconstruction with titanium mesh for FCCD of the skull from April 2014 to June 2018 were retrospectively analyzed. The demographic and radiological characteristics of the patients with FCCD were investigated. The characteristics associated with surgery and outcome were also evaluated.

Results : The frequency of TBI in men (94.7%) was significantly higher than that in women. Most FCCDs (73.7%) occurred during work, the rest were caused by traffic accidents. The mean interval between TBI and surgery was 7.0 ± 3.9 hours. The median Glasgow coma scale score was 15 (range, 8–15) at admission and 15 (range, 10–15) at discharge. FCCD was frequently located in the frontal (57.9%) and parietal (31.6%) bones than in other regions. Of the patients with FCCDs in the frontal bone, 62.5% had paranasal sinus injury. There were five patients with fractures of orbital bone, and they were easily reconstructed using titanium mesh. These patients were cosmetically satisfied. Postoperatively, antibiotics were used for an average of 12.6 days. The mean hospital stay was 17.6 ± 7.5 days (range, 8–33). There was no postoperative seizure or complications, such as infection.

Conclusion : Immediate bony fragments replacement and reconstruction with reconstruction titanium mesh for FCCD did not increase infectious sequelae, even though FCCD involved sinus. This suggests that immediate single-stage reconstruction with titanium mesh for FCCD is a suitable surgical option with potential benefits in terms of cost-effectiveness, safety, and cosmetic and psychological outcomes.

Key Words : Fractures, Comminuted · Brain injuries, Traumatic · Cranioplasty · Infections.

INTRODUCTION

Compound comminuted depressed fracture (FCCD) of the

skull is a type of depressed fracture with a laceration in the overlying scalp and galea in continuity with the fracture site and has been traditionally treated with surgery^{4,5)}. In a simple

• Received : August 26, 2019 • Revised : October 23, 2019 • Accepted : February 4, 2020

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depressed skull fracture, there is no tear in the galea, and it is conventionally treated with surgical elevation only if the degree of depression is equal to or exceeds the thickness of the adjacent intact bone or if there is a degree of intracranial hematoma with mass effect that needs to be removed⁵. Up to 6% of traumatic brain injuries (TBIs) may be complicated by depressed skull fractures, and FCCD accounts for up to 90% of these injuries^{4,5,19}. FCCD is associated with an infection rate of 1.9 to 10.6%^{5,11,19}.

There is no doubt regarding the surgical treatment technique and timing of surgery for FCCD after TBI for a long time¹⁴. To prevent infection in FCCD cases, it has been preferred to remove bone fragments, debride the wound, provide sufficient irrigation, and leave the cranial defect and wait for a sufficient period of time and then perform secondary cranioplasty^{5,14}. The main reason for delayed cranioplasty was to reduce the risk of infection-related complications, such as sinusitis, osteomyelitis, meningitis, and empyema. However, recently, some studies have demonstrated that there is no difference in infection rate between immediate single-stage reconstruction of FCCD with titanium mesh and delayed secondary cranioplasty, and immediate single-stage reconstruction of FCCD with titanium mesh is a suitable surgical option with potential benefits in terms of cost-effectiveness, safety, and cosmetic and psychological outcomes. Moreover, the safety and feasibility of immediate titanium mesh implantation even in patients with postcraniotomy surgical site infection have been reported^{6,18}. Here, the author performed immediate reconstruction with titanium mesh in consecutive patients with FCCD after TBI, reported the surgical results, and reviewed previous studies.

MATERIALS AND METHODS

The study was approved by the Institute Ethical Committee of Wonkwang University Hospital (WKUH) and in compliance with institute's requirements (WKUH 201908013). The author retrospectively analyzed the medical records and radiological images of 19 consecutive patients who underwent single-stage reconstruction with titanium mesh for FCCD of the skull after TBI from April 2014 to June 2018. All patients with FCCD confirmed by computed tomography (CT) in the emergency room (ER) were included in the study. All surgeries were performed by one neurosurgeon.

The demographic characteristics of patients with FCCD, including sex, age distribution, cause of injury, time from damage to arrival in the hospital, time to surgery after arrival at the hospital, Glasgow coma scale (GCS) at admission and discharge, and hospital stay, were analyzed. The radiological demographic characteristics, including location and size of FCCD, FCCD associated lesions, and involvement of the paranasal sinus, were evaluated. FCCD-associated findings included skull fracture alone, acute epidural hematoma (AEDH), acute subdural hematoma (ASDH), traumatic subarachnoid hemorrhage (TSAH), and traumatic intracranial hemorrhage (TICH). The characteristics associated with surgery and infection, including the presence of dural tear, period of postoperative intravenous antibiotic administration, postoperative complications, changes in inflammatory markers and body temperature, and outcome, were investigated. Inflammatory markers included white blood cell (WBC; normal range, 4000–10000/ μ L), erythrocyte sedimentation rate (ESR; normal range, 0–20 mm/h), and C-reactive protein (CRP; normal range, 0–5 mg/L). All patients were followed over a period of 10 months after discharge to assess long-term outcome and complications.

Surgical technique

Prophylactic antibiotics with ceftriaxone (2 g per day) were injected intravenously in all patients preoperatively in the ER. All patients underwent sufficient irrigation with normal saline prior to surgical draping under general anesthesia. The author performed removal of foreign bodies and hematomas, debridement of damaged tissues, removal of fragmented bones, drilling of suspected contaminated bone, suture of the torn dura mater, meticulous hemostasis, and sufficient irrigations with normal saline mixed with antibiotics through lacerations in the overlying scalp. Three patients (patient No. 1, 4, and 15) underwent surgery through a bicoronal skin incision due to small sized skin wound and fractures of orbital wall. The author performed removal or cauterization of the mucosa of the opening of the frontal sinus and then obliteration of the rest of the frontal sinus using noncontaminated free fat, muscle, and pericranial flaps. Some of the bone fragments that could be used sufficiently because of their large size and mild depression were reconstructed using a titanium mini plate. The author performed primary reconstruction of the skull defect in all patients using titanium mesh plates, and it was fixed using

several 4- or 5-mm titanium microscrews. Titanium microscrews were inserted through the mesh and into the underlying bone circumferentially to fix the mesh. The scalp and skin were closed with monofilament suture material. Immediately after the surgery, brain CT was performed to confirm that there was no additional postoperative hematoma. All patients were intravenously injected with ceftriaxone (2 g per day) for approximately 1–2 weeks postoperatively.

RESULTS

Demographic characteristics

A total of 19 consecutive patients who underwent immediate single-stage reconstruction with titanium mesh for FCCD of the skull after TBI were included in this study. The demo-

graphic characteristics of patients are summarized in Table 1. The mean patient age was 50.4 ± 13.6 years (range, 28–76) with 18 men (94.7%) and one woman (5.3%); the frequency of TBI in men was significantly higher than that in women. The causes of FCCD included direct impact in seven patients (36.8%), fall in four (20.1%), traffic accidents (TAs) in five (26.3%) (passenger TA in three, motorcycle TA in two), and slip in three (15.8%). All FCCD occurred during work, except for FCCD due to TA. Furthermore, there was no pedestrian TA among the causes of FCCD. The mean duration from TBI to arrival in the ER was 114.3 ± 99.8 minutes (range, 95–394), and the mean duration from arrival in the ER to surgery was 305.1 ± 228.1 minutes (range, 44–755). The mean GCS score was 13.9 ± 2.0 (range, 8–15) at admission and 14.6 ± 1.2 (range, 10–15) at discharge. The median GCS score was 15 at admission and 15 at discharge. The mean hospital stay was 17.6 ± 7.5

Table 1. Demographic and radiological characteristics of patients with FCCD of the skull

Patient No.	Age (years)	Sex	Cause of injury	Time interval (minutes)		GCS score		Hospital stay (days)	FCCD		Associated lesion	Injury of the paranasal sinus
				From injury to ER	From ER to surgery	Adm	Dis		Location	H×V×D (mm)		
1	36	M	Fall	95	365	15	15	21	Frontal*	22×18×2	TICH	Yes
2	56	M	Direct impact	68	180	15	15	13	Parietal	41×48×17	AEDH	No
3	66	M	Slip	86	44	15	15	21	Parietal	32×18×10	TSAH	No
4	62	M	Fall	205	186	15	15	15	Frontal*	41×36×8	None	Yes
5	55	F	Direct impact	53	217	14	15	11	Occipital	29×30×7	TSAH	No
6	37	M	Passenger TA	62	744	14	15	31	Parietal	58×21×7	None	No
7	76	M	Fall	317	223	15	15	14	Temporal	52×48×10	None	No
8	70	M	Direct impact	52	178	15	15	11	Frontal	26×21×10	ASDH	Yes
9	44	M	Direct impact	86	567	15	15	16	Parietal	19×18×23	TSAH	No
10	51	M	Motorcycle TA	27	165	13	14	17	Frontal	48×42×3	AEDH	No
11	54	M	Direct impact	55	190	15	15	12	Frontal	25×36×6	None	Yes
12	31	M	Slip	33	360	15	15	21	Frontal*	38×33×8	AEDH	Yes
13	28	M	Slip	394	103	15	15	8	Frontal	28×24×10	None	No
14	53	M	Passenger TA	166	281	14	14	20	Frontal*	51×48×9	TICH	Yes
15	54	M	Passenger TA	175	755	14	14	32	Frontal*	58×45×17	TICH	Yes
16	60	M	Direct impact	142	158	15	15	9	Parietal	27×18×19	TSAH	No
17	31	M	Direct impact	42	749	14	15	16	Frontal	46×33×15	TICH	Yes
18	46	M	Motorcycle TA	76	113	9	15	33	Frontal	21×42×7	TICH	No
19	47	M	Fall	38	219	8	10	14	Parietal	37×30×10	TSAH	No

*In case of fractures of orbital bone. FCCD : compound comminuted depressed fracture, ER : emergency room, GCS : Glasgow coma scale, Adm : admission, Dis : discharge, H : horizontal, V : vertical, D : depth, M : male, TICH : traumatic intracranial hemorrhage, AEDH : acute epidural hematoma, TSAH : traumatic subarachnoid hemorrhage, F : female, TA : traffic accident, ASDH : acute subdural hematoma

days (range, 8–33).

Radiological characteristics on CT

The radiological characteristics of patients are also summarized in Table 1. The location of FCCD included frontal bone in 11 patients (57.9%), parietal bone in six (31.6%), temporal bone in one (5.3%), and occipital bone in one (5.3%). FCCD was frequently located in the frontal and parietal bones than in other regions. Five of the patients (patient No. 1, 4, 12, 14, and 15) with FCCD in the frontal bone were accompanied by fractures of orbital bone (superior wall). The mean size of FCCD was $1252 \pm 745 \text{ mm}^2$ (range, 336–2615), and the mean of maximal depth was $10 \pm 6 \text{ mm}$ (range, 2–23). The associated lesion on CT included TSAH in five patients (26.3%), TICH in five (26.3%), skull fracture alone in five (26.3%), AEDH in three (15.8%), and ASDH in one (5.3%). The paranasal sinus

was injured in eight patients (42.1%) and intact in 11 patients (57.9%). Of the patients with FCCD in the frontal bone, 62.5% (five patients) had paranasal sinus injury.

Characteristics associated with surgery and infection

The characteristics associated with surgery and infection of patients are summarized in Table 2. The dura mater was torn in eight patients (42.1%) and intact in 11 patients (57.9%). Postoperative antibiotics were intravenously injected for an average of 12.6 ± 4.9 days (range, 6–21). The mean WBC count was $15200 \pm 9786/\mu\text{L}$ preoperatively, $8929 \pm 3146/\mu\text{L}$ after 7 postoperative days, and $7255 \pm 2235/\mu\text{L}$ after 14 postoperative days. The mean ESR count was $7.6 \pm 9.4 \text{ mm/h}$ preoperatively, $27.1 \pm 15.5 \text{ mm/h}$ after 7 postoperative days, and $21.4 \pm 12.9 \text{ mm/h}$ after 14 postoperative days. The mean CRP count was 3.3 ± 6.2

Table 2. Characteristics associated with surgery and infection of patients with FCCD of the skull

Patient No.	Dural tear	Period of postop. antibiotics (day)	Inflammatory markers and BT												Postop. complication
			Preop.				POD 7				POD 14				
			WBC* (/μL)	ESR† (mm/h)	CRP‡ (mg/L)	BT (°C)	WBC* (/μL)	ESR† (mm/h)	CRP‡ (mg/L)	BT (°C)	WBC* (/μL)	ESR† (mm/h)	CRP‡ (mg/L)	BT (°C)	
1	Yes	18	13910	5	1.89	36.5	9440	13	5.19	37.2	9530	3	2.14	36.4	None
2	No	6	10710	5	0.65	37	6190	15	3.29	37.1	5410	4	0.89	36.9	None
3	No	21	17180	9	22.47	37.1	9400	16	26.19	37.1	7890	13	13.58	36.2	None
4	No	14	23240	2	0.99	36.7	16460	20	30.56	37.6	8210	22	15.69	36.8	None
5	No	10	25280	2	1.11	36.2	7490	49	49.65	37.1	7310	38	22.06	36.9	None
6	No	11	23330	2	2.64	37.8	10000	25	27.37	38.5	5980	17	2.46	36.9	None
7	Yes	13	12080	26	4.18	37.2	7390	51	13.75	36.9	8280	40	5.8	36.7	None
8	No	11	6790	7	0.97	37	4470	26	4.89	37.1	4690	16	3.94	37	None
9	No	6	5910	2	0.26	37.2	4810	14	4.46	36.8	4830	5	0.54	36.2	None
10	Yes	21	46970	2	0.24	37.1	8570	20	27.92	37.3	8580	28	2.49	37	None
11	Yes	12	7780	3	0.34	36.6	6560	19	3.37	37.4	5400	18	0.96	36.4	None
12	No	8	15500	2	0.56	37.2	10900	17	8.29	37.5	9300	12	13.12	36.8	None
13	No	8	7740	17	18.68	36.2	9510	15	7.83	36.5	5560	32	4.29	36.9	None
14	No	9	6910	13	0.86	36.7	4870	52	1.73	37.3	3000	47	2.72	38.1	None
15	Yes	18	17430	36	0.15	36.9	10640	49	47.82	38.4	9530	26	37.24	36.4	None
16	No	7	6800	5	1.21	36.4	12490	6	1.21	37.1	5400	18	3.54	36.5	None
17	Yes	14	9480	2	3.77	36.8	8140	27	29.61	37.4	8450	19	7.33	37.3	None
18	Yes	19	16530	2	0.28	37.1	8140	53	48.2	36.6	8460	38	4.85	36.6	None
19	Yes	14	15230	2	1.61	37.4	14190	28	77.26	36.4	12050	11	40.85	36.6	None

*Normal range : 4000–10000/μL. †Normal range : 0–20 mm/h. ‡Normal range : 0–5 mg/L. FCCD : compound comminuted depressed fracture, postop. : postoperative, preop. : preoperative, WBC : white blood cell, ESR : erythrocyte sedimentation rate, CRP : C-reactive protein, BT : body temperature, POD : postoperative day

mg/L preoperatively, 22.0 ± 21.4 mg/L after 7 postoperative days, and 9.7 ± 11.9 mg/L after 14 postoperative days. The mean body temperature was $36.9 \pm 0.4^\circ\text{C}$ preoperatively, $37.2 \pm 0.5^\circ\text{C}$ after 7 postoperative days, and $36.8 \pm 0.4^\circ\text{C}$ after 14 postoperative days. There were no postoperative seizure and complications in all patients.

Illustrative case (patient No. 15)

A 54-year-old male patient came to the hospital with multiple TBIs caused by a passenger TA. Upon arrival at the hospital, he was in a lethargic state (GCS, E3V5M6), with loss of right direct and left consensual light reflexes due to damage to the right optic nerve. Cranial CT showed comminuted de-

pressed fractures of the right frontal bone, a Le Fort type I and III comminuted fracture of the midfacial bones, and TICH in the right frontal lobe with pneumocephalus (Fig. 1). He underwent removal of fragmented bones, evacuation of TICH, dural repair, obliteration of the frontal sinus, and single-stage reconstruction through a bicoronal skin incision. Postoperative cranial CT showed that fragmented bones and hematoma were removed and the bony defect was reconstructed well along the contour of the native skull using titanium mesh and microscrews (Fig. 2). After 6 days, open reduction and internal fixation was performed on the orbital wall for multiple mild facial fractures in the Department of Plastic Surgery. The postoperative course was uneventful, and the patient was dis-

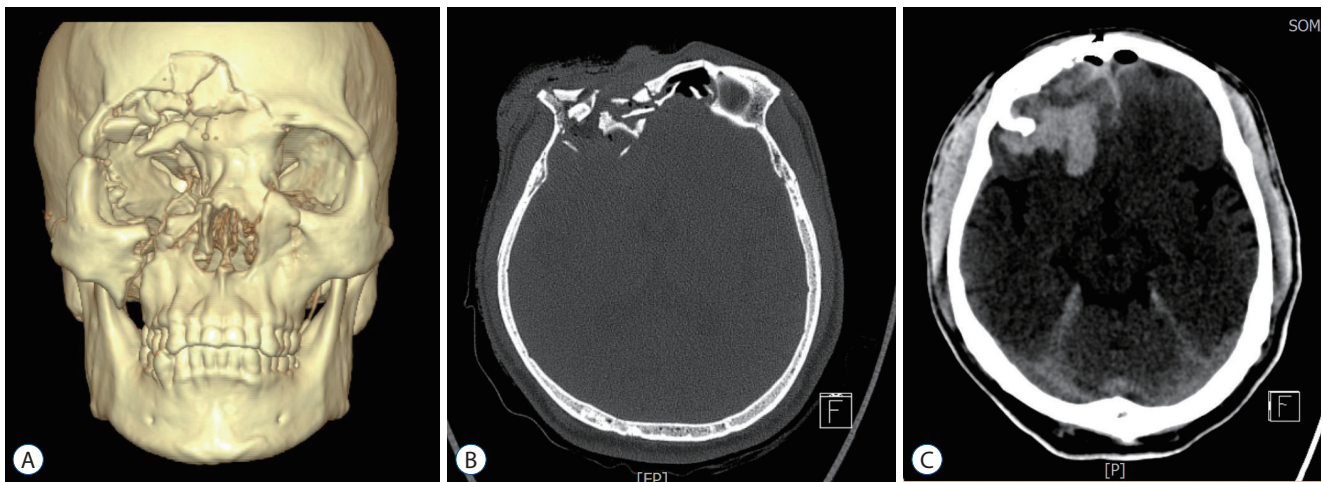


Fig. 1. A-C: Preoperative cranial computed tomography showing the comminuted depressed fractures of the right frontal bone, a Le Fort type I and III comminuted fracture of the midfacial bones, and traumatic intracranial hematoma in the right frontal lobe with pneumocephalus.

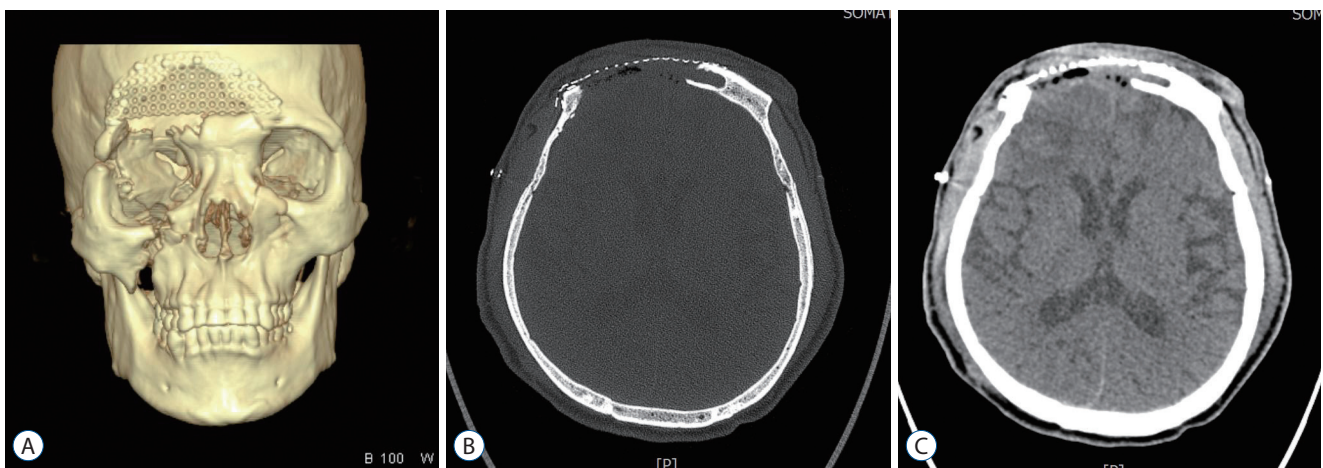


Fig. 2. A-C: Postoperative cranial computed tomography showing that fragmented bones and hematoma were removed, and the bony defect was reconstructed using titanium mesh and microscrews.

charged after 32 days with no additional neurological deficits. Cranial CT after 4 months showed a well-fixed titanium mesh along the periphery of the bony defect without additional abnormality (Fig. 3).

DISCUSSION

The majority of previous studies supports the removal of contaminated fragmented bone and elevation of FCCD as soon as possible after TBI^{5,11}. The rationale for immediate surgery of FCCD originates from its association with infection and late epilepsy⁵. Jennett and Miller¹¹ reported an incidence of infection of 10.6% in a series of 359 patients with compound cranial fractures. They revealed that these infections were associated with a remarkably higher incidence of persistent neurological deficit, late epilepsy, and death. They also demonstrated that proper removal and replacement of the fragmented bone were safe, and there was no difference in infection rate when fragmented bones were removed rapidly and adequately, even if the dura mater was torn. Immediate surgery in FCCD cases including surgical debridement reduced the infection rate to 4.6%. Therefore, they reported that this primary surgery may not be considered dangerous, and that avoiding delayed cranioplasty could be advantageous.

The traditional treatment in patients with FCCD includes wound debridement, elevation of the fracture, removal of bone fragments, evaluation of intracranial pathological findings, and delayed cranioplasty^{5,14}. Most clinical concerns re-

garding single-stage reconstruction with cranioplasty were related to infection. Most of the studies supporting two-stage surgery with delayed cranioplasty were based on combat-related injuries that were significantly different from those of civilians^{9,10,17}. Combat-related injuries cause a higher degree of fragmentation and contamination than civilian trauma. However, numerous studies of civilian TBI have begun to counter the major concerns of infection in early primary single-stage surgery¹⁴. Recently reported studies show that if surgery is performed rapidly, immediate replacement of the fragmented bone does not seem to increase the infection rate, and this primary replacement does not require subsequent cranioplasty and prevents its attendant risks and complications^{1,3-5,14,19}. Braakman⁴ reported that there were five cases (4.6%) of infection in 109 cases of replacement and the same number (8.9%) in 56 cases where the fragments had been completely removed in 225 consecutive patients with a depressed skull fracture. Wylen et al.¹⁹ also retrospectively reviewed 32 consecutive patients treated with debridement and elevation of compound depressed skull fractures with primary replacement of bone fragments within 72 hours of injury, and reported that there were no infectious sequelae; they concluded that immediate replacement of bone fragments in compound depressed skull fractures does not increase the risk of infectious complications. Blankenship et al.³ also reported that there were no instances of wound infection or osteomyelitis in a retrospective study of 31 consecutive children with compound depressed skull fractures treated with bone fragment replacement. Therefore, no child required subsequent cranioplasty. They

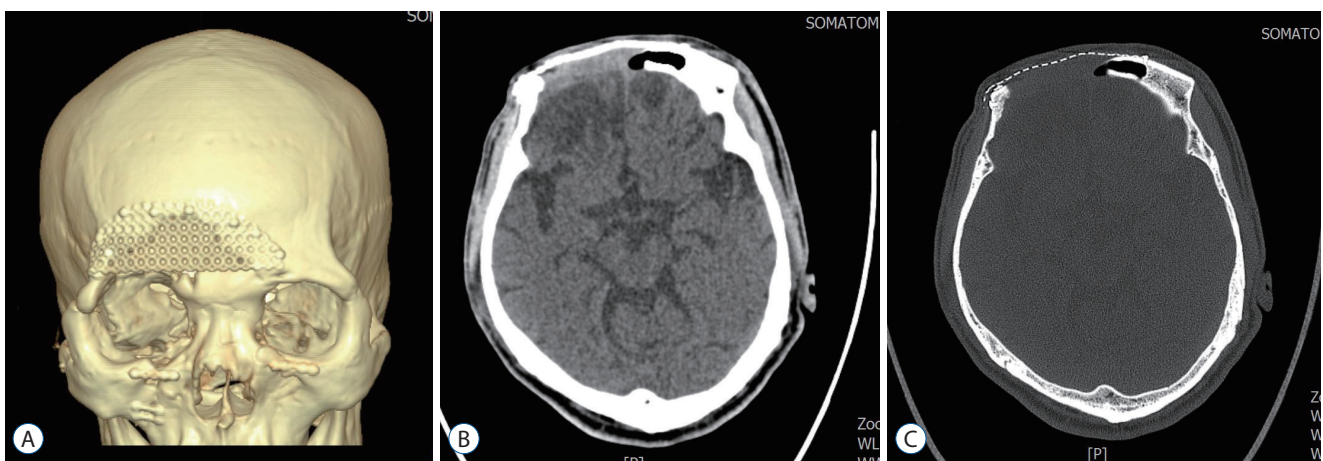


Fig. 3. A-C : Cranial computed tomography after 4 months showing well-fixed titanium mesh along the periphery of the bony defect without additional abnormality.

proposed that bone fragment removal for compound depressed skull fractures, regardless of the degree of contamination, presence of dural laceration, or degree of intracerebral injury, is unnecessary and that bone fragment replacement avoids a second surgery for cranioplasty. Similarly, Adeloje and Shokunbi¹¹ described a 0% infection rate in 12 patients with compound depressed skull fractures whose post-debridement cranial defects were treated with immediate bone replacement. They recommended primary repair of skull defects with bone fragments as the treatment of choice during debridement of compound depressed skull fractures of mild to moderate severity within 1 day of injury.

Additionally, surgeons have to consider cosmetic aspects and infection-related issues when deciding on the type of surgery. There are many alloplastic grafts available for cranioplasty. It has a variety of advantages and disadvantages depending on the materials. Polymethyl methacrylate is an acrylic resin that can be molded and provides strength and protection similar to that by the skull but has the disadvantage of an infection rate similar to that of cranioplasty with autog-

enous or autoclaved graft⁷). Hydroxyapatite, a calcium-based bone cement, has the advantages of increased osteoconduction and osteointegration, but it can become infected and can cause severe foreign body inflammatory reaction and extrusion¹²). In contrast, dynamic titanium mesh has good properties of high tensile strength and biological inactivity, and several studies have shown that the infection rate of cranioplasty with titanium mesh is low¹⁸). Titanium spinal implants have been used for pyogenic and tuberculous spondylitis and discitis without causing persistent infection¹³). Titanium is a widely used implant substance with excellent characteristics because of its adequate radiolucent, no magnetic, or paramagnetic properties and excellent biocompatibility¹⁴). The improved complex mesh patterns can be more convenient and rapidly fit the implants to the contour of the skull properly for both small and large skull defects while maintaining strength¹⁴). The frontal bone is one of the most important parts in terms of cosmetics aspect, even more so when including the fracture of orbital bone. In this study, there were five patients with fractures of orbital bone, all of whom were quickly and easily

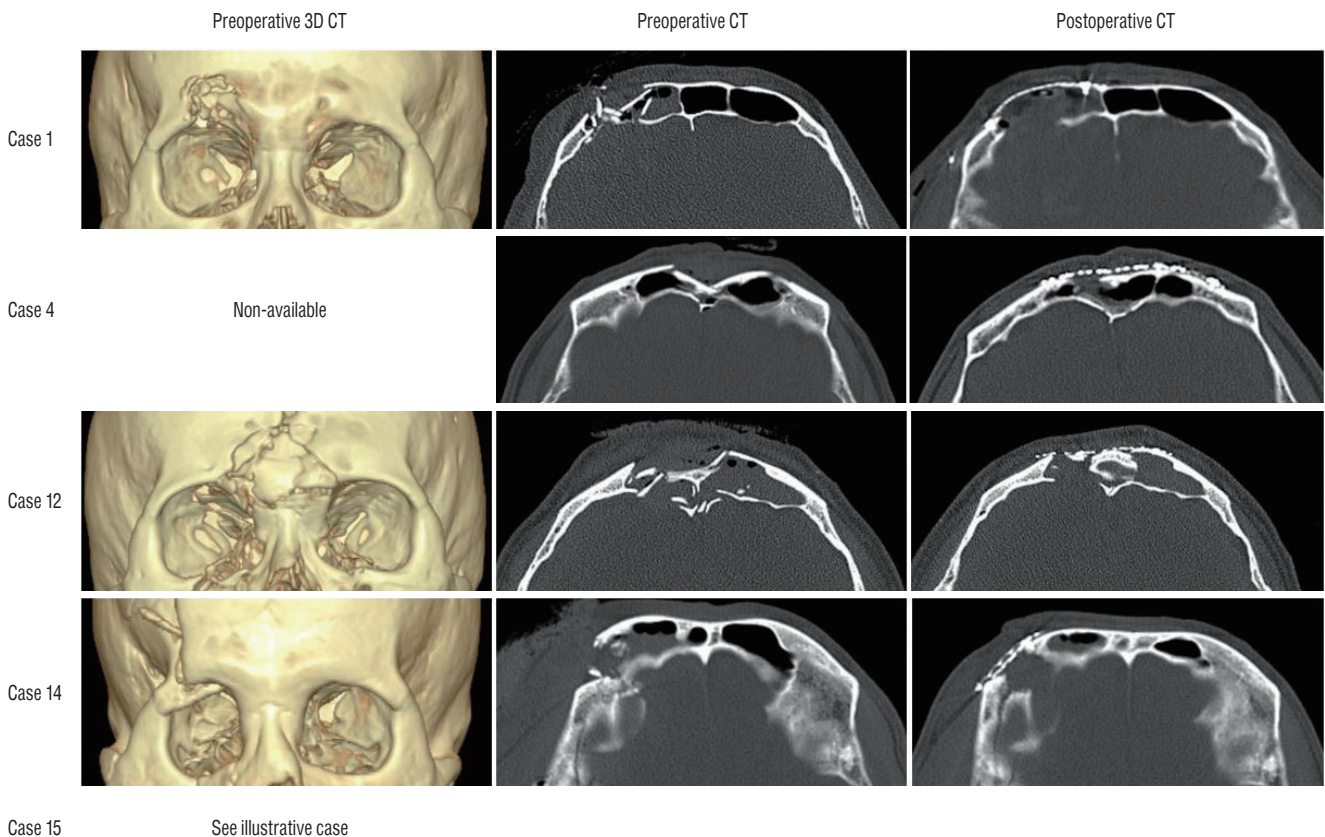


Fig. 4. Preoperative and postoperative cranial CT of patients with fractures of orbital bone. CT : computed tomography.

reconstruct using titanium mesh. These patients were also cosmetically satisfied and there were no postoperative complications (Fig. 4).

Marbacher et al.¹⁴⁾ showed that primary reconstruction with titanium mesh for FCCD was feasible, safe, cost-effective, and cosmetically preferable than the conventional staged approach. This also prevents the risks and costs associated with a delayed cranioplasty, which is usually performed under general anesthesia¹⁸⁾. Titanium mesh implantation has been used for some postcraniotomy surgical infections. Ehrlich et al.⁶⁾ and Wind et al.¹⁸⁾ demonstrated that immediate titanium mesh cranioplasty is a cost-effective, safe, and cosmetically suitable alternative to delayed cranioplasty in selected patients and may be a suitable option for the treatment of postcraniotomy infections.

In this study, the mean duration from TBI to surgery was 7.0 ± 3.9 hours, and all patients underwent surgery on the day of injury. This suggests that the immediate administration of antibiotics in the ER and rapid surgery after TBI reduced the likelihood of infectious complications. The mean hospital stay was 18 days, which was not significantly different compared to those in other types of traumatic neurosurgical diseases. However, since additional hospital stay for delayed secondary cranioplasty in two-stage surgery was not necessary, immediate single-stage reconstruction of FCCD with titanium mesh had potential advantages in terms of cost-effectiveness.

FCCD was frequently located in the frontal and parietal bones than in other regions. Of patients with FCCD in the frontal bone, 62.5% had paranasal sinus injury. Therefore, when performing surgery for FCCD in the frontal bone, it is necessary to pay close attention to the opening of the paranasal sinus. Several studies have been reported to determine whether antibiotics reduce the incidence of meningitis in patients with FCCD. Mendelow et al.¹⁵⁾ reported that the early treatment with ampicillin and sulphonamide, in addition to adequate surgical debridement, is recommended in patient with compound depressed skull fractures in 176 patients with FCCD. Ali and Ghosh²⁾ commented that the incidence of infectious complications other than meningitis in the non-antibiotic group was higher than in the group given antibiotics. There are some literatures that the benefit of prophylactic antibiotics in the FCCD could not be proved. Prakash et al.¹⁶⁾ analyzed 453 patients with depressed skull fractures concluded that there was substantial data to support the use of prophy-

lactic antibiotics in patients to reduce chances of infection with it. Haines examined that the evidence regarding antibiotic prophylaxis in five specific neurosurgical situations (clean surgical procedures, cerebrospinal fluid shunts, external ventriculostomies, basilar skull fractures, and compound skull fractures)⁸⁾. In addition, he concluded that it was unclear whether all patients with FCCD required antibiotic treatment⁸⁾. Postoperatively, antibiotics were used for an average of 12.6 days. The mean WBC count remained within normal ranges pre- and postoperatively, and mean ESR and CRP count were slightly increased 7 days postoperatively and subsequently decreased. This temporary increase was not indicative of infection. There was no postoperative seizure or complications, such as infection or cerebrospinal fluid leakage, in all patients.

CONCLUSION

Based on the author's surgical experience and review of previous literature, there is no doubt that immediate bone fragment replacement does not increase infectious sequelae compared to two-stage surgery with delayed cranioplasty. This suggests that the risk associated with surgery and economic, psychological, and cosmetic burden of the second surgery is avoided. Although more well-controlled studies may be needed, the treatment strategy of FCCD may be changed to a primary single-stage surgery with immediate reconstruction rather than a traditional two-stage surgery.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

INFORMED CONSENT

Although this type of study does not require informed consent, informed consent was obtained from patient No. 15 for illustrative case.

AUTHOR CONTRIBUTIONS

Conceptualization : KSE
Data curation : KSE
Formal analysis : KSE
Funding acquisition : KSE
Methodology : KSE
Project administration : KSE
Visualization : KSE
Writing - original draft : KSE
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• Acknowledgements

This paper was supported by Wonkwang University in 2019.

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