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Original Article

Effect of cranioplasty on FIM in patients with severe cerebral infarction after cerebral decompression

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ABSTRACT
Arai N, Abe Y, Metani H, Hiraoka T, Hanayama K. Effect of cranioplasty on FIM in patients with severe cerebral infarction after cerebral decompression. Jpn J Compr Rehabil Sci 2023; 14: 33−38.
Objective: The functional effects of cranioplasty were measured in patients with severe cerebral infarction who had undergone cerebral decompression by comparing the functional independence measure (FIM) during convalescent rehabilitation before and after cranioplasty.
Methods: The study design was a single-center retrospective cohort study.
Results: Fifty-five patients underwent cerebral decompression after cerebral infarction at our hospital, six of whom were included in this study. Two patients who exhibited cranial depression had no changes in FIM one month prior to cranioplasty. However, the FIM increased one month postoperatively. These patients showed a large increase in the scores for movement and transfer.
Discussion: Cranioplasty may play a role in improving ability during convalescent rehabilitation in patients with severe cerebral infarction who undergo cerebral decompression, especially in movement and transfer items.
Key words: cerebral decompression, severe cerebral infarction, cranioplasty, FIM

Introduction

Cerebral decompression is a treatment for severe cerebral damage caused by trauma or cerebral stroke. The 2016 Randomized Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure trial (The RESCUEicp trial: an international, multicenter, parallel-group, superiority randomized controlled trial) reported that patients undergoing cerebral decompression had a lower six-month mortality rate and a comparable or lower functional prognosis than those undergoing conservative treatment [1]. These results suggest that cerebral decompression results in the survival of patients with severe cerebral damage. Therefore, there is expected to be an increased need for rehabilitation in patients with severe cerebral damage.

Cranioplasty is often performed on patients who have undergone cerebral decompression and may affect physical and cognitive functions. When considering rehabilitation after cerebral decompression, the functional effects of cranioplasty must also be considered. Studies have reported the effects of cranioplasty on functional impairment in patients with severe cerebral damage, including head injuries, cerebral hemorrhage, and subarachnoid hemorrhage [2−7]. However, these studies focused on the functional changes one to two weeks postoperatively and did not examine the mid- to long-term effects of cranioplasty.

Several randomized controlled trials have reported that patients with cerebral infarction who undergo cerebral decompression within 96 hours of symptom onset are expected to have improved survival and activities of daily living [6−9]. However, the functional effects of cerebral decompression in patients with cerebral damage caused by cerebral infarction may differ from those in patients with severe cerebral damage due to other causes. Furthermore, there have been no reports regarding the mid-to long-term functional effects of cranioplasty in patients with severe cerebral infarction who have undergone cerebral decompression.

This study examined the effects of cranioplasty on convalescent functional improvement in patients with cerebral infarction who underwent cerebral decompression. The functional independence measure (FIM) scores during convalescent rehabilitation before

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and after cranioplasty were compared.

Methods

1. Patients

Patients with initial cerebral infarction who underwent cerebral decompression at our hospital between January 1, 2010 and March 15, 2020 and were admitted to the convalescent rehabilitation ward before and after cranioplasty were included in this study. All patients included in this study were 20 years or older with a premorbid modified Rankin scale (mRS) score of 0 or 1.

Patients with a change in medication that may have affected cognitive function (such as psychotropic and antidementia medications) before or after cranioplasty during hospitalization, those who suffered complications of cranioplasty, those undergoing surgery other than cerebral decompression or cranioplasty (including shunt procedures), those with hydrocephalus, and those with an FIM score ≥ 108 at the time of admission to the convalescent rehabilitation ward before cranioplasty were excluded from this study.

2. Measured variables

Patient age, gender, premorbid activity (mRS), Glasgow coma scale (GCS) score before cerebral decompression, National Institute of Health Stroke Scale (NIHSS) score on admission, obstructed arteries, Charlson comorbidity index score, medical history, site of cerebral decompression (left or right), date and time of symptom onset, date and time of cerebral decompression, history of cranioplasty (including date and materials used), head computed tomography (CT) images obtained immediately before cranioplasty, postoperative complications, surgical history, and oral medications administered during hospitalization were obtained from the patients' medical records. The patients' history of admission to the convalescent rehabilitation ward (including date of admission and discharge from the ward before and after cranioplasty) were also obtained from the medical records.

3. Analysis

As this study included a small patient population, time-series changes in FIM during the observation period were graphed for each patient to examine the effects of cranioplasty. SPSS ver. 27 was used to analyze the data.

Results

During the study period, 55 patients underwent cerebral decompression at our hospital, including 30 who underwent cranioplasty. Eleven patients were admitted to the convalescent rehabilitation ward before and after cranioplasty. Of the 11 patients, one was excluded from this study due to a medication change, one patient had hydrocephalus and a medication change, two patients developed complications after cranioplasty (cerebral abscess or sepsis), and one patient underwent surgery other than cranioplasty (aortic dissection) and had a medication change. No patients had an FIM score ≥ 108 at the time of admission to the convalescent rehabilitation ward before cranioplasty. Therefore, six patients were included in this study (Figure 1).

The patient age ranged from 43 to 72 years (median: 63 years), and the time from onset to admission was 24–63 days (median: 32.5 days). The FIM score at the time of admission to the convalescent rehabilitation ward was 18–44 (median: 27), and the time from onset to cranioplasty was 78–135 days (median: 82.5 days).

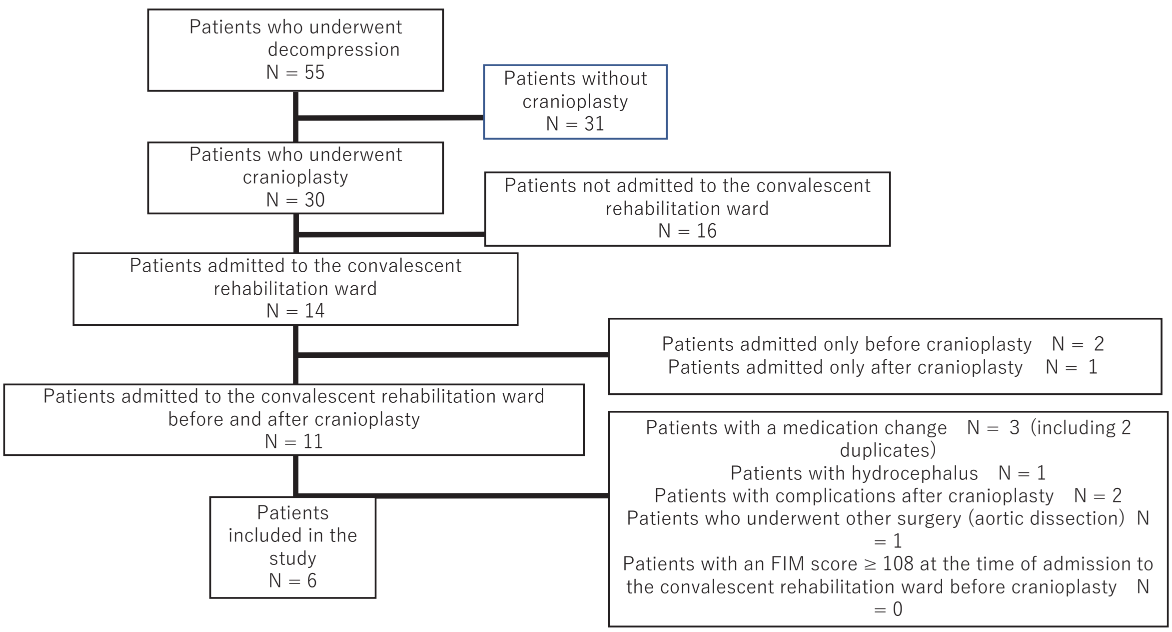

Figure 1. Patient flowchart.

Table 1. Patient characteristics (*N* = 6).

Case	Gender	Age	Obstructed artery	Time to cerebral decompression	NIHSS	Charlson Comorbidity Index	Material used	Time from onset to admission (days)	Time from cerebral decompression to cranioplasty (days)
1	Male	63	Left internal carotid artery	Less than 48 hours	14	0	Autologous bone	18	84
2	Male	63	Left middle cerebral artery	Less than 48 hours	21	0	Artificial bone	34	81
3	Female	43	Left middle cerebral artery	Less than 48 hours	24	0	Autologous bone	44	135
4	Male	72	Left internal carotid artery	Less than 48 hours	24	2	Artificial bone	29	79
5	Male	66	Right middle cerebral artery	Between 48 and 96 hours	16	2	Autologous bone	22	78
6	Male	63	Right internal carotid artery	Less than 48 hours	27	4	Artificial bone	28	100

Abbreviations: NIHSS, National Institutes of Health Stroke Scale (NIHSS)
※Convalescent rehabilitation ward
※Functional Independent Measure (FIM)

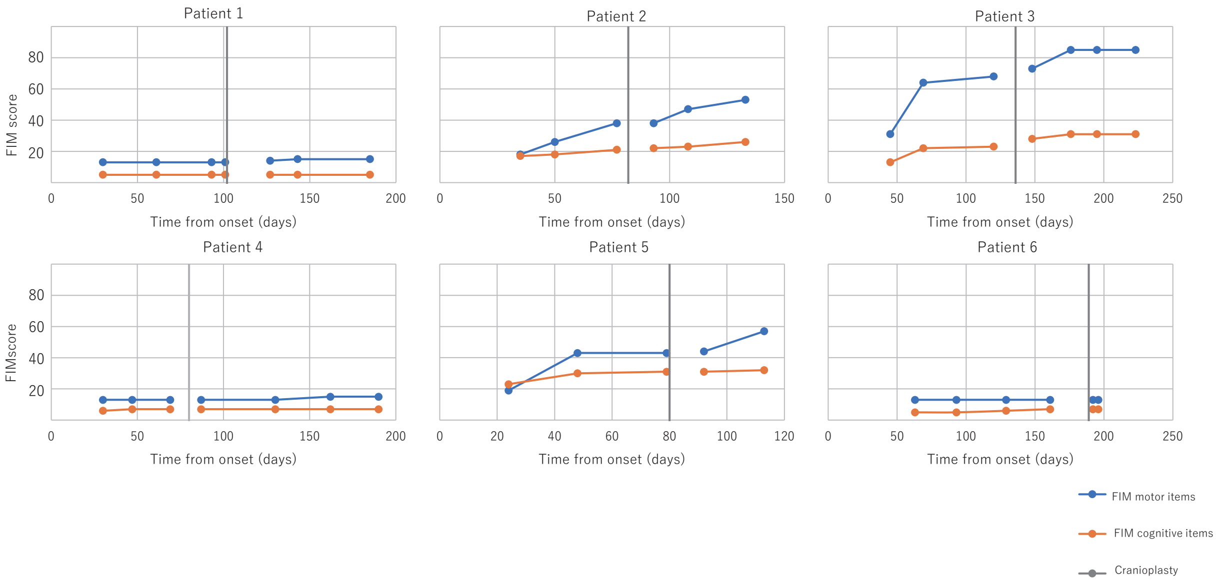

Figure 2. FIM score and number of days from onset.
Patients 1, 4, and 6 had no major changes in FIM score.
The FIM score increased before and after cranioplasty in patient 2. The FIM efficiency immediately after cranioplasty was higher than that immediately before cranioplasty, though the timing of cranioplasty may have overlapped with the timing of significant improvement in FIM score. The increase in FIM score was stable before cranioplasty, but increased after cranioplasty in patients 3 and 5.

Patient characteristics are shown in Table 1. The relationship between the number of days from symptom onset and the total FIM score is shown in Figure 2. Patients 3 and 5 exhibited a skin flap depression immediately before cranioplasty, which was not recorded in other patients (Figure 3). Patients 3 and 5 had small changes in FIM scores during convalescent rehabilitation one month before cranioplasty, but they had increased FIM scores one month after cranioplasty, especially in movement and transfer items (Table 2).

Discussion

No patients in this study underwent cerebral decompression less than 24 hours or more than 96 hours after the onset of cerebral infarction. Cerebral decompression performed within 48 hours of the onset of cerebral infarction is associated with favorable outcomes, even in elderly patients, while cerebral decompression performed more than 96 hours after the onset is associated with poor outcomes [6–9].

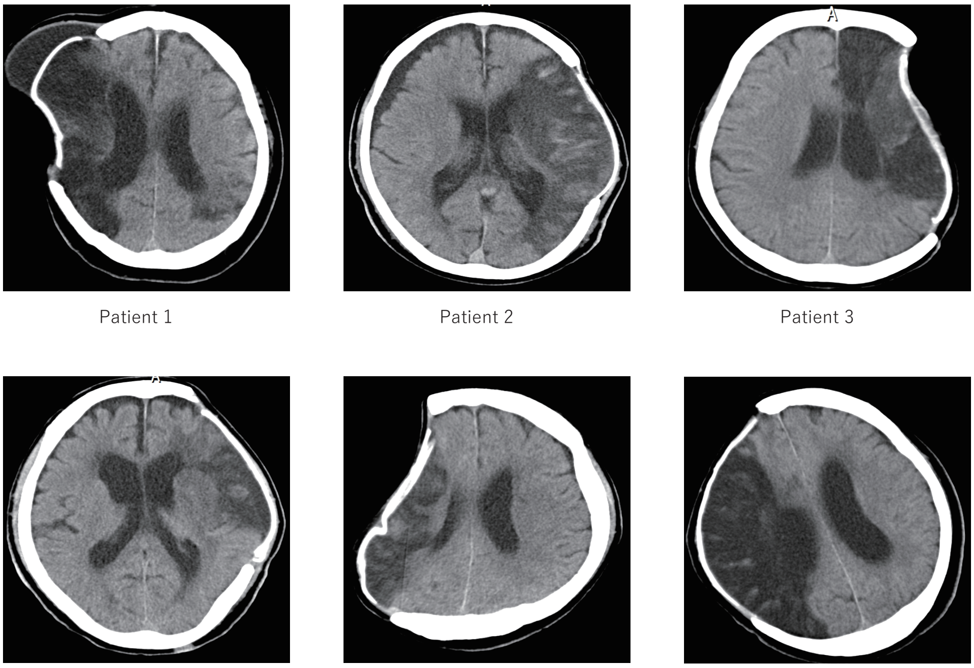

Figure 3. Head CT images obtained immediately before cranioplasty.
The intracranial pressure of patients 3 and 5 was less than atmospheric pressure, while the intracranial pressure of other patients was higher than or comparable to atmospheric pressure.

Table 2. Changes in functional independent measure.

Case	Overall changes in FIM one month before cranioplasty (Motor items: Cognitive items)	Overall changes in FIM one month after cranioplasty (Motor items: Cognitive items)	Motor-item FIM gain one month before cranioplasty (Self-care: Movement and transfer)	Changes in motor items one month after cranioplasty (Self-care: Movement and transfer)	FIM efficiency one month before cranioplasty (Motor items: Cognitive items)	FIM efficiency one month after cranioplasty (Motor items: Cognitive items)
1	18⇒18 (13⇒13 : 18⇒21)	19⇒20 (14⇒15 : 5⇒5)	0 (0 : 0)	1 (1 : 0)	0.00 (0.00 : 0.00)	0.06 (0.06 : 0.00)
2	44⇒59 (26⇒38 : 18⇒21)	60⇒70 (38⇒47 : 22⇒23)	12 (8 : 4)	9 (5 : 4)	0.56 (0.45 : 0.11)	0.67 (0.60 : 0.07)
3	86⇒91 (64⇒68 : 22⇒23)	101⇒116 (73⇒85 : 28⇒31)	4 (1 : 3)	13 (2 : 11)	0.10 (0.08 : 0.02)	0.54 (0.43 : 0.09)
4	20⇒20 (13⇒13 : 7⇒7)	20⇒20 (13⇒13 : 7⇒7)	0 (0 : 0)	0 (0 : 0)	0.00 (0.00 : 0.00)	0.00 (0.00 : 0.00)
5	73⇒74 (43⇒43 : 30⇒31)	75⇒89 (44⇒57 : 31⇒32)	0 (0 : 0)	13 (5 : 8)	0.03 (0.00 : 0.03)	0.67 (0.62 : 0.15)
6	19⇒20 (13⇒13 : 6⇒7)	20⇒20 (13⇒13 : 7⇒7)	1 (0 : 1)	0 (0 : 0)	0.03 (0.00 : 0.03)	0.00 (0.00 : 0.00)

Abbreviations: FIM, Functional Independent Measure (FIM).

Cerebral decompression performed within 24 hours of the onset of cerebral infarction results in favorable functional outcomes [10]. The timing of cerebral decompression did not affect the patients' functional prognoses in this study.

The effects of cranioplasty in patients 1, 4, and 6 were unclear due to small increases in the FIM scores from onset to discharge or transfer. However, there was no decrease in the FIM scores after cranioplasty, and two patients had a higher FIM score one month after cranioplasty than one month before cranioplasty, indicating that cranioplasty had no adverse effects.

Patient 2 had an increased FIM score immediately before and after cranioplasty. It is not clear whether this increase was due to the effects of cranioplasty or if the timing of the cranioplasty coincided with the timing of the ability improvement. However, the FIM efficiency was higher one month after cranioplasty than one month before cranioplasty, suggesting that cranioplasty had no adverse effects on the patient's improvement in ability during convalescent rehabilitation.

As shown in Figure 2, the FIM efficiency of patients

1 and 5 one month before cranioplasty was lower than that one month after cranioplasty, suggesting that the FIMs may have reached a plateau before cranioplasty. However, the FIM efficiency one month after cranioplasty was higher than that one month before cranioplasty. In these patients, cranioplasty resulted in increased FIM scores due to more favorable effects on motor items than on cognitive items, especially the movement and transfer items (Table 2).

Based on head CT images obtained immediately before cranioplasty (Figure 3), patients 3 and 5 had depression at the site of calvarial defects, indicating that their intracranial pressure was lower than atmospheric pressure. In recent years, trephine syndrome has been noted as a mid-term complication of cerebral decompression. Symptoms of trephine syndrome include headache, dizziness, pain and discomfort at the site of calvarial defects, mood swings, and impaired abilities. Patients with trephine syndrome experience headache and motor dysfunction several weeks to several months after cerebral decompression, and these symptoms significantly improve immediately after osteoplasty [5, 11]. A systematic review published in 2016 reported that symptoms of trephine syndrome appear several weeks to several months after cerebral decompression, regardless of the site of injury, and that clinical functional improvement is observed after cranioplasty [12]. Therefore, calvarial defects have adverse effects on the regulation of intracranial pressure, and cranioplasty is believed to eliminate these adverse effects. Impaired regulation of intracranial pressure associated with calvarial defects may have adverse effects on functional improvement during convalescent rehabilitation in patients with cerebral infarction, preventing functional improvement prior to cranioplasty. Therefore, cranioplasty may have favorable effects on the postoperative FIM score and on training for functional improvement during convalescent rehabilitation.

In addition to the improved regulation of intracranial pressure by cranioplasty, patient 3 had NIHSS and Charlson comorbidity index scores of 24 and 0, respectively, and patient 5 had scores of 16 and 2, respectively. These scores indicate that the effects of cranioplasty may not contribute to the severity at onset or comorbidities.

As this was a retrospective study, there were several limitations. Many patients undergoing cerebral decompression are classified as severe and are likely to develop complications. In addition, patients with a change in oral medications that affect the central nervous system were excluded from this study due to the effects of these medications on cognitive function. This exclusion criterion resulted in a small patient population. Therefore, by observing the time-series changes in FIM score of each patient, the functional effects of cranioplasty during convalescent rehabilitation in patients with severe cerebral infarction who underwent cerebral decompression were examined. The results of this study suggest that cranioplasty may have favorable mid- to long-term functional effects in these patients. In addition, head CT images obtained immediately before cranioplasty revealed depression at the site of calvarial defects in some patients. Regardless of comorbidities or severity at onset, these patients may have an increased FIM score immediately after cranioplasty, especially in movement and transfer items, even when the FIM scores were stable immediately before cranioplasty. These findings can be used to predict outcomes during convalescent rehabilitation. Although this study may have been affected by selection bias, no prospective randomized controlled trials on the functional effects of cranioplasty in patients with severe cerebral infarction who underwent cerebral decompression have been reported. The results of this study indicate that cranioplasty may have mid- to long-term favorable effects and are useful for future prospective studies on the functional effects of cranioplasty in this patient population.

Conclusion

The functional effects of cranioplasty in patients with cerebral infarction who underwent cerebral decompression were examined using FIM score changes during convalescent rehabilitation before and after cranioplasty. In this study, head CT images obtained immediately before cranioplasty revealed depression at the site of calvarial defects in some patients, in whom the FIM score was stable before cranioplasty and increased during post-operative convalescent rehabilitation, especially in the movement and transfer items.

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