Traumatic intracranial hemorrhages in patients with maxillofacial / jaw fractures

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ABSTRACT Patients sustaining maxillofacial fractures are at risk of accompanying traumatic intracranial hematomas, which are a major cause of morbidity and mortality. Prompt recognition of the clinical signs, followed by a neurosurgical inspection and diagnosis, is crucial for improving patient survival and recovery. To look for a relationship between the pattern of maxillofacial fractures and the risk of an intracranial hemorrhage, this retrospective study examined the records of 188 patients with maxillofacial fractures treated at the Division of Oral and Maxillofacial Surgery, Kagawa Prefectural Central Hospital, Kagawa, Japan, between January 2005 and June 2008. The patients' age, gender, cause, type, and location of maxillofacial fracture, and the intracranial injuries, were analyzed. Intracranial hemorrhage occurred in 17 patients (9.0%) and included intracerebral (6.4%), subarachnoid (4.8%), subdural (3.7%), and epidural (0.5%) hemorrhages. Central mid-face (LeFort-2/3), cranial vault, and basal skull fractures had much higher risks of an accompanying intracranial hemorrhage. Pan-facial maxillofacial fractures (OR 19.1) and high-energy injuries (OR 50.8) increased the risk of an accompanying intracranial hemorrhage. Nevertheless, traumatic intracranial hemorrhages were seen with one simple fracture of the zygoma, one of the maxilla, two fractures of the mandible, and even two maxillary alveolar fractures. Four patients (23.5%) had to undergo neurosurgery to decompress an intracranial hematoma. High-energy injuries may affect the intracranial vessels, leading to hemorrhage in different intracranial compartments. Therefore, when treating maxillofacial fractures, oral and maxillofacial surgeons and emergency and critical care physicians should always consider the clinical signs of traumatic intracranial hemorrhage, in close consultation with critical care centers and neurosurgeons.

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Introductions

Patients with craniomaxillofacial fractures may have accompanying traumatic intracranial injuries¹⁻³⁾. The leading cause of morbidity and mortality in head trauma patients is a traumatic intracranial hematoma¹⁻⁴⁾. A clinical review reported that the frequency of neurological injury associated with facial fractures is as high as 76% and that

localized injuries to the face and head resulting in maxillofacial fractures might also involve the brain and meninges^{4, 5)}. While most patients with minor head injuries with or without maxillofacial trauma usually recover quickly, some deteriorate, necessitating intervention for an intracranial hematoma²⁻⁵⁾. A study demonstrated that 2.8% of facial fracture patients who are conscious with a Glasgow Coma Scale (GCS) score of 15 in the absence of clinical neurological abnormalities have an accompanying intracranial hematoma^{2-4, 6)}. However, the relationship between maxillofacial fractures and intracranial hemorrhage remains to be clarified. Prompt detection and a neurosurgery consultation may improve the outcome of head injury^{5, 6)}.

In general hospitals, computed tomography (CT) is now performed routinely for patients with impaired consciousness or neurological signs such as vomiting, nausea, and

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seizures^{7,8)}. By contrast, although patients with severe pan-facial fractures are probably expected to be subject to head CT screening, patients with a maxillofacial trauma/jaw fracture only, such as with trauma to the alveolus or mandible, are often screened and diagnosed using plain radiographs. Consequently, any accompanying traumatic intracranial hemorrhage is discovered only after clinical deterioration of the patient, with the development of seizures, vomiting, and nausea^{4,6)}. Although CT is expensive and involves high radiation exposure, data indicate that its selective use could reduce healthcare costs^{4,7,8)}.

This study sought to identify maxillofacial fracture patterns predisposing patients to intracranial hemorrhage. Occasionally a patient with minor maxillofacial trauma requires neurosurgical intervention, which prompted us to calculate the risk for accompanying intracranial hemorrhages in maxillofacial fracture patients. These data may enable the more efficient use of CT, thereby improving the treatment of maxillofacial fractures by oral and maxillofacial and trauma surgeons at emergency and critical care centers.

Patients and Methods

The medical records of patients with maxillofacial fractures treated at the Division of Oral and Maxillofacial Surgery (OMS) of Kagawa Prefectural Central Hospital, Kagawa, Japan between January 2005 and June 2008 were reviewed. The patients had been deemed to have a craniomaxillofacial fracture based on CT or plain radiographs; an initial head CT had been performed in patients with impaired consciousness; neurological signs such as vomiting, nausea, and seizures; or clinical signs of basal skull or cranial vault fractures. Fractures in the LeFort categories had been evaluated in the zygomatic or nasal-maxillary complex group, as these bones were involved. Pan-facial fractures were those with more than two craniomaxillofacial bone fractures. Brain injuries such as intracranial hemorrhage had been diagnosed by experienced neurosurgeons following clinical inspection and had been treated immediately after their detection, as warranted.

The patients' age, gender, route to visit the hospital, cause, type, and location of craniomaxillofacial fractures, and neurological injuries were analyzed.

Statistics

The statistical analysis included a descriptive analysis,

the chi-square test, and Fisher's exact test (when the expected counts were less than five) for categorical variables. To test for age differences between trauma patients with or without accompanying intracranial hemorrhage, the Student's t-test was used, with $p < 0.05$ considered significant. Multivariate logistic regression analysis was performed to determine the odds ratios (ORs) and 95% confidence intervals (CIs) for different potential predictors of intracranial hemorrhage.

Results

In total, 188 patients [119 (63.3%) male and 69 (36.7%) female; mean age, 40 years; range 1-99 years] with maxillofacial fractures were treated at the Division of Oral and Maxillofacial Surgery and were included in this study (**Table 1**). As shown in Table 1, alveolar fractures (42.6%) constituted nearly half the total, followed by mandibular (32.4%), pan-facial maxillofacial (13.8%), zygoma (7.4%), and maxilla (3.7%) fractures. The pan-facial maxillofacial fractures (26 cases) included severe injuries extending to the cranial bones, comprising cranial vault fractures (6 cases), basal skull fractures (5 cases), and severe LeFort-2 or -3 mid-face fractures (6 cases) (Table 1). The main cause of maxillofacial fractures was traffic accidents (47.3%); this was followed by falls, and these two categories accounted for more than 75% of the trauma patients (Table 1). Furthermore, high-energy injuries were a frequent cause of injury in general, as much as 19.7%. Male patients dominated in most categories of trauma causing maxillofacial fractures. Of the trauma patients, 54.3% were sent directly to our critical care center usually by ambulance, followed by a consultation regarding oral-maxillofacial trauma. Other patients from other medical hospitals, critical care centers (18.6%) or medical and dental clinics (13.6%) usually visited our OMS outpatient clinic directly. These three visiting routes accounted for almost all of the patients needing maxillofacial trauma treatment and care included in this study (Table 1).

Seventeen (9.0%) of the 188 patients (12 male and 5 female; mean age, 49.3 years; range, 16-80 years) suffered from traumatic intracranial hemorrhage, which included intracerebral (12 cases, 6.4%), subarachnoid (9 cases, 4.8%), subdural (7 cases, 3.7%), and epidural (1 case, 0.5%) hemorrhages (Table 2a-c). The difference in patient age between the groups with or without intracranial hemorrhage was not significant ($p > 0.05$). Two patients (1.1%), one with a pan-facial fracture (zygoma and severe mandibular fractures) and the other with a zygoma fracture,

Table 1. Description, type, location, cause, and route to the oral-maxillofacial surgery division of the maxillofacial fractures in 188 patients.

Patients	N=188	
Male	119	(63.3%)
Female	69	(36.7%)
Age range (years)	1-99	
Mean age	40.0	
Maxillofacial fractures		
Pan-facial	26	(13.8%)
(Cranial vault fracture)	(6)	
(Basal skull fracture)	(5)	
(LeFort II or III)	(6)	
Zygoma	14	(7.4%)
Maxilla	7	(3.7%)
Mandible	61	(32.4%)
Alveolus	80	(42.6%)
Cause of trauma		
High-energy injury	37	(19.7%)
Traffic accident	89	(47.3%)
Fall	57	(30.3%)
Sports	14	(7.4%)
Assault	13	(6.9%)
Working accidents	6	(3.2%)
Other accidents	9	(4.8%)
Route to the Division of OMS		
Emergency and Critical Care Center	102	(54.3%)
Other medical hospitals/clinics	35	(18.6%)
Other dental/OMS clinics	26	(13.8%)
Other divisions in the hospital	7	(3.7%)
No references	18	(9.6%)

developed chronic subdural hematomas after treatment of the initial maxillofacial fracture. The first was treated with transcranial drainage through a burr hole and the second was followed carefully by neurosurgeons. **Table 2a** lists the clearly defined locations of the maxillofacial fractures related to traumatic intracranial hemorrhage. Of the 26 pan-facial fracture patients, 11 (42.3%) suffered from intracranial hemorrhage. All six cranial vault fractures and all five basal skull fractures had accompanying intracranial hemorrhages, as did five (83.3%) of the six patients with a severe mid-face LeFort-2 or -3 fracture. In the multivariate logistic regression model, pan-facial maxillofacial/jaw fracture (odds ratio (OR) 19.1) was the strongest independent predictor of intracranial bleeding in maxillofacial fracture patients (**Table 3a**). Nevertheless, traumatic intracranial hemorrhages were seen in one simple fracture of the zygoma (7.1%), one of the maxilla (14.3%), two fractures

Table 2. Description and type of intracranial hemorrhage in 17 patients.

a		
Intracranial hemorrhages	17	9.0%
Epidural	1	0.5%
Subdural	7	3.7%
Subarachnoid	9	4.8%
Intracerebral	12	6.4%
Chronic subdural hematoma	2	1.1%
b		
Male	12	
Female	5	
c		
Age range (years)	16-80	
Mean age	49.3	

of the mandible (3.3%), and even two maxillary alveolar fractures (2.5%) (OR 0.16), although these ORs were not significant as independent predictors of the risk for maxillofacial trauma accompanying intracranial bleeding, except for alveolar fractures (**Table 3a**).

As shown in **Table 3b**, 13 (76.5%) of the 17 patients with intracranial hemorrhages had been involved in traffic accidents, which was a significant risk factor (OR 4.06), three were in falls (17.6%), and one was in a workplace accident (5.9%). For these three categories of maxillofacial trauma, the logistic regression model further revealed that by far the most significant risk factor for intracranial hemorrhage was high-energy injuries (OR 50.8).

Overall, four of the 17 intracranial hemorrhage patients (23.5%) needed to undergo emergency neurosurgical decompression by neurosurgeons.

Discussion

High-energy trauma that breaks craniomaxillofacial-facial bones can result in the rupture of intracranial vessels, leading to intracranial hemorrhage in different compartments, as described previously, and as reflected in the incidence of hemorrhages following traffic accidents reported here^{4-6, 9}. The injuries accompanying maxillofacial trauma can be a greater threat to life than the fractures themselves¹⁻³. In addition, a study reported that the presence of an intracranial hemorrhage was associated with a poor survival^{4-6, 10}. Therefore, in our hospital, as soon as we identify an intracranial hemorrhage related to maxillofacial trauma, we con-

Table 3. Independent predictors of intracranial hemorrhage in patients with maxillofacial fractures.

a			%	OR	OR 95% CI	p
Pan-Facial	11 / 26	42.3	19.1	6.18-58.85	<0.0001	
(Cranial vault fracture)	(6) / (6)	(100)				
(Basal skull fracture)	(5) / (5)	(100)				
(LeFort II and/or III)	(5) / (6)	(83.3)				
Zygoma	1 / 14	7.1	0.76	0.09-6.19	>0.9999	
Maxilla	1 / 7	14.3	1.72	0.19-15.18	0.491	
Mandible	2 / 61	3.3	0.26	0.06-1.16	0.099	
Alveolus	2 / 80	2.5	0.16	0.04-0.76	0.009	
b			%	OR	OR 95% CI	p
High-energy injury	15 / 37	40.5	50.8	10.87-237.38	<0.0001	
Traffic accident	13 / 89	14.6	4.06	1.27-12.97	0.0196	
Fall	3 / 57	5.3	0.46	0.13-1.68	0.281	
Working accident	1 / 6	16.7	2.08	0.23-18.87	0.438	

OR: odds ratio, CI: confidence interval

sult with neurosurgeons. Overall, the number of patients requiring neurosurgical decompression of an intracranial hemorrhage was comparatively low and was similar to the number in a previous study^{2-4, 6}. Four patients (23.5% of all intracranial hemorrhage or 2.1% of all 188 maxillofacial fracture patients) underwent neurosurgery for decompression. In most cases, simple clinical signs such as seizures, vomiting, nausea, headache, and a history of a closed head injury suggested an intracranial hemorrhage, and we performed screening head CT. Often, these early considerations allowed us to detect patients at elevated risk for an intracranial hemorrhage. Based on our series and previous similar studies, cranial vault and basal skull fractures are the strongest predictors of intracranial bleeding, as are severe mid-face fractures^{1-3, 6, 11}. A previous study demonstrated that head trauma presenting with facial injuries can sometimes mask traumatic intracranial hemorrhage until clinical deterioration occurs⁴. Therefore, it is crucial to consider traumatic intracranial hemorrhage ensuing from the initial trauma as a possibility, as about 9% of all maxillofacial fracture patients sustain an intracranial hemorrhage requiring immediate neurosurgical intervention, as suggested in this study (Table 2). Moreover, the risk is greater with pan-facial fractures associated with high-energy trauma. This study used a multivariable logistic regression model to verify and identify pan-facial maxillofacial/jaw fractures (OR 19.1) and high-energy injury (OR 50.8) as the strongest independent predictors of intracranial bleeding in facial fractures

patients, which until now was, at best, an empirical, unproven assumption (Table 3).

Surprisingly, our series revealed that trauma causing simple single fractures of the maxilla, zygoma, or even the maxillary alveoli could cause an intracranial hemorrhage (Table 2a). Two patients who had sustained mandibular fractures after falling on asphalt developed intracranial hemorrhages and required close neurological observation in the hospital. This could be, in part, because the tolerance of the mid-face, maxilla, nose, and zygoma to energy forces is lower than that of the frontal and mandibular bones, as reported in a biomechanical study^{6, 11}. Although most of our cases had clinical signs of intracranial hemorrhage, including seizures, vomiting, nausea, and headache, we should carefully observe the maxillofacial fracture patient in hospital, or warn them or their family of the possibility of an intracranial hemorrhage if they prefer to go home against advice.

In the last decade, some clinical studies have identified high-risk findings that clearly indicated which groups of patients with head injuries should undergo head CT¹²⁻¹⁵. They reported a 3 to 19% incidence of a positive head CT in those patient groups, and the need for neurosurgical intervention was 0.08 to 3.3%, similar to our findings^{1, 6, 12-15}. Some clinical reviews have concluded that patients with minor head and facial injuries and a normal neurological examination could be discharged home safely^{14, 16, 17}. Nevertheless, 2.8% of 2,195 craniomaxillofacial fracture pa-

tients with a presenting GCS score of 15 following minor head trauma had an intracranial hemorrhage requiring neurosurgery¹¹. Overall, in patients with a history of loss of conscious or amnesia, but with no nausea, vomiting, headache, dizziness, or signs of depressed skull vault fractures, routine head CT may have a minimal effect on trauma management and may not be warranted¹²⁻¹⁸.

It remains difficult to identify clear indications for routine head CT for screening maxillofacial fracture patients for intracranial hemorrhage. Nevertheless, this study clearly suggested that routine head CT screening be required for maxillofacial trauma patients with high-energy injuries or pan-facial maxillofacial/jaw fractures, as high-risk indicators. Maxillofacial trauma surgeons and the trauma team should consider an intracranial hemorrhage as accompanying maxillofacial fractures from the initial admission and should not neglect a screening examination that includes head CT and neurosurgical consultation, in order to diagnose intracranial hemorrhage immediately. Our goal is to avoid the discharge of a craniomaxillofacial fracture patient, even a patient with a small maxillofacial fracture, from the emergency department, with an undiagnosed intracranial hemorrhage.

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原著論文

顎顔面骨骨折における頭蓋内出血の合併損傷

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要旨 顎顔面外傷においては、頭蓋内損傷を合併することがあり、早期の精査及び診断が予後に直結し重要である。今回我々は、顎顔面骨骨折患者における頭蓋内出血の合併損傷について、そのリスクを *retrospective* に検討を行った。対象は2005年1月から2008年6月までの3年6か月間に香川県立中央病院歯科口腔外科にて加療を行った顎顔面骨骨折を有する188例（男性119名、女性69名、平均年齢40.0歳）について診療録、X線撮影記録を用い評価を行った。合併頭蓋内損傷については脳神経外科にて診断、加療がなされた。17例（9.0%）の顎顔面骨骨折患者に頭蓋内出血の合併を認め、内訳は脳内12例（6.4%）、クモ膜下9例（4.8%）、硬膜下7例（3.7%）、硬膜外1例（0.5%）であった。中顔面骨骨折（LeFort-2/3）、頭蓋骨骨折、頭蓋底骨折においてはリスクが高く、高頻度で頭蓋内出血の合併を来していた。一方、重症度の低い、単独での頬骨骨折、上顎骨骨折、下顎骨骨折や上顎歯槽骨骨折においても頭蓋内出血の合併が認められた。頭蓋内出血を合併した17例中4例（23.5%）において血腫除去術が施行された。とくに顎顔面多発骨骨折（OR 19.1）、高エネルギー外傷（OR 50.8）による顔面外傷に頭蓋内出血を合併するリスクが有意に高く、頭部CT撮影による評価が必須であることが示唆された。したがって、顎顔面外傷治療にあたっては、頭蓋内損傷、頭蓋内出血合併の可能性を考慮し、評価・診断にあたることが重要であると考えられた。

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