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• 원 저 •

안면부 골절과 전산화 단층 촬영으로 진단된 두부 손상의 연관성

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송진우 · 조익준 · 한상국[1] · 정연권

— Abstract —

The Relationship between Facial Fractures and Radiologically-proven Cranial Injuries

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Purpose: In this study, we retrospectively investigated the medical records of patients with facial fractures and suspected cranial injuries in order to determine if there was any relationship between various facial fracture patterns and cranial injuries.

Methods: Medical records were reviewed to identify patients diagnosed with facial fractures who underwent cranial computed tomography (CT) scans. Records were reviewed for gender, age, injury mechanism, facial fracture pattern, and presence or absence of cranial injuries. Facial fracture patterns were classified as isolated fractures (tripod, zygomatic arch, maxilla, orbit, and mandible), combined fractures, or total fractures. Cranial injuries included skull fractures, traumatic subarachnoid hemorrhages, subdural hemorrhages, epidural hemorrhages, and contusional hemorrhages. All cranial injuries were established by using cranial CT scans, and these kinds of cranial injuries were defined radiologically-proven cranial injuries (RPCIs). We evaluated the relationship between each pattern of facial fractures and the incidence of RPCIs.

Results: Of 132 eligible patients with facial fractures who underwent cranial CT scans, a total of 27 (20.5%) patients had RPCIs associated with facial fractures. Falls and slips were the most common causes of the fractures (31.8%), followed by assaults and motor vehicle accidents (MVAs). One hundred one (76.5%) patients had isolated facial fractures, and 31 (23.5%) patients had combined facial fractures. Fractures were found most commonly in the orbital and maxillary bones. Patients with isolated maxillary fractures had a lower incidence of RPCIs than those with total mandibular fractures. RPCIs frequently accompanied combined facial fractures.

Conclusion: Combined facial fractures had a significant positive correlation with RPCIs. This means that facial fractures caused by stronger or multidirectional external force are likely to be accompanied by cranial injuries.

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Key Words: Facial fracture, Cranial injury, Traumatic brain injury, Cranial CT

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I. Introduction

Facial fractures and concomitant injuries have been the focus of numerous investigations over the past three decades.(1-6) Because the facial bones are proximate and contiguous with the cranium, there have been a substantial number of studies on the relationship between facial fractures and cranial injuries.(7-13) Traditionally, it was thought that the facial architecture protects the neurocranium from injury by acting as a cushion against impact.(4,14,15) However, some more recent studies have challenged this assumption by suggesting that the face may actually transmit forces directly to the neurocranium, resulting in more serious brain injury.(9-12) The precise mechanism of this force transfer has not yet been elucidated. There are a few studies on the relationship between each pattern of facial fractures and cranial injuries. In this study, we sought to determine the relationship between facial fractures and radiologically-proven cranial injuries (RPCIs).

II. Materials and Methods

During a two-year period between May 1, 2005, and April 30, 2007, a total of 494 patients with facial fractures presented to the emergency department at Samsung Medical Center, a tertiary teaching hospital located in an urban area. Among this group, 204 patients underwent cranial computed tomography (CT) scans for suspected cranial injuries. Facial fractures were established by radiologist interpretation of facial bone CT scans. From these 204 eligible patients, individuals who had isolated nasal bone fractures, isolated alveolar fractures, or incomplete medical records were excluded from our study.(7,13) One hundred thirty-two patients were eventually enrolled in the current

Table 1. Demographic characteristics of the patients

	Total	RPCI-positive group*	RPCI-negative group†
Mean age (year)	36.0 ± 19.5	32.0 ± 18.5	37.0 ± 19.7
Gender			
No. of male	100	22	78
No. of female	32	5	27
Male/Female	3.1	4.4	2.9
No. of patient	132	27	105

* RPCI-positive group, the group of facial fracture with radiologically-proven head injuries; †RPCI-negative group, the group of facial fracture without radiologically-proven head injuries.

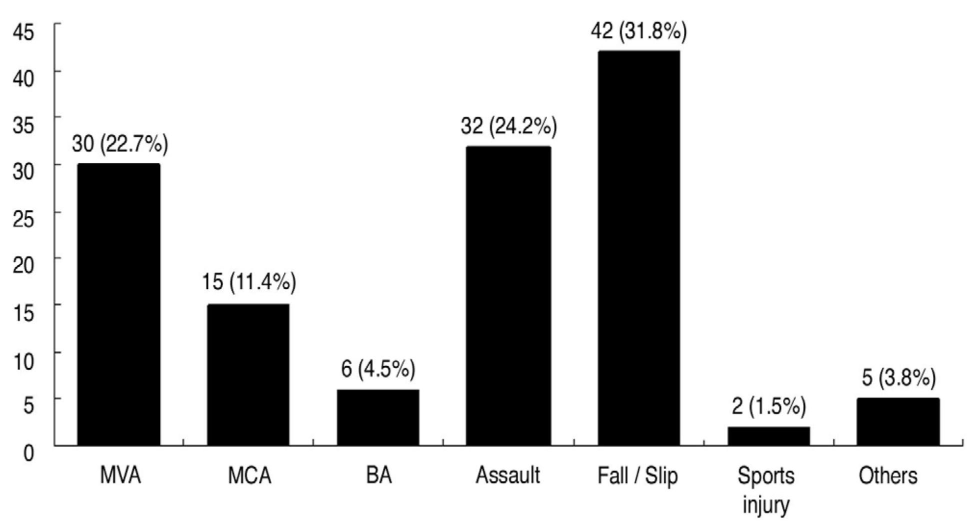

Fig. 1. Distribution of injury mechanism
MVA, motor vehicle accident; MCA, motorcycle accident; BA, bicycle accident.

study (100 men, 32 women; M:F ratio 3.1:1). This study was approved by the institutional review board.

We reviewed the medical records of each patient to establish gender, age, injury mechanism, facial fracture pattern, and presence or absence of cranial injuries. Injury mechanisms were classified into motor vehicle accidents (MVAs), motorcycle accidents (MCAs), bicycle accidents, assault injuries, falls and slips, sports injuries, and other injuries. One emergency physician classified the various patterns of facial fractures based on the descriptions made by the radiologists.

Facial fracture patterns were primarily divided into isolated fractures and combined fractures. Fractures were considered 'isolated' when only one facial bone was involved and considered 'combined' when two or more facial bones were involved. Isolated facial fractures were further classified as tripod, zygomatic arch, maxillary, orbital, or mandibular fractures. Combined facial fractures were largely divided into two-part and three-part facial fractures. Then, total facial fractures were compiled by isolated facial fractures and each facial fracture composing of combined facial fractures.

Cranial injuries included skull fractures, traumatic subarachnoid hemorrhages, subdural hemorrhages, epidural hemorrhages, and contusional hemorrhages. All cranial injuries were established by cranial CT scans interpreted by radiologists, we defined these cranial injuries as RPCI. In order to evaluate the relationship between facial fractures and RPCIs, an analysis was made between each facial fracture pattern and the incidence of RPCIs.

Data were analyzed using the SPSS version 10.0 statistical software package (SPSS, Inc, Chicago, IL, USA). Student t-test was used to analyze continuous variables, and Fisher's exact test was used to analyze categorical data. Mantel-Haenszel's common odds ratio estimate was also used to analyze categorical data. Statistical significance was set a priori as a p value <0.05 (two-sided).

III. Results

A total of 132 patients were enrolled during the two-year study period. Twenty-seven (20.5%) of these patients had RPCIs associated with facial fractures (RPCI-positive group). Twenty-two of these patients were men (Table 1).

Falls and slips were the most common causes of injury (31.8%), followed by assault (24.2%), MVA (22.7%), MCA (11.4%), bicycle accident (4.5%), and sports injury (1.5%) (Fig. 1). Analysis of the relationship between injury mechanism and RPCIs showed that assault-induced facial fractures had a significant negative association with RPCI ($p=0.000$) (Table 2).

There were 101 isolated and 31 combined facial fractures (Table 3). In the isolated facial fracture group, orbital bone fracture (31.8%) was the most common pattern of facial fracture, followed by maxillary (22.7%), tripod (13.6%), mandibular (7.6%), and zygomatic arch fractures (0.8%). There were 28 two-part facial fractures and 3 three-part facial fractures. With each combined facial fracture case being regarded as a single facial fracture, there were a total of 166 facial fractures in 132 patients. Of these, orbital fractures were the most common kind, followed by maxillary, tripod, mandibular, and zygomatic arch fractures.

Combined facial fractures had a significant positive association with RPCIs ($p=0.000$; OR = 6.95; 95% CI 2.75 to 17.57). Isolated maxillary fractures had a significant negative association with RPCIs ($p=0.008$; OR=0.10; 95% CI 0.01 to 0.78). Mandibular fractures had a significant positive association with RPCIs ($p=0.008$; OR=4.49; 95% CI 1.54 to 13.12).

Table 2. Relationship between injury mechanism and radiologically-proven head injury

Injury mechanism	Number of cases			Common odds ratio (95% CI†)	p-value
	Total	RPCI (+)*	RPCI (-)†		
Motor vehicle accidents	30	9	21	2.00 (0.79~5.08)	0.196
Motorcycle accidents	15	4	11	1.49 (0.43~5.09)	0.507
Bicycle accidents	6	1	5	0.77 (0.09~6.87)	1.000
Assault	32	0	32	-	0.000
Fall or slip injuries	42	10	32	1.34 (0.55~3.25)	0.499
Sports injuries	2	1	1	4.00 (0.24~66.10)	0.368
Other injuries	5	2	3	2.72 (0.43~17.16)	0.271

* RPCI (+), facial fracture with radiologically-proven head injuries; †RPCI (-), facial fracture without radiologically-proven head injuries; †CI, confidence interval.

IV. Discussion

We were principally interested in the relationship between facial fractures and RPCIs. To this end, we found that isolated maxillary fractures had a significant negative association with RPCIs, but total maxillary fractures showed no such relationship. Total mandibular fractures were associated with a higher incidence of cranial injury. Combined facial fractures were associated with a higher incidence of RPCIs. Haug et al.(9) reported that mandible fractures were the fracture type most frequently associated with closed head injuries and that isolated maxillary fractures were least frequently associated with closed head injuries. Lee et al.(15) found that combined facial fractures were not associated with skull fractures, intracranial hemorrhage, scalp laceration, or concussion. When excluding scalp laceration and concussion, we found that combined facial fractures had a significant association with a higher incidence of cranial injuries.

Although there is wide variation in human tolerance to facial fractures, Hampson,(17) in an extensive review of published data on the pressures of facial fractures, showed a wide range in the energy levels necessary to fracture specific bones of the face. According to the review, pressure tolerance is lowest in the nasal bone, followed by the maxillary bone, zygomatic arch, and zygomatic bone; the strongest bone is the mandible. This pattern may explain our findings in isolated maxillary and total mandibular fractures.

The power of the external force is the most important consideration in assessing facial bone fractures and the impact on the neurocranium. However, multiple origins of injury and potentially significant confounding variables make accurate assessment of the association between traumatic head injury and facial fractures difficult.(11) Some authors have found that the type of craniofacial injury resulting from a MVA depends on the following: force and direction of the collision, impact interface geometry (shape and texture of opposing surface), and energy-absorbing characteristics of the opposing objects.(18,19) Of all the factors that influence craniofacial injuries, force and direction of collision seem to be most important. We should take these factors into consideration when analyzing data related to craniofacial injuries.

Generally, in our study, combined facial fractures were induced through relatively strong and/or multidirectional external force rather than by relatively weak and/or unidirectional force. Combined facial fractures were frequently accompanied by RPCIs. This finding implies that facial fractures caused by stronger external and/or multidirectional force are prone to be accompanied by cranial injuries.

In an ideal scenario, all patients with facial fractures would have undergone cranial CT scans, and we could have obtained more reliable results on the relationship between facial fractures and cranial injuries. However, this was not practical. The study pool did not include all of the patients with facial fractures, but did include those who

Table 3. Relationship between facial fracture and radiologically-proven head injury

Combined and isolated facial fractures	Total	Number of cases RPCI (+)*	RPCI (-)†	Common odds ratio (95% CI‡)	*p* value
Combined facial fractures	31	15	16	6.95 (2.75~17.57)	0.000
Isolated tripod fractures	18	2	6	0.45 (0.10~2.07)	0.364
Isolated zygomatic arch fractures	1	0	1	-	1.000
Isolated maxillary fractures	30	1	29	0.10 (0.01~0.78)	0.008
Isolated orbital fractures	42	7	35	0.70 (0.27~1.81)	0.644
Isolated mandibular fractures	10	2	8	0.97 (0.19~4.86)	1.000
Total facial fractures	**Total**	**No. of cases RPCI (+)**	**RPCI (-)**	**Common odds ratio (95% CI)**	***p* value**
Total tripod fractures	30	7	23	1.25 (0.47~3.32)	0.618
Total zygomatic arch fractures	11	4	7	2.44 (0.66~9.02)	0.235
Total maxillary fractures	48	11	37	1.26 (0.53~3.00)	0.656
Total orbital fractures	60	15	45	1.67 (0.71~3.91)	0.281
Total mandibular fractures	17	8	9	4.49 (1.54~13.12)	0.008

* RPCI (+), facial fracture with radiologically-proven head injuries; †RPCI (-), facial fracture without radiologically-proven head injuries; ‡CI, confidence interval.

had facial fractures and simultaneously underwent cranial CT scans for suspected cranial injuries. Although this focused sampling may have limited the study, we believe the setting was more clinically realistic.

In most previous studies, loss of consciousness (LOC) and scalp laceration have been included under the heading of cranial injuries.(3,6,8,9,11-13,15) LOC is often seen by physicians as suggestive of cranial injuries. However, LOC is a very subjective symptom, and some studies have failed to established it as a predictor of traumatic brain injury.(20,21) Moreover, the scalp is easily lacerated by weak forces that seldom impact the neurocranium, and scalp lacerations are not difficult to detect. We felt that cranial injuries of practical importance are those demonstrated by imaging studies, and we excluded LOC and scalp lacerations.(14)

MVA and assault have previously been reported to be the two most common causes of facial fractures.(3,8-10,14,22) In contrast, our study showed that falls and slips were the most common causes, followed by assault and MVA. This finding may be affected by demographic factors such as geographic region, socioeconomic status, era in time, and type of facility.(3,16) In the analysis of the relationship between injury mechanism and RPCIs, facial fractures due to assault did not tend to be accompanied by RPCIs. Some authors found that victims of MVAs sustained more severe injuries compared to those involved in blunt assault.(9,23) We felt this finding suggested that a relatively weak external force could break facial bones, but not induce cranial injuries. However, this study was not carried out on all of the patients with facial fractures. Further studies based on injury mechanism are capable of verifying this hypothesis.

The most common facial fracture pattern was orbital fracture, followed by maxillary fracture and tripod fracture, in both the isolated and total facial fracture groups. The orbital rim and zygoma are the most pronounced areas of the face besides the nose, and are most susceptible to injury by external force. Orbital fractures and tripod fractures with zygomatic arch fractures are frequently caused by falls and slips and assault.(24,25) Of the 11 cases of total zygomatic arch fractures seen in this study, an isolated zygomatic arch fracture was seen in just 1 case; 10 cases were zygomatic arch fractures composed of combined facial fractures. This finding implies that cranial CT scans were seldom performed on patients with isolated zygomatic arch fractures. In other words, when isolated zygomatic arch fractures were present, the physicians had a lower suspicion of concomitant cranial injuries.

V. Conclusion

This study shows that combined facial fractures have a significant positive association with RPCIs. Therefore, cranial injuries should be highly suspected when facial fractures are caused by stronger or multidirectional external force. Isolated maxillary fractures are seldom accompanied by RPCIs. Total mandibular fractures tend to be accompanied by RPCIs.

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