

Clinical Article

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Posttraumatic Anosmia and Ageusia : Incidence and Recovery with Relevance to the Hemorrhage and Fracture on the Frontal Base

Objective : We studied whether frontal skull base fracture has an impact on the occurrence and recovery of anosmia and/or ageusia following frontal traumatic brain injury (TBI).

Methods : Between May 2003 and April 2005, 102 consecutive patients who had hemorrhage or contusion on the frontal lobe base were conservatively treated. Relevant clinical and radiographic data were collected, and assessment of impaired smell and taste sensation were also surveyed up to at least 12 months post-injury.

Results : Among 102 patients, anosmia was noted in 22 (21.6%), of whom 10 had ageusia at a mean 4.4 days after trauma. Bilateral frontal lobe injuries were noted in 20 of 22 patients with anosmia and in all 10 patients with ageusia. Frontal skull base fracture was noted in 41 patients, of whom 9 (21.4%) had anosmia and 4 (9.5%) had ageusia. There was no statistical difference in the occurrence of anosmia and ageusia between patients with or without fracture. Of the 22 patients with anosmia, recovery from anosmia occurred in nine (40.9%) at the interval of 6 to 24 months after trauma, of whom six had frontal skull base fracture and three were not associated with fracture. Recovery of anosmia was significantly higher in patients without fracture than those with fracture ($p < 0.05$). Recovery from ageusia occurred in only two of 10 patients at the interval of 18 to 20 months after trauma and was not eminent in patients without fracture.

Conclusion : One should be alert and seek possible occurrence of the anosmia and/or ageusia following frontal TBI. It is suggested that recovery is quite less likely if such patients have fractures on the frontal base, and these patients should wait for at least 6 to 18 months to anticipate such recovery if there is no injury to the central olfactory structures.

KEY WORDS : Ageusia · Anosmia · Fracture · Frontal base · Hemorrhage · Traumatic brain injury (TBI).

INTRODUCTION

In contrast to the visual, hearing and tactile senses, smell and taste senses are exclusively mediated through chemical substrate that can be seldom accurately assessed by quantitative measures²⁰. For this reason, loss of both smell (anosmia) and taste (ageusia) are likely to be underestimated and overlooked as important neurological sequelae following traumatic brain injury (TBI). According to the guideline of the American Medical Association, a person with complete bilateral loss of either sense is endowed at best 3% of impairment and the prognosis is important only in patients for occupational and social consideration².

In reality, a survey by the National Institute on Deafness and Other Communication Disorders indicated that more than 2.7 million adults in the United States, 1.4% of the whole population have chronic olfactory impairment and 1.1 million, 0.6% of the entire population complain a gustatory problem⁸. These losses result from various conditions including head injury, neoplasm, medications, toxic exposure, upper respiratory tract infection, surgical trauma and congenital defects^{4,6,7,17,18}. Despite the relatively high prevalence, there is a lack of public awareness regarding this problem especially in neurosurgical field of practice.

It is reported that patients with persistent olfactory impairment are also known to have a higher level of disability and lower quality of life than those without such compromise¹³. Furthermore, these patients are reported to have a higher prevalence of mild-to-severe depression than being found in the general population²². The purpose of this study is to validate the impact of fracture on the frontal base on the occurrence and recovery of the anosmia and/or ageusia following TBI. In doing so, it is hope to provide a reasonable basis to predict

• Received : December 7, 2006
 • Accepted : June 25, 2007
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outcome when discussing with the patients and their family members or surrogates.

MATERIALS AND METHODS

Data collection

Between May 2003 to April 2005, 121 consecutive patients were admitted to our department for treatment of frontal TBI. All patients had radiographic evidences of contusion or hemorrhage on the frontal lobe base. These patients were selected on the basis of the neurosurgical diagnosis as a main diagnostic code at the time of hospital discharge (ICD-10; International Disease Classification-10). These one-hundred and twenty-one patients represent 32.4% of total 373 patients with TBI being admitted during the same period. Among 121 patients, 19 were excluded from this study for the following reasons: 1) loss of follow-up due to transfer to other hospital (n=10); 2) in-hospital mortality due to grave condition or significant interim medical complications (n=7); or 3) inability to comprehend simple diagnostic command due to severe dementia (n=2). Therefore, 102 patients were enrolled in the current study.

This retrospective investigation was conducted to collect pertinent clinical data (sex, age, cause of injury, associated conditions, Glasgow coma scale (GCS)¹⁹⁾ score on admission and discharge, recovery of anosmia and ageusia, and follow-up period) by medical charts, radiographic images and consult sheets to the other departments including otorhinology, reconstructive surgery and ophthalmology. Patient's diagnosis was based on plain x-rays and computed tomographic (CT) findings of the brain and skull including facial bones. All patients had high-density lesions in the base of frontal lobe with the Hounsfield unit (HU) of 50-100 on the initial CT scans. Fracture line was detected by plain skull and facial x-rays, facial CT, or brain CT scan with bone-window setting. If there was pneumocephalus on the frontal pole on the CT scan, it was also regarded as having a basal skull fracture. The fracture was seen as a linear line crossing frontal sinus, medial or superior orbital wall in the x-rays or line traversing the anterior cranial fossa including cribriform plate, sphenoid bone, and ethmoid or sphenoid sinus in the CT scan. Pure fracture on the frontal vault remote to the skull base were not included.

Assessment of anosmia or ageusia

Impairment of smell or taste was initially detected by neurosurgical resident only after the patient was fully awakened. These impairments were consecutively assessed by rhinology specialists during their follow-up periods. Patients visited the outpatient clinic up to at least 12 months

post-injury and this surveillance period was sometimes lengthened up to 24 months post-injury by direct patient visit or telephone questionnaire. In our institute, T&T Olfactometer (Takasago International Co, Tokyo, Japan) was used to detect and assess the degree of anosmia. The patients were asked to assign a score ranging from 0 to 2 regarding their residual posttraumatic taste and olfactory abilities. On the assessment scale, based on the work by van Damme and Freihofer²⁰⁾, a score of 0 is equal to absent taste and smell, 1 corresponds to reduced sensitivity, and 2 indicates complete or unmodified sensitivity when compared to the premorbid state.

Statistical analysis

The relation between occurrence of anosmia/ageusia and presence of fracture were studied statistically. Recovery rates of such impairments were also considered depending on presence of fracture. Statistical significance was calculated with commercially available software (SPSS 10, Chicago, IL) by Fisher's exact test. And, it was considered significant when p-value being less than 0.05.

RESULTS

Demographic data

Among the 102 patients who had parenchymal hemorrhage or contusion on the frontal base, 22 (21.6%) showed anosmia, and 10 (9.8%) exhibited ageusia. All patients with ageusia also had anosmia at the initial evaluation. Table 1 shows clinical characteristics of these 22 patients. The mean age in the 19 men and 3 women was 44.5 years (range 11 to 81 years). Traffic accident was the most common cause of the injury, followed by fall-down injury and assault. Patients were found to have such complaints at mean 4.5 days post-injury (range 1 to 10 days) and this is mostly attributed to difficulty in initial evaluation of the anosmia. The mean initial GCS was 13.5 (range from 9 to 15), but all patients discharged from hospital with mean GCS of 14.5. The mean follow-up period was 19.5 months post-injury (ranges from 12 to 28 months). Ten patients had associated diseases during their hospital stay. One patient suffered from optic neuropathy that did not resolve, and another one patient complained of diplopia that was improved at 12 months post-injury. There were 2 patients with cerebrospinal fluid (CSF) leakage from the nose and both of them had fractures on the frontal base (Table 1).

Radiologic findings

Table 1 shows that 20 out of 22 patients with anosmia and all 10 patients with ageusia have bilateral hemorrhage

Table 1. Clinical summary of 22 patients with posttraumatic anosmia and/or ageusia*

No	Sex/Age	Hemorrhage	Fracture	Anosmia	Ageusia	GCS		Cause of injury	Associated condition	Recovery from anosmia(Mo)	Recovery from ageusia (Mo)	F/U (Mo)
				(HD)	(HD)	Adm	D/C					
1	M/81	Bilateral	+	+ (1)	+ (1)	15	15	TA	Optic neuropathy	-	-	18
2	M/27	Bilateral	+	+ (3)	+ (3)	15	15	TA		+ (12)	+ (18)	18
3	M/35	Bilateral	+	+ (3)	+ (3)	14	14	assault	CSF rhinorrhea	-	-	24
4	M/38	Bilateral	-	+ (5)	+ (5)	14	15	fall-down		+ (12)	+ (20)	20
5	M/42	Bilateral	+	+ (8)	+ (8)	12	14	TA	Occipital H	-	-	18
6	F/55	Bilateral	-	+ (7)	+ (7)	14	15	assault		-	-	28
7	M/62	Bilateral	+	+ (4)	+ (5)	15	15	TA	Temporo-occipital H	-	-	22
8	M/70	Bilateral	-	+ (5)	+ (5)	13	14	TA	Parieto-occipital H	+ (24)	-	24
9	M/43	Bilateral	+	+ (2)	+ (2)	14	14	TA	CSF rhinorrhea	-	-	19
10	M/59	Bilateral	-	+ (3)	+ (5)	12	14	fall-down		-	-	26
11	M/11	Bilateral	-	+ (2)	-	13	14	fall-down	Diplopia	+ (24)	-	24
12	M/73	Bilateral	+	+ (1)	-	14	15	assault		-	-	17
13	M/56	Bilateral	-	+ (5)	-	15	15	TA		+ (6)	-	12
14	F/47	Bilateral	+	+ (7)	-	13	14	TA	Occipital H	+ (6)	-	12
15	M/36	Unilateral	-	+ (10)	-	9	14	assault		-	-	20
16	F/18	Bilateral	+	+ (7)	-	12	14	fall-down	Temporal H	+ (24)	-	24
17	M/22	Bilateral	+	+ (8)	-	13	15	TA		-	-	16
18	M/49	Unilateral	-	+ (5)	-	14	15	TA		+ (6)	-	12
19	M/65	Bilateral	+	+ (3)	-	15	15	fall-down		-	-	15
20	M/31	Bilateral	+	+ (5)	-	13	15	fall-down	C-spine injury	-	-	20
21	M/19	Bilateral	-	+ (4)	-	14	14	TA		+ (24)	-	24
22	M/40	Bilateral	+	+ (5)	-	14	14	TA		-	-	15

*M : male, F : female, HD : hospital day at which symptom appeared, GCS : Glasgow coma scale, CSF : cerebrospinal fluid, Mo : post-injury month in which symptom resolved, F/U : follow-up, Adm : at admission, D/C : at discharge, TA : traffic accident, H : hemorrhage, C-spine : cervical spine

Table 2. Incidence of posttraumatic amnesia and ageusia according to frontal skull base fracture in 102 patients who had contusion or hemorrhage on frontal lobe base

Symptom	Frontal skull base fracture		Total
	Present (%)	Absent (%)	
Absent	32 (40.0)	48 (60.0)	80
Anosmia	9 (40.9)	13 (59.1)	22
Ageusia*	4 (40.0)	6 (60.0)	10

*Among the 22 patients with anosmia, 10 had also ageusia. Thus, total number of patients is over 102 patients

on the initial CT scans. With regards to fracture, 13 out of 22 patients (59.1%) with anosmia had such bony disruption and 6 among 10 patients (60%) with ageusia shows fracture on the basis of X-ray and CT scan.

Recovery of anosmia or ageusia

There was no statistical difference in occurrence of post-traumatic anosmia and ageusia between patients with fracture and those without fracture (Table 2). However, when recovery from anosmia was considered, 6 patients without fracture showed recovery (66.7%) while only 3 patients with fracture showed such recovery (23.1%) ($p < 0.05$) (Table 3). On the contrary to the anosmia, only 2 patients with ageusia showed recovery of lost sensation. There was no difference between two groups with and without fracture (Table 3).

In this study, recovery from anosmia was found among

9 out of 22 patients during at least 6 months post-injury. Three patients showed recovery from anosmia within 6 months, 2 patients within 12 months, and 4 patients within 24 months post-injury. However, recovery from ageusia was more delayed comparing with that of anosmia, and 2 patients with ageusia showed recovery within 24 months post-injury (Table 4).

DISCUSSION

The prevalence of posttraumatic anosmia ranges from 24% to 30% among patients who have sustained severe TBI, 15% to 19% among those with moderate TBI, and 0% to 16% among patients with mild TBI⁵. In overall, about 5% of all patients admitted to hospital with a TBI is known to have anosmia¹⁰. The precise cause and mechanism is not clearly uncovered yet. However, shearing injuries at the cribriform plate that lacerate the primary olfactory nerves extending from the nasal cavity to the olfactory bulb seem to be the most common mechanism involved in posttraumatic smell loss^{12,14}. Yousem et al.²³ estimated that the injury sites were olfactory bulb and tract (88%), subfrontal region (60%), and temporal lobes (32%) in 24 patients with posttraumatic olfactory dysfunction using by magnetic resonance image (MRI). Decrease in volume and size of the olfactory bulb

Table 3. Recovery rate according to frontal skull base fracture in 22 patients who had posttraumatic anosmia and in 10 patients who had ageusia

Frontal skull base fracture	Recovery from anosmia*		Recovery from ageusia	
	Yes (%)	No (%)	Yes (%)	No (%)
Present	3 (33.3)	10 (76.9)	1 (50)	5 (62.5)
Absent	6 (66.7)	3 (23.1)	1 (50)	3 (37.5)
Total	9	13	2	8

*When frontal skull base fracture is absent, the opportunity of recovery from anosmia is statistically higher ($p < 0.05$ by Fisher's exact test)

Table 4. Time interval between recovery of anosmia/ageusia and onset of fracture

Time interval (months)	Number of patients	
	Anosmia	Ageusia
0-6	3	0
6.1-12	2	0
12.1-24	4	2
Total	9	2

was also reported in anosmia patients by using MRI¹¹. Our study has major limitation in utilizing MRI only in a restricted number of patients to prove such anatomical details. Posttraumatic gustatory dysfunction is even rarer than olfactory dysfunction, but may occur as a result of direct injury to the tongue, injury to cranial nerves VII or IX, or brain contusion or hemorrhage¹⁵.

Recovery of olfactory function after head trauma is not consistent. Most large series report a return of olfactory function in 15% to 50% of patients who were initially anosmic, depending how carefully the deficit was sought. They asserted that such recovery after 3 months is rare^{10,21}. Olfactory neurons have the capacity for neurogenesis, allowing new receptor growth, so it is surmised that the late return of function may be related to a peripheral mechanism such as olfactory nerves, bulbs or tracts rather than a more central one including septal nuclei and rhinencephalon³. In humans, it is believed that there may be fibrotic scarring at the cribriform plate that may prevent regeneration of axons from connecting to the secondary neurons of the olfactory bulb⁹. In our study, recovery of anosmia has taken place at least 6 months after TBI and this is much later than those of previous reports. We presume that recovery from the posttraumatic anosmia is possible albeit quite late, when the injury is confined to the peripheral sites such as olfactory bulb or orbitofrontal cortex without involvement of more central locations.

With regard to the fracture, Renzi G et al.¹⁶ reported that hyposmia or anosmia was found in 19 among 86 patients with facial fractures (nosozygomatic-Le Fort fractures, fronto-orbital fractures, and pure Le Fort fractures). And, hypogeusia or ageusia was discovered in 21 among 86 patients with such fractures. van Damme and Freihofer²⁰ also reported

on impairment of smell and taste after 109 patients with high central mid-facial fractures. They found post-traumatic smell impairment in 41 patients (38%), posttraumatic taste deficit in 25 patients (23%) and simultaneous impairment in 23 patients (21%). The above incidence is far

from that of the present study, and this discrepancy in incidence is deemed the result of excluding such patients with midfacial fractures who had been surgically treated in our study.

In the current study, we encountered 2 patients with CSF leakage from the nose. And, these two patients had simultaneous anosmia and ageusia that haven't been recovered until the latest follow-up period of 24 months post-injury. It is not certain whether this leakage involved rather serious injury or not, nevertheless we tentatively concluded that such leakage has adverse impact on the recovery of the anosmia and ageusia. Risk factors for the anosmia are reported to be anterior skull base fractures, bilateral subfrontal lobe injury, dural lacerations, and CSF leakage¹⁰. About 50% of patients with anterior cranial fossa fracture are known to have anosmia and 80% of patients have persistent anosmia who sustained surgical procedure for the CSF leakage¹¹. To obtain a statistically proven evidence of correlation between CSF rhinorrhea and anosmia, a large cohort study should be conducted.

In most instances, initial discovery of such deficits is delayed for several days. It is likely to give little attention to this sort of neurological sequelae than any other serious ones such as mental deterioration, motor weakness, infection, etc. Accordingly, it is possible to miss the impairments unless we have a high index of suspicion when encountering similar group of patients with TBI. Early detection by prompt consulting to corresponding department and discussing outcome with patient in an evidence-based attitude will prevent future annoyance, because there has been no established therapy up until present time.

CONCLUSION

One should be alert to potential occurrence of the anosmia and ageusia following frontal TBI although there is no proven management. Once identified, we can tell that recovery is less likely if such patients have fractures on the frontal base. Recovery from anosmia is required for at least 6 to 24 months when there is no injury to the central olfactory structures, whereas recovery of ageusia is barely anticipated when compared with that of anosmia.

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COMMENTARY

The authors have evaluated the impact of frontal skull base fracture on the occurrence and recovery of anosmia

and/or ageusia in the patients who had hemorrhage or contusion in the frontal lobe base. In this study, anosmia and ageusia occurred in 21.6% and 9.8%, respectively. Bilateral frontal lobe injuries were noted in 91% of the patients with anosmia and in 100% of those with ageusia. Among the patients who had skull fractures, anosmia and ageusia were noted in 21.4% and 9.5%, respectively. Of 22 patients who had anosmia, 9 (40.9%) showed recovery at the interval of 6 to 24 months, of whom 3 had skull fracture and 6 did not have it. The authors suggest that recovery from anosmia is poor in patients who had frontal skull base fracture.

The mechanisms for anosmia and ageusia are different each other. Particularly, mechanism for ageusia include tongue injury, cranial nerve VII, IX, or X damage, and brainstem or cortical contusion or hemorrhage. Thus, temporal bone fracture and associated facial nerve injury can result in taste loss. In addition, strong evidence link head and facial injuries with posttraumatic anosmia¹⁾. In this paper, it seems to be interesting that frontal skull base fracture is considered as the factor of the poor recovery from anosmia. However, both anosmia and ageusia are more common with increasing severity of injury. Moreover, anosmia usually occur due to damage to the olfactory apparatus, olfactory nerve filament shearing or tearing, and intracranial hemorrhage or contusion in the olfactory brain regions¹⁾. In this paper, there is no patient who had only ageusia. Among the patients who had anosmia, 45% have associated with ageusia. How to affect frontal skull base fracture on ageusia ? It may be related to the injury severity. Thus, to investigate the impact of frontal skull base fracture on the occurrence and recovery of anosmia and/or ageusia, anatomical information for frontobasal contusion or hemorrhage should be precisely given through the radiological imaging technique. In addition, frontal skull base fractures should be classified. Even though this article can be considered to be important due to the disability evaluation and medicolegal problems, methodological problems are still remained.

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