Differences in clinical characteristics of head injuries to snowboarders by skill level: differences between beginners and intermediates or experts from a prospective analysis of 2367 patients during nine seasons from 1999/2000 to 2007/2008

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ABSTRACT

Objective: Many reports have compared head injuries between snowboarding and skiing. However, detailed studies comparing snowboarding head injuries between beginners and intermediates/experts have been lacking. We investigated differences in clinical characteristics of head injuries to snowboarders between beginners (Group B) and intermediates/experts (Group IE).

Methods: Subjects in this cross-sectional study comprised 2367 patients treated at Saito Memorial Hospital and Yuzawa Community Health Medical Center, Niigata Prefecture, Japan, during 9 seasons from 1999/2000 to 2007/2008.

Results: Group B comprised 959 patients (mean age, 23.0 years; 52% males). Group IE comprised 1408 patients (mean age, 24.8 years; 72% males). Accidents in Group B predominantly occurred as falls on gentle slopes (37%) and intermediate slopes (33%), whereas accidents in Group IE occurred mostly during jumping (48%). Impact point on the head was predominantly occipital in both groups, but Group IE showed a significantly higher frequency of trauma to the frontal region. The ratio of neurological abnormalities was significantly higher in Group IE, but the ratio of surgical cases was significantly higher in Group B (n=10, 1.04%) than in Group IE (n=5, 0.36%). Many more acute subdural hematomas were seen in Group B, and more fractures, contusions and acute epidural hematomas were seen in Group IE. Two beginners and 1 expert died during this study.

Conclusions: Our data suggest significant differences in clinical states between beginners and intermediates/experts. Preventive methods for severe head injuries among snowboarders need to be devised based on differences in skill levels.

Key Terms: beginner; expert; head injury; intermediate; snowboarding

INTRODUCTION

Snowboarding, first introduced to Japan in the latter 1970s, was initially banned by many ski resorts. However, the popularity of snowboarding boomed in the 1990s, and the number of ski resorts with terrain parks equipped with kickers, rails and half pipes subsequently increased.

At the same time, head injuries sustained by snowboarders first began to be reported from the 1990s, and studies comparing snowboarding and snow skiing have documented that the incidence of head injuries is 1.5-5 times higher for snowboarding[1-5]. Since both feet are fixed to a single board, stability in the anteroposterior direction is poor, and snowboarders are more likely to sustain blows to the occipital regions[1,6]. Snowboarding injuries are more likely to be complicated by acute subdural hematoma, representing a common cause of death[3]. Beginners tend to fall on beginner slopes, while intermediates sustain injuries by jumping[7], although no previous studies have targeted this issue. The present prospective study compared and investigated differences in clinical characteristics, such as type, frequency and severity of head injury, and situations surrounding head injury in snowboarders between beginners (Group B) and intermediates/experts (Group IE). Based on the results, characteristics of severe head injury in each group were described in the hope of devising methods for accident prevention.

SUBJECTS AND METHODS

Of 2,487 snowboarders with head injuries who were examined in the Department of Neurosurgery at Saito Memorial Hospital and Yuzawa Community Health Medical Center, (Niigata Prefecture, Japan) over 9 seasons from 1999/2000 to 2007/2008, a total of 120 patients were excluded because their skill levels were unknown. Subjects thus comprised 2,367 patients. When these patients were examined, patients or their friends or companions were asked to complete a questionnaire, and through these and interviews conducted by primary physicians,

patients were assigned to Group B or Group IE. Groups were compared in terms of patient composition, skill level, slope angle, cause of injury, location of head injury, neurological findings, imaging findings, surgery and outcomes. For statistical analyses, a χ^2 test was conducted with the level of significance set at $p<0.05$.

The hospital is located in the northern region of the Jyoetsu line ski area and is the only hospital in the area that can perform neurosurgery. The Jyoetsu line ski area is close to the Tokyo Metropolitan Area and is one of the most famous ski areas in Japan. An area with a south-north distance of 50 km contains 30 ski resorts, including Naeba, Kandatsu, Iwahara, Ishiuchi Maruyama and Hakkaisan. At present, about 4.5 million skiers and snowboarders visit the area each season.

RESULTS

1. Composition

Of the 2,367 patients, 959 patients were beginners and 1,408 patients were intermediates/experts. The number of patients peaked in the 2001/2002 season and then decreased thereafter for both Group B and Group IE (Fig. 1). Compared to the 2001/2002 season, numbers in the 2006/2007 season had decreased to less than half in Group B and to less than one-third in Group IE.

The male to female ratio was 52% male (male:female = 497:462) for Group B and 72% male (male:female = 1016:392) for Group IE, representing a significant difference ($p<0.01$).

2. Situation surrounding and cause of injury

For Group B, gentle slopes accounted for 37% and intermediate slopes accounted for 33%, totaling 70%. For Group IE, jump-related injury was the most common, at 48%. In both

parameters, significant differences existed between groups ($p<0.01$) (Fig. 2).

As for causes, falls accounted for 67% in Group B, while jumps accounted for 48% in Group IE (Fig. 3). In Group IE, colliding with obstacles accounted for 2.64%.

3. Location of injury

Locations of injury were categorized as frontal (including the face), temporal, parietal, occipital or unknown. For Group B, the breakdown was 14.8%, 7.5%, 2.4%, 56.2% and 19.1%, respectively, compared to 21.9%, 7.9%, 3.7%, 43.9% and 22.7%, respectively, for Group IE. In both groups, the occipital region was the most common location of injury. Injuries to the frontal region were significantly more common in Group IE than in Group B ($p<0.01$).

4. Neurological findings

Traumatic amnesia and loss of consciousness accounted for about 24% and 11%, respectively, in Group B, and for about 34% and 16%, respectively, in Group IE. These conditions were thus significantly more frequent in Group IE ($p<0.01$) (Fig. 4). Neurological severity of injury was higher for Group IE.

5. Severe head injury

Patients with abnormal radiological findings

For Group B, acute subdural hematoma was the most common (n=29, 53%), and most patients (n=28) did not have concurrent cerebral contusion. One patient showed acute subdural hematoma after falling on a slope despite wearing a hard helmet. For Group IE, head fracture including facial bone fracture was the most common (n=60, 55%), and other significant findings included acute epidural hematoma (n=7, 6%) and cerebral contusion (n=12, 11%) ($p<0.01$) (Fig.

5). Ratios of fractures between Groups B and IE were 41% to 42% (n=7 and n=25, respectively) for maxillary sinus fractures, 24% to 13% (n=4 and n=8, respectively) for orbital fractures, 18% to 32% (n=3 and n=19, respectively) for other facial bone fractures (nasal or cheek bone) and 18% to 13% (n=3 and n=8, respectively) for skull fractures.

As for injury causes, the most common cause was falls for Group B (n=34, 71%) and Group IE (n=34, 44%), but collision was one of the major causes for Group IE (n=25, 32%) (Fig. 6). Twelve patients had collided with obstacles (mainly trees), 9 patients had collided with other snowboarders and 4 patients had collided with skiers.

Surgical cases

For Group B, 10 (1.04%) of the 959 patients required surgery (Table 1). These patients comprised 5 men and 5 women with a mean age of 23.4 years (range, 16-29 years), and all 10 patients sustained acute subdural hematoma without cerebral contusion. Four of the 10 patients were first-time snowboarders, and 7 patients fell on a flat or beginner slope. As for outcomes, 2 patients showed good recovery (GR), 4 patients showed moderate disability (MD), 2 patients showed vegetative state (VS) and 2 patients died (D). The deaths in cases 5 and 8 occurred when the individuals were separated from their friends and fell. In each case, more than 30-60 min elapsed before someone realized that they were missing, and by the time a rescue group arrived, both pupils were dilated.

For Group IE, 5 (0.36%) of the 1408 patients required surgery (Table 2). All patients were men with a mean age of 31.2 years (range, 22-47 years). Three patients had head injury accompanied by cerebral contusion, 1 patient showed acute epidural hematoma and 1 patient displayed acute subdural hematoma without cerebral contusion. Two of the 5 patients had collided with trees, and 1 patient fell outside the run. Outcomes comprised GR in 1 case, MD in

1 case, severe disability (SD) in 2 cases and D in 1 case.

DISCUSSION

Several studies have compared head injuries between snow skiers and snowboarders[1,3-5,8-11] and mechanisms of head injuries in snowboarders[7,12,13]. Tohyama et al.[14] compared snowboarders with <1 year of experience and those with ≥1 year of experience, but focused on orthopedic surgery, and did not touch on head injury. Few studies have compared head injuries between beginners and intermediates/experts. Under these circumstances, this study represents the first to compare and investigate head injuries in snowboarders between beginners and intermediates/experts.

Characteristics of Group B, and preventive measures

The percentage of men was 52%, lower than the 63-81% found in past studies[3]. One characteristic of Group B was thus the relatively high percentage of women.

As for circumstances and causes, many patients fell on gentle and intermediate slopes and were likely to hit the occipital region. In snowboarding, because both feet are fixed, beginners who are not used to snowboarding can easily fall[7,9,10]. As preventing falls using the upper limbs is difficult when falling backwards, snowboarders can easily hit the occipital region[7]. Sugimoto et al.[15] reported that in cases where no technical instruction was received, the incidence of head injury accompanied by organic abnormality was significantly high in beginners. First-time snowboarders should thus learn to fall correctly before snowboarding. How-to books on snowboarding state that falling from as close to the ground as possible is important. For example, when falling backwards, blows to the occipital region can be minimized by rounding the back from a low posture, pulling the chin down and pushing off the

snow surface using both hands, similar to a judo falling technique[16].

Compared to Group IE, neurological severity was significantly milder for Group B, but the number of patients requiring surgery was significantly greater. Common abnormal radiological findings included acute subdural hematoma without cerebral contusion.

Sakai et al.[7,10] and Nakaguchi et al.[12,13] reported that the "reverse edge" phenomenon is important for the onset of acute subdural hematoma in beginners. On gentle slopes, the distance between the hill-side edge and snow surface is small, and the reverse edge phenomenon is likely to occur. When falling backwards, the occipital region is hit strongly due to the rotational force around the axis of the hill-side edge, creating a marked gap between the cerebral parenchyma and skull, thus damaging the bridging veins and leading to acute subdural hematoma. Whether helmets are actually effective against such external rotational forces is unclear, and more patient data need to be accumulated[2,3,7,8,10].

Characteristics of Group IE, and preventive measures

The percentage of male patients was high at 72%, agreeing with past studies[3]. Compared to Group B, the ratio of male patients was significantly higher.

As to circumstances and causes, jump-related falls were common. Compared to Group B, Group IE snowboarders were more likely to sustain frontal (including facial) injuries. Some of the thrills for intermediate and expert snowboarders involve doing air and ground tricks. Loss of balance while jumping leads to a fall, and such falls are often unavoidable. To prevent jump-related falls, having the training and correct knowledge of jumps are crucial. We believe that increasing the degree of difficulty in stages from small to larger jumps is important, and jumps that are beyond the skill level of the snowboarder should be avoided. Furthermore, equipment such as helmets and supporters are necessary for unavoidable falls. Fukuda et al.[8,17]

conducted a prospective study of 1,190 patients and reported that the incidence of severe head injury was significantly lower for snowboarders wearing knit caps or helmets compared with those wearing no head protection.

Compared to Group B, neurological severity was significantly higher for Group IE. The reason for this was that because intermediates and experts fell from much higher heights by jumping, they sustained high-energy injuries with much greater impacts on the head. Tohyama et al.[14] examined systemic injuries in snowboarders with <1 year of experience and those with ≥1 year of experience and reported that the incidence of systemic injury was significantly lower for snowboarders with <1 year of experience, while the incidence of fractures was higher for snowboarders with ≥1 year of experience. The reason for this was that more accidents occurred at higher speed and while landing from jumps in snowboarders with ≥1 year of experience. This also applied to the neurological severity of head injury.

For Group IE, collision was one of the important elements for severe head injury. As for the cause of systemic injury for Group IE, collision with obstacles only accounted for 2.64%, but this figure increased to 16% in patients with abnormal radiological findings. In addition, 2 of the 5 patients who required surgery had collided with a tree. Such injuries show increased severity at higher speed. Also, most collisions with standing trees appear to occur in out-of-boundary areas. To prevent collisions, avoiding boarding in out-of-boundary areas and boarding at speeds over one's skill level is important.

Common abnormal radiological findings included fractures, acute epidural hematoma and cerebral contusion, and cerebral contusion and skull fracture were common among surgical patients. The major causes of cerebral contusion, fracture and acute epidural hematoma are contra-coup injury and coup injury due to external linear force rather than external rotational force[2]. Such injuries caused by external linear force are thought to be alleviated by wearing a

helmet. Sulheim et al.[18] compared 3,277 skiers and snowboarders who sustained head injuries and 2,992 skiers and snowboarders without head injury using multivariate logistic regression analysis and reported that wearing a helmet reduced the risk of head injury by 60% in skiers and snowboarders. The results of that study are persuasive, because they examined a very large number of subjects and not just those with injuries. However, the study did not examine relationships between helmets and mechanisms of head injury. In the future, ascertaining the effectiveness of helmets in reducing head injury will be desirable.

CONCLUSION

Beginners are at some risk for sustaining fall-related loss of consciousness or fatally severe head injury. Our experiences in daily clinical practice suggest that awareness of this fact is unfortunately lacking. We hope that snowboarders and their friends will enjoy snowboarding while always keeping this point in mind. Mizusawa[19] proposed the distribution of pamphlets regarding head injury at ski resorts (with a map of nearby medical institutions), and educational activities for snowboarders are also believed to be effective.

For intermediates and experts, a strict ban on boarding in out-of-boundary areas and prevention of collision accidents seems advisable. For example, one penalty may be to confiscate lift tickets from boarders in out-of-boundary areas. All sports have rules, and snowboarding is no exception.

When snowboarders experience disturbance of consciousness, they often become separated from friends, delaying discovery of the injury. Transporting emergency patients takes time in ski resorts, and any delay in discovery will delay initial therapy and may well exacerbate conditions. Establishing a communication network among ski resorts and neurosurgery facilities is important to allow prompt transport and treatment of patients[3,7].

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FIGURE LEGENDS

Figure 1: Numbers of patients in the beginner and intermediate/expert groups during each season.

Figure 2: Percentage of injuries on each slope type.

Figure 3: Percentage of causes of head injury.

Figure 4: Percentage of neurologic findings.

Figure 5: Numbers of abnormal findings on CT. Fra, fracture; SAH, subarachnoid hematoma; SDH, subdural hematoma; EDH, epidural hematoma; Cont, contusion.

Figure 6: Number of cases of head injury with abnormal findings on CT.

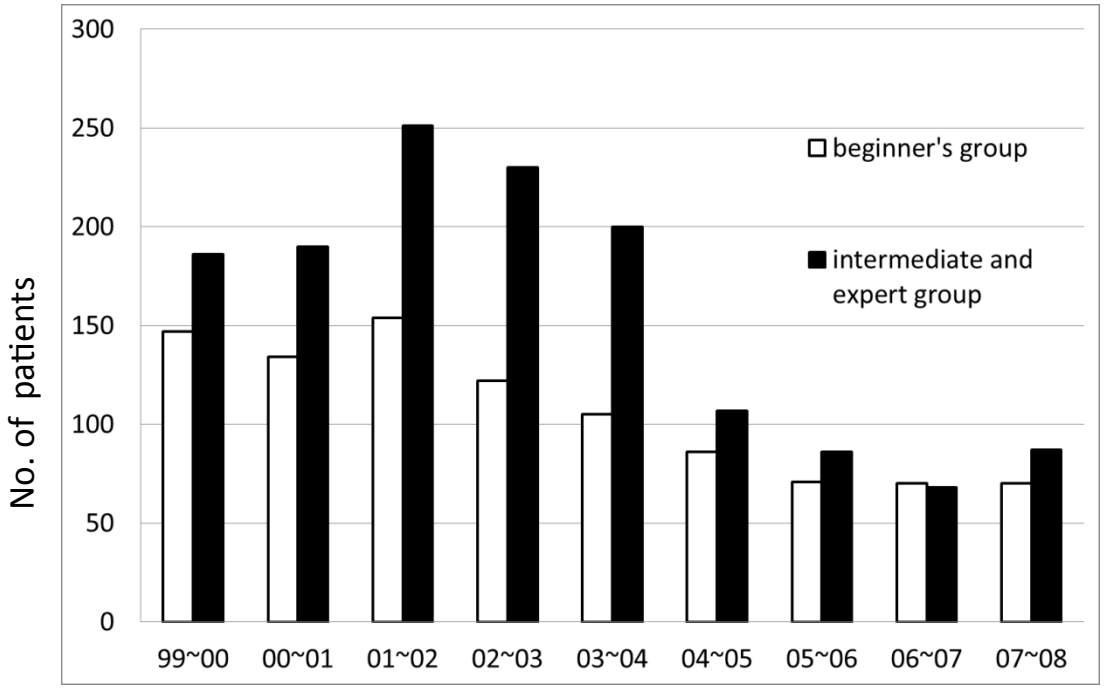

Figure 1: Numbers of patients in the beginner and intermediate/expert groups during each season.

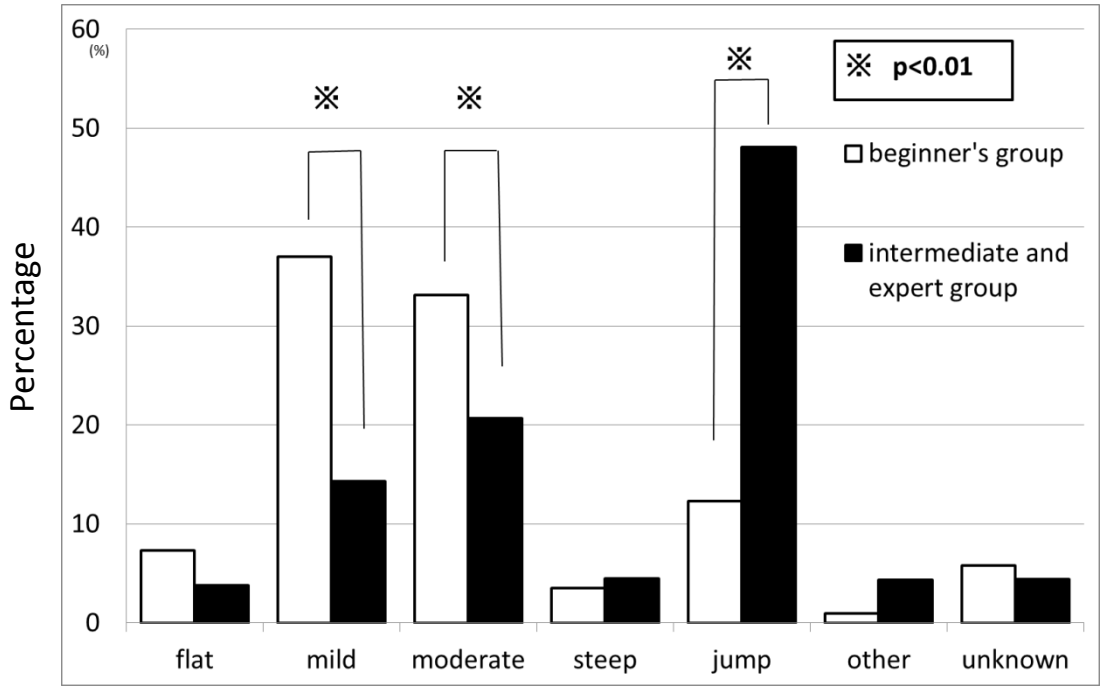

Figure 2: Percentage of injuries on each slope type.

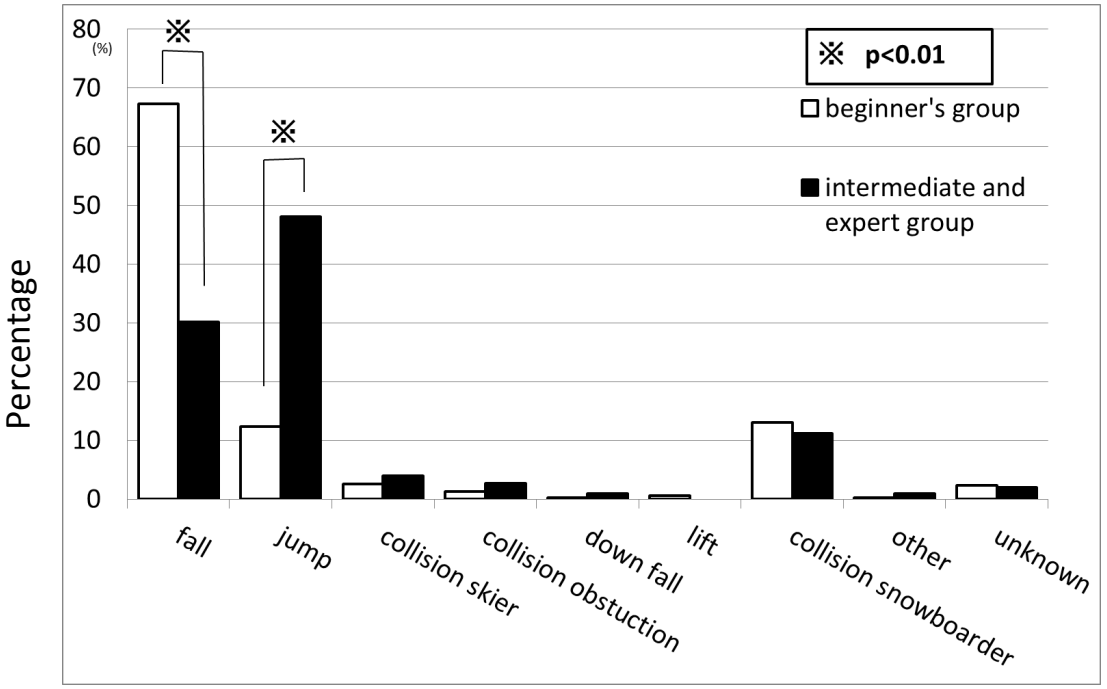

Figure 3: Percentage of causes of head injury.

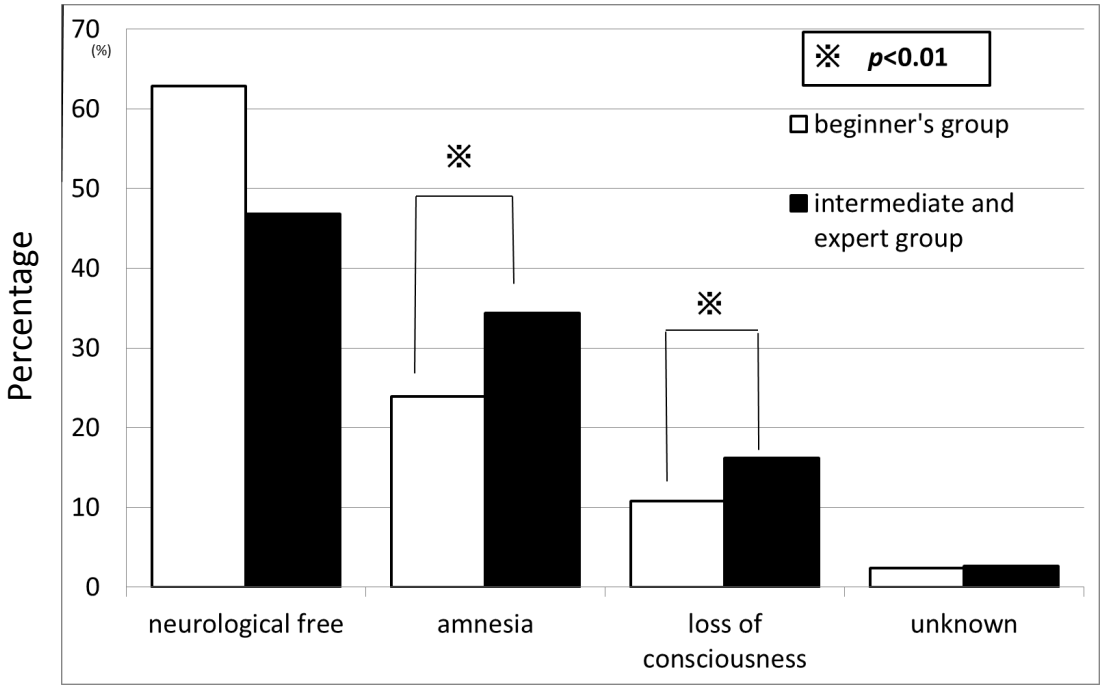

Figure 4: Percentage of neurologic findings.

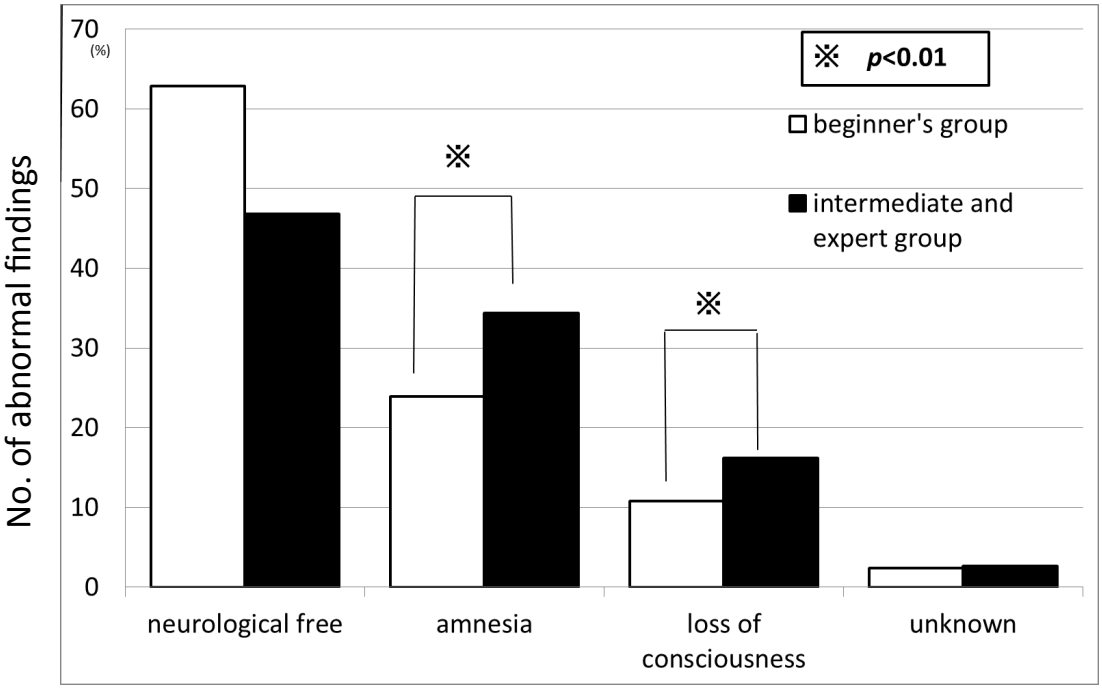

Figure 5: Numbers of abnormal findings on CT. Fra, fracture; SAH, subarachnoid hematoma; SDH, subdural hematoma; EDH, epidural hematoma; Cont, contusion.

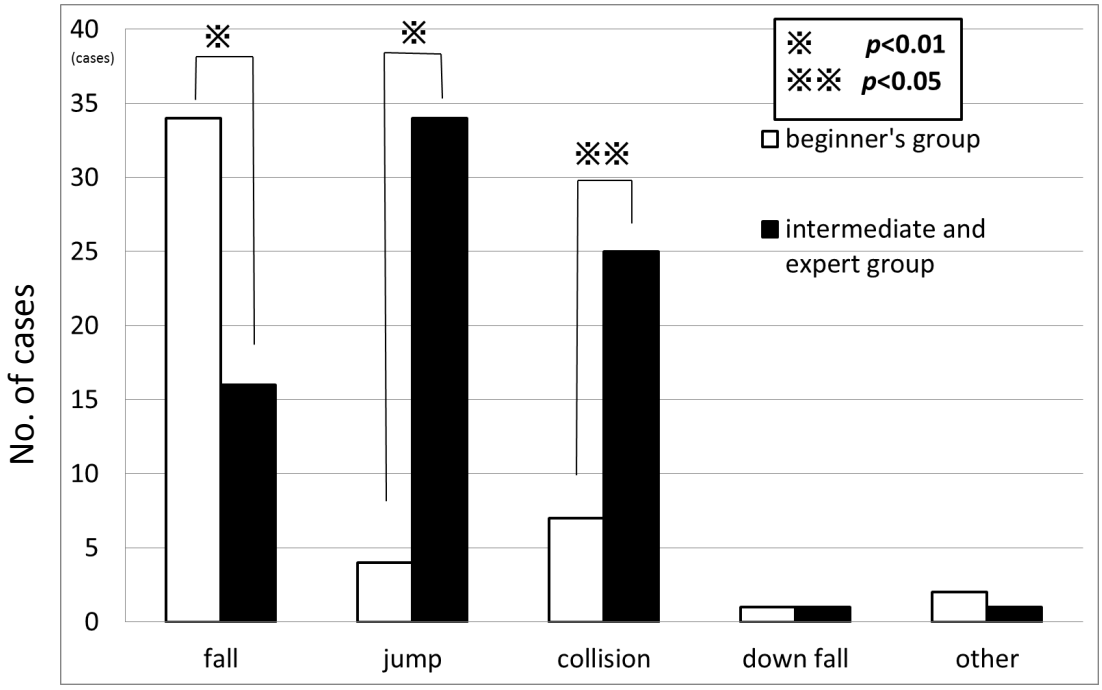

Figure 6: Number of cases of head injury with abnormal findings on CT.

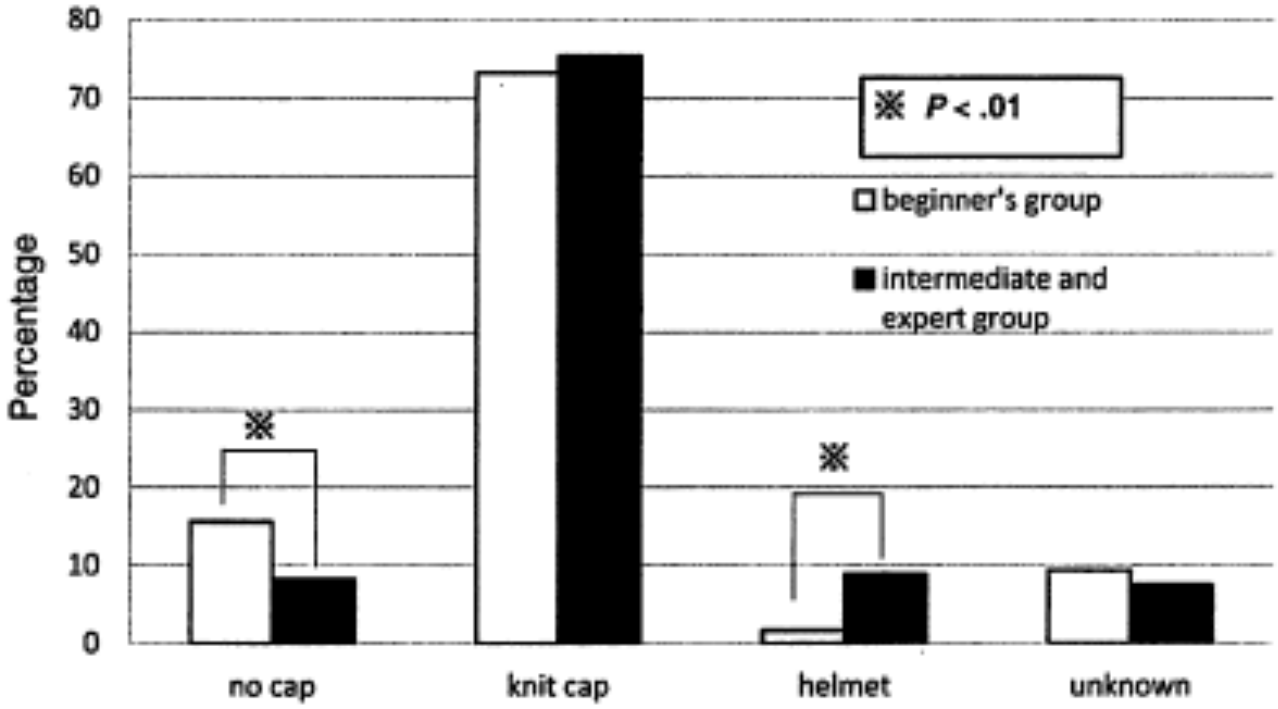

Figure 7. Percentage of each type of head protection.

Table 1. 10 cases who underwent surgical treatment in beginner group.

case	age	sex	skill	finding	slope	case	outcome
1	27	M	first time	ASDH	mild	fall	MD
2	22	M	first time	ASDH	mild	fall	GR
3	24	M	biginner	ASDH	mild	fall	GR
4	29	F	biginner	ASDH	mild	fall	MD
5	25	F	biginner	ASDH	flat	fall	D
6	16	F	first time	ASDH	moderate	fall	MD
7	20	M	first time	ASDH	unknown	unknown	MD
8	26	F	biginner	ASDH	flat	fall	D
9	21	M	biginner	ASDH	steep	fall	VS
10	24	F	biginner	ASDH	mild	fall	VS

M : male, F : female, ASDH : acute subudural hematoma, GR : good recovery, MD : moderate disabled, D : death, VS : vegitate state

Table 2. 5 cases who underwent surgical treatment in intermediate & expert group.

case	age	sex	skill	finding	slope	case	outcome
1	22	M	intermediate	ASDH, Cont., Fra.	steep	unknown	SD
2	26	M	intermediate	ASDH	unknown	fall	SD
3	34	M	expert	ASDH, SAH, Cont.	unknown	unknown	MD
4	27	M	intermediate	AEDH, Fra.	mild	collision with tree	GR
5	47	M	expert	Cont., Fra.	moderate	collision with tree	D

M : male, ASDH : acute subdural hematoma, Cont. : contusion, Fra. : fracture, AEDH : acute epidural hematoma, SD : severe disabled, MD : moderate disabled, GR : good recovery, D : death