

## Original

# Wrist Trauma Related with Skiing and Snowboarding

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**Abstract :** Considering the increasing incidence of snowboarding-related wrist trauma, clarification of the morphology of such injuries and the development of preventive approaches are necessary. We compared the injury morphology of skiing-related and snowboarding-related wrist trauma, and conducted a related literature review. Participants included 10,561 individuals who consulted the Ishiuchi Ski Clinic for skiing-related and snowboarding-related injuries between December 1996 and March 2014. As well as reviewing medical records and questionnaire surveys, we also analyzed videotaped skiing and snowboarding events to examine the statistics and injury morphology of wrist trauma. Over the study period, there were 3,703 patients with skiing-related trauma, including 89 (2.4%) with wrist trauma, and 6,858 patients with snowboarding-related trauma, including 1,123 (16.4%) with wrist trauma. These 1,123 patients included 925 (13.5%) with fractures and 148 (2.2%) with sprains. The most common skiing-related injuries were knee sprains, including medial collateral and anterior cruciate ligament injuries (23.3%). However, the most common snowboarding-related injuries were wrist fractures, including distal radius fractures (13.5%). Trauma was most commonly caused by falling during ski runs or snowboarding jumps. Videos of snowboarders' postures during landing revealed that wrist fractures often occurred when their palms impacted the ground in front of the board. The increased wrist trauma associated with snowboarding compared to skiing could be attributed to the following reasons: (i) absence of ski poles and use of the snowboarding posture (sideways stance with both feet fixed on the same board); (ii) bindings not releasing during falls; and (iii) sudden hand impact caused by "reverse edge" falls on moderate slopes (hands hitting the snow before the trunk). These cause wrist dorsiflexion, predisposing to traumatic injuries, during falls and jumps.

**Key words :** ski, snowboard, wrist, radius, radial fracture

## Introduction

Japan won a host of medals at the 2016 Rio Olympic Games, and the nation is now eagerly awaiting the 2018 Winter Olympics in Pyeongchang, South Korea. However, along with raised anticipation, these sporting competitions also increase the incidence of sports-related injuries. The

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popularization of skiing and snowboarding competitions has been accompanied by endless reports of trauma. In general, sports are associated with a certain level of risk. However, winter sports are considered to have an intrinsically higher level of risk. In December 1956, the Ishiuchi Ski Clinic began its operations at the Ishiuchi Maruyama Ski Resort in Minami Uonuma City, Niigata Prefecture, and started examining skiing-related trauma at locations where these injuries took place.

Snowboarding started gaining popularity in Japan back in 1995. The number of individuals involved in this sport has rapidly increased since then. As its popularity rises, snowboarding-related injuries have also become more frequent. Thus far, 15 snowboarding-related fatalities have been reported in Japan. Around 1996, the Ishiuchi Ski Resort started accommodating snowboarding on all its runs, which led to the occurrence of snowboarding-related injuries. From this time, the clinic started examining both snowboarding- and skiing-related trauma. We analyzed the statistics of skiing-related and snowboarding-related injuries during an 18-year period, and observed that wrist trauma was more likely during snowboarding than during skiing. This finding necessitates elucidation of the morphology of such injuries and methods for their prevention. Thus, in this study, we compared the morphology of skiing-related and snowboarding-related wrist injury, and conducted a review of the relevant medical literature.

## **Materials and methods**

A total of 10,561 individuals were examined at the Ishiuchi Ski Clinic, Department of Orthopedic Surgery, Showa University School of Medicine, for skiing-related and snowboarding-related injuries between December 1996 and March 2014 (18 winter seasons). We reviewed their medical records and questionnaire survey findings, and videotaped skiing and snowboarding events to evaluate (1) injury statistics and (2) injury morphology of skiing-related and snowboarding-related wrist trauma. We classified incidents on the basis of injury morphology as either those from falls during skiing/snowboarding or those from falls when landing jumps. We observed falls during skiing/snowboarding on a clear day for a 1-hr period from 2 p.m. to 3 p.m., which is the peak time for injuries as per data from the National Ski Safety Council, on a steep and moderate slope at the ski resort entrance, which was close to the clinic. This made it possible to observe the injury morphology during falls at an average competitive level from beginner to advanced skiers and snowboarders. The falls were recorded, with video recordings being used where possible. When a video camera was installed at a jump spot, recordings were taken from the moment of the jump to the moment of landing. In the video recordings, the trajectory that formed the parabola from the moment of the jump until landing was converted into still-image frame-by-frame playback and a still image of the landing posture, which was the final point of the parabola, was recorded. Still images in particular were organized into typical groups according to the landing posture, and the influence of the landing posture on the wrist was analyzed.

The questionnaire survey included detailed questions on the cause and site of injury, as well as questions on the equipment used, such as the type of board, boots, and protective gear.

## Results

### 1. Injury statistics

While investigating the number of skiing-related and snowboarding-related injuries per year during the 18-year study period, we observed a decline in the number of skiers and in the number of guests at the ski resort since 1996. The overall number of guests with skiing-related and snowboarding-related injuries also decreased over this period. The proportion of snowboarding-related injuries compared with skiing-related injuries was 47.0% in 1996 (452 snowboarders vs. 509 skiers), 55.6% in 1997 (390 snowboarders vs. 311 skiers), 62.3% in 1998 (475 snowboarders vs. 288 skiers), and 68.6% in 2014 (405 snowboarders vs. 185 skiers), indicating an increasing trend in the incidence of snowboarding-related injuries. Among the total guests at the ski resort, the overall rate of skiing-related and snowboarding-related injuries was 0.176% in 2008, and exhibited an increase to 0.2% after 2010. Approximately two in every 1,000 guests at the resort consulted our clinic as trauma patients (Fig. 1).

During the 18-year study period, there were 3,703 patients with skiing-related trauma. A total of 2,127 cases (57.4%) of lower limb trauma were recorded, which accounted for more than half of all injuries. There were 865 patients (23.4%) with upper limb trauma, 382 (10.3%) with head and face trauma, and 329 (8.9%) with trunk trauma (Table 1). Of the patients with upper limb trauma, 89 (2.4%) had wrist injuries, including 63 (1.7%) with bone fractures, and 17 (0.5%) with sprains.

During the same 18-year study period, 6,858 individuals sustained snowboarding-related injuries. Upper limb trauma accounted for a total of 3,625 cases (52.9%), which was more than half of all the snowboarding-related injuries. There were 1,428 patients (20.8%) with lower limb trauma,

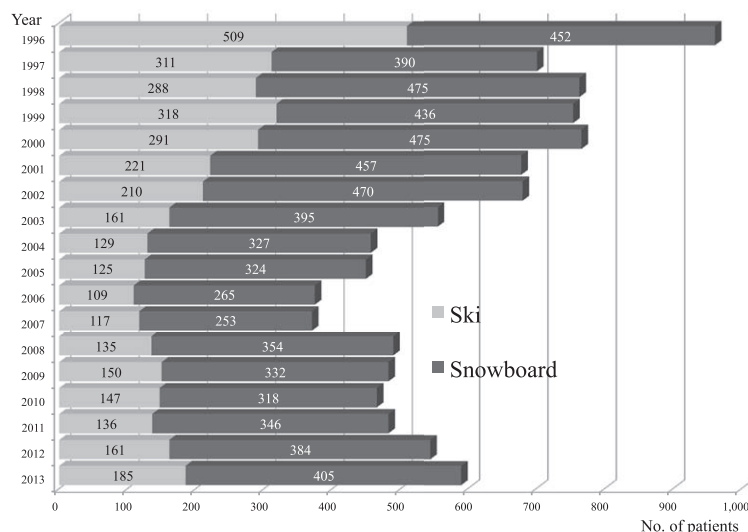


Fig. 1. The yearly incidence of skiing-related and snowboarding-related injuries over an 18-year period

Compared with skiing-related trauma, the incidence of snowboarding-related trauma tended to increase each year.

Table 1. Breakdown of skiing-related sites and types of injuries during an 18-year period (from December 1996 to March 2014)

Site/Injury		Fracture	Sprain	Laceration/ Contusion	Bruise	Dislocation	Other	Total		
Head/Face		4	0	312 <sup>②</sup>	54	1	11	382	382	10.3%
Upper limb	Clavicle	110 <sup>⑦</sup>	3	0	4	30	0	147	865	23.4%
	Shoulder/blade	27	30	1	46	144 <sup>⑤</sup>	5	253		
	Humerus	107 <sup>⑧</sup>	0	2	11	3	0	123		
	Elbow	8	15	2	12	6	3	46		
	Forearm	11	1	4	5	0	0	21		
	<b>Wrist</b>	<b>63</b>	<b>17</b>	<b>6</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>89</b>		
	Finger	61	57	37	14	14	3	186		
Trunk	Lower back/Spine	40	92 <sup>⑩</sup>	7	78	2	6	225	329	8.9%
	Chest/Abdomen	64	0	4	34	0	2	104		
Lower limb	Femur	39	26	12	28	5	4	114	2,127	57.4%
	Knee	142 <sup>⑥</sup>	861 <sup>①</sup>	33	67	8	53	1,164		
	Lower leg	267 <sup>③</sup>	87	78	77	0	42	551		
	Ankle	96 <sup>⑨</sup>	175 <sup>④</sup>	0	1	7	5	284		
	Toe	2	5	0	2	3	2	14		
Total		1,041	1,369	498	435	223	137	3,703	3,703	
%		28.1%	37.0%	13.4%	11.7%	6.0%	3.7%			100.0%

<sup>①-⑩</sup>, Top 10 most common skiing-related injuries.

Table 2. Breakdown of snowboarding-related sites and types of injuries during an 18-year period (from December 1996 to March 2014)

Site/Injury		Fracture	Sprain	Laceration/ Contusion	Bruise	Dislocation	Other	Total		
Head/Face		10	0	596 <sup>②</sup>	103	1	4	714	714	10.4%
Upper limb	Clavicle	334 <sup>④</sup>	12	0	6	149	0	501	3,625	52.9%
	Shoulder/blade	32	77	1	132	511 <sup>③</sup>	8	761		
	Humerus	272 <sup>⑨</sup>	2	0	15	0	0	289		
	Elbow	138	251	11	48	181	3	632		
	Forearm	59	1	30	21	0	0	111		
	<b>Wrist</b>	<b>925<sup>①</sup></b>	<b>148</b>	<b>9</b>	<b>32</b>	<b>6</b>	<b>3</b>	<b>1,123</b>		
	Finger	71	42	60	19	13	3	208		
Trunk	Lower back/Spine	293 <sup>⑦</sup>	147	22	288 <sup>⑧</sup>	2	4	756	1,091	15.9%
	Chest/Abdomen	196	2	4	124	1	8	335		
Lower limb	Femur	16	20	8	27	9	1	81	1,428	20.8%
	Knee	9	298 <sup>⑥</sup>	44	63	3	9	426		
	Lower leg	72	39	244 <sup>⑩</sup>	45	0	13	413		
	Ankle	115	327 <sup>⑤</sup>	0	6	3	1	452		
	Toe	29	19	1	4	0	3	56		
Total		2,571	1,385	1,030	933	879	60	6,858	6,858	
%		37.5%	20.2%	15.0%	13.6%	12.8%	0.9%			100.0%

<sup>①-⑩</sup>, Top 10 most common snowboarding-related injuries.

Table 3. Order of frequency of injuries from December 1996 to March 2014

Skiing			Snowboarding	
Rank	Injury	%	Injury	%
1	Knee sprain	23.3%	Wrist fracture	13.5%
2	Head/face laceration/contusion	8.4%	Head/face laceration/contusion	8.7%
3	Lower leg fracture	7.2%	Shoulder dislocation	7.5%
4	Ankle sprain	4.7%	Clavicle fracture	5.0%
5	Shoulder dislocation	3.9%	Ankle sprain	4.8%
6	Knee fracture	3.8%	Knee sprain	4.4%
7	Clavicle fracture	3.0%	Spinal fracture	4.3%
8	Humerus fracture	2.9%	Lumbar bruise	4.2%
9	Ankle fracture	2.6%	Humerus fracture	4.0%
10	Lumbar/cervical sprain	2.5%	Lower leg laceration/contusion	3.6%

1,091 (15.9%) with trunk trauma, and 714 (10.4%) with head and face trauma (Table 2). Wrist trauma occurred in 1,123 patients (16.4%), including 925 (13.5%) with bone fractures, and 148 (2.2%) with sprains.

Investigation into the frequency of the various types of trauma indicated that for skiing, knee sprains (medial collateral ligament and anterior cruciate ligament injuries) were the most common injuries (23.3%), followed by lacerations and contusions of the head and face (8.4%), lower limb fractures (7.2%), ankle sprains (4.7%), and shoulder dislocations (3.9%). For snowboarding, however, wrist fractures (distal radius fractures) were the most common injuries (13.5%), followed by lacerations and contusions of the head and face (8.7%), shoulder dislocations (7.5%), fractures of the clavicle (5.0%), and ankle sprains (4.8% ; Table 3).

## 2. Injury morphology

The most common cause of injury in skiers was falling during ski runs. Injury-inducing falls occurred on steep, moderate, and flat slopes in 74.3%, 24.3%, and 2.0% of cases, respectively, indicating that trauma was most commonly sustained on steep slopes. By contrast, in snowboarding, the slope of the run at the time of injury was steep in 26.8% of cases, moderate in 61.5% of cases, and flat in 11.7% of cases, indicating that many injuries occurred on runs with moderate slopes. However, we found that injuries were more likely to occur at jump spots than by falling during runs.

Although it was difficult to identify the posture of skiers at the time of a fall during a ski run, we were able to install a video camera at jump spots on snowboarding courses and thus observe the posture of snowboarders when they landed (hereafter referred to as the landing posture).

Typical landing postures resulting in trauma were classified as follows: (i) despite landing with the board on the landing zone, the snowboarder falls with an anteflexion of their trunk in an attempt to avoid falling; (ii) the snowboarder directly lands on his/her lumbar spine, causing

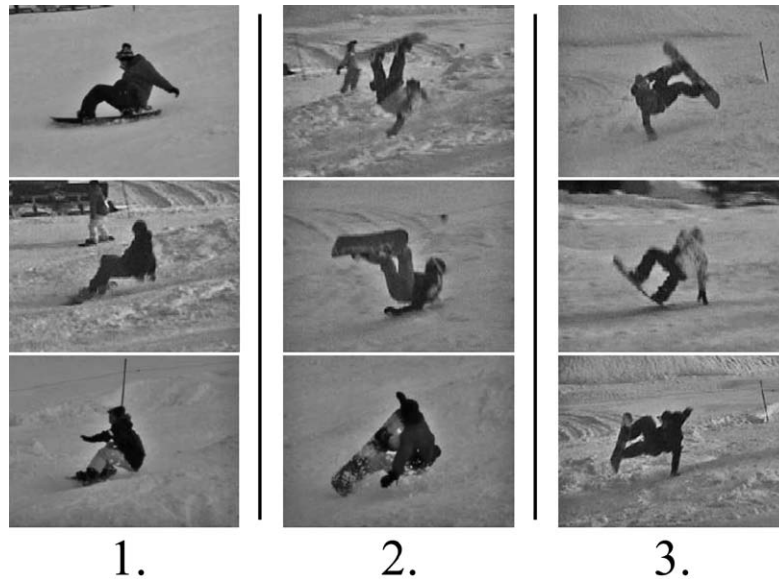


Fig. 2. Different landing postures resulting from falls after typical snowboard jumps

1. Despite landing with the board on the landing zone, the snowboarder falls due to antelexion of their trunk in an attempt to avoid falling.
2. The snowboarder directly lands on his/her lumbar spine, causing a powerful impact.
3. The snowboarder's palms impact the ground in front of the board, resulting in trauma by both direct and indirect forces to the upper extremities.

a powerful impact; and (iii) the snowboarder's palms impact the ground in front of the board, resulting in trauma by both direct and indirect forces to the upper extremities. Wrist trauma was commonly observed in snowboarders with landing posture (iii) (Fig. 2).

## Discussion

We compared the records from our 18-year study period with records taken over four decades (1957–1997) and found consistent results in skiing-related injuries. Lower limb trauma, including knee sprains, constituted the majority of injuries, whereas upper limb trauma, including wrist fractures, was less common. Of the total of 61,378 individuals with skiing-related injuries from 1957–1997, there were 43,263 patients (70.5%) with lower limb trauma, 8,587 patients (14.0%) with upper limb trauma, 7,121 patients (11.6%) with head and face trauma, and 2,407 patients (3.9%) with trunk trauma. Furthermore, skiing-related injuries appear to be closely associated with changes in skiing equipment - the hard, deep plastic ski boots that are currently in use hold and protect the ankles securely, thereby decreasing the frequency of ankle trauma. However, there has been an increase in the frequency of knee sprains and lower limb fractures, such as “boot top fractures”, which occur when the top of the ski boot is used as the point of weight-bearing during anterior falls.

Since the invention of the snowboard by Sherman Poppen in 1965, new materials have been



Table 4. The relative incidence of wrist trauma while skiing compared to while snowboarding

Wrist only	Wrist trauma		Total Trauma			
Ski	①	89	②	3,703	Skiing : Incidence of wrist trauma	① ÷ ② = ⑤ 0.0240
Snowboard	③	1,123	④	6,858	Snowboarding : Incidence of wrist trauma	③ ÷ ④ = ⑥ 0.1638
Total		1,212		10,561	Relative incidence	⑤ ÷ ⑥ 0.1465
Incidence of wrist trauma while skiing is 14.65% that of snowboarding						
Based on total trauma	Wrist trauma		Total Trauma			
Ski	①	89	②	3,703	Skiing : Incidence of wrist trauma	① ÷ ⑦ = ⑤ 0.0084
Snowboard	③	1,123	④	6,858	Snowboarding : Incidence of wrist trauma	③ ÷ ⑦ = ⑥ 0.1063
Total		1,212	⑦	10,561	Relative incidence	⑤ ÷ ⑥ 0.0790
Based on the total number of injuries, the incidence of wrist trauma while skiing is 7.90% that of snowboarding						

developed, and several snowboarding associations have been established. Yet, safety measures have been unable to keep up with the popularity of snowboarding. Since the study of Pino and Colville in 1989<sup>1)</sup>, several other studies on snowboarding-related trauma have been published<sup>2-7)</sup>. Although it is difficult to ascertain the total number of skiers and snowboarders on any given course, the risk and incidence of wrist trauma are higher for snowboarders than for skiers (Table 4). In a 2005 study, Hagel *et al*<sup>8)</sup> reported that according to snowboarding-related injury statistics in Canada, over the 2-year period from 2001 to 2002, there were 527 reports (49.4%) of wrist trauma among 1,066 reports of upper limb trauma. These authors reported that fractures accounted for 46.5% of wrist trauma while sprains accounted for 45.4%, results which are consistent with our study findings.

Snowboarding is associated with more falls than skiing because of the following reasons: (i) ski poles are not used, (ii) unique positions are used during runs (sideways stance with both feet fixed on the board parallel to each other), and (iii) “reverse edge” falls occur on moderate slopes. Snowboarding-related wrist trauma is often sustained when the hands hit the ground during a fall and pressure is applied to the wrists in dorsiflexion, thereby causing ligament injury and fractures. Snowboard bindings are not detached during falls, and because ski poles are not used, the shock of the fall is absorbed entirely by the arms. Furthermore, because the participants wear boots that are fixed on the snowboard in a parallel stance and snowboards are shorter than skis, any effect from a rotational force on the ankles and knees during a fall is unlikely, making lower limb trauma rare. However, the injury morphology underlying skiing-related and snowboarding-related trauma differs, i.e., falls during runs vs. falls when landing a jump. Moreover, even if the head, face, or palms directly hit the snow when falling, fewer injuries are caused to these regions by the edge of the snowboard than those caused by skis that have come off during a fall. As snowboard bindings are designed not to come free when falling,

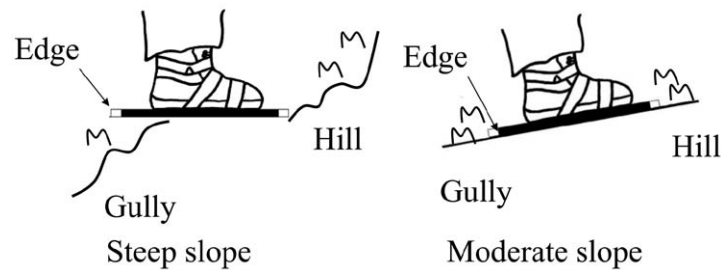


Fig. 3. "Reverse edge" fall due to snowboarding

As shown in the figure, snowboarders slide by placing their center of gravity over the edge of their board facing the hill while the edge of their board facing the gully floats in the air. However, unlike on steep slopes, on gentle slopes, the edge of the board facing the gully tends to be caught in the snow surface, causing the rider to fall toward the gully. Falls from a "reverse edge" tend to occur particularly suddenly and unexpectedly.

there is no rebound of the board into the snowboarder's body. In contrast, skis use safety bindings to prevent leg sprains and forced external bending, which frequently leads to lacerations and contusions to the head, face, and palms as the skis become detached. More than 60% of snowboarding-related injuries occurred on moderate slopes. Many injuries involve novice snowboarders who have a tendency to fall, and a cause of falls on moderate slopes appears to be "reverse edge falls" (Fig. 3)<sup>9,10</sup>. "Reverse edge" falls, in particular, occur suddenly and without warning. Snowboarders are therefore liable to fall "hands first" (hands hit the surface of the snow before the trunk), which is a common cause of wrist trauma.

Upper limb trauma is more common in snowboarding than skiing because of the following reasons: (i) the unique position used during runs without ski poles (sideways stance); (ii) the bindings do not come free when falling; (iii) common "reverse edge falls" on moderate slopes; and (iv) the palms directly hit the snow's surface when falling after landing a jump causing wrist dorsiflexion.

Wrist trauma can be prevented by using protective gear and developing a better balance to help prevent falls. Wrist protectors may prevent trauma by firmly wrapping the wrists. Given the changes in ski equipment and the associated shift in the incidence of ski trauma from the ankles to the knees, the use of wrist protectors may shift snowboarding-related trauma from the wrists to the elbows. In our previous survey of 453 patients with snowboarding-related trauma, all 11 patients wearing wrist protectors avoided wrist trauma. Nonetheless, three of these 11 patients (27.3%) sustained elbow dislocation or sprains<sup>11</sup>. While improving wrist protectors is a task for future research, most of the patients with snowboarding-related injuries treated at our hospital did not wear wrist protectors. This suggests that not wearing wrist protectors is associated with a high rate of wrist trauma. Educating snowboarders on the importance of wearing wrist protectors is likely to decrease the number of related wrist injuries and is a key to decreasing the overall number of snowboarding-related injuries.



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The study was based on anonymized data of injured patients obtained from the Showa University, Ishiuchi Ski Clinic, and Japan Snowboarding Association (JSBA).

## Conflict of interest disclosure

The authors declare that they have no conflicts of interest.

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