

The Snowboarder's Foot and Ankle*

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ABSTRACT

We undertook a prospective study to determine the type and distribution of foot and ankle snowboarding injuries. Reports of 3213 snowboarding injuries were collected from 12 Colorado ski resorts between 1988 and 1995. Of these, 491 (15.3%) were ankle injuries and 58 (1.8%) were foot injuries. Ankle injuries included 216 (44%) fractures and 255 (52%) sprains. Thirty-three (57%) of the foot injuries were fractures and 16 (28%) were sprains. The remaining injuries were soft tissue injuries, contusions, or abrasions. There was no significant correlation between boot type (soft, hybrid, or hard) and overall foot or ankle injury rate. There were significantly fewer ankle sprains in patients wearing hybrid boots and fewer fractures of the lateral process of the talus in patients wearing soft boots. An unexpectedly high number of fractures of the lateral process of the talus were noted. These 74 fractures represented 2.3% of all snowboarding injuries, 15% of all ankle injuries, and 34% of the ankle fractures. Many of these fractures are not visible on plain radiographs and require computed tomography imaging to be diagnosed. Diagnosis of this fracture pattern is paramount; the physician should be very suspicious of anterolateral ankle pain in the snowboarder, where subtle fractures that may require surgical intervention can be confused with anterior talofibular ligament sprains.

Primitive forms of snowboarding were first described in the 1920s. However, it was not until 1972, with Dimitrije

Milovich's "Winterstick" and the technical advances by Jake Burton of Vermont and Tom Sims of California, that the modern snowboard entered into mainstream winter sports. Since that time, snowboarding has enjoyed a rapid rate of growth, and the U.S. Consumer Product Safety Commission estimates that there were over 2 million participants as of January 1995.⁴⁰ Recent information suggests that 80% of children who participate in snow sports have ridden snowboards by their 12th birthdays.²⁷ These increases in snowboarding popularity are mirrored in the sales of sliding-snow sport equipment, of which 39% are sales of snowboards.²⁷

The modern snowboard makes use of several different types of boot-binding combinations. The most common is a soft, "pack-type" boot, with a nonreleasable strap binding. The Canadian Ski Council 1994 survey showed that 74% of riders preferred soft boots.¹⁰ Harder, alpine ski boot styles are also used with either releasable or nonreleasable plate bindings. The use of relatively soft boots has resulted in larger numbers of foot and ankle injuries compared with downhill skiing. This same trend for increased ankle trauma with softer boots was demonstrated with the evolution of alpine equipment. While studies examining snowboarding trauma have shown ankle injuries to represent 12% to 38% of all injuries, only 5% to 6% of all alpine skiing injuries are ankle-related (Refs. 1, 7-9, 16, 19, 31, 34, 36; P. C. Janes and R. Nicholas, unpublished data, 1995).

As ankle trauma in snowboarding is examined more closely, some definite patterns of injury are apparent. Of note is the recognition of fractures of the lateral process of the talus, a fracture pattern previously thought to be rare (Refs. 7, 19; P.C. Janes and R. Nicholas, unpublished data, 1995). A number of snowboard studies have identified and quantified this injury. In 1993, Bladin et al.⁷ found 4 lateral process fractures representing 6% of the 67 foot and ankle injuries in his series. In 1994, Janes and Nicholas (unpublished data) found 63 lateral process fractures among 2699 snowboard injuries, for an incidence of 2.3%.

The present study focuses on defining the spectrum of

* Presented at the 27th Annual Winter Meeting of the American Orthopaedic Foot and Ankle Society, San Francisco, California, February 1997, and at the 12th International Symposium on Ski Trauma and Skiing Safety, Whistler Blackcomb, BC, Canada May 1997.

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No author or related institution has received any financial benefit from research in this study.

injury to the foot and ankle of the snowboarder. An attempt is made to correlate injury patterns and frequency with boot type. Attention is directed toward proper diagnosis and treatment of talus fractures.

MATERIALS AND METHODS

Between the fall of 1988 and the spring of 1995, data were collected prospectively on individual snowboard injuries from 12 Colorado ski resorts. A comprehensive data collection form was employed to collect and store the data. Information collected included a subjective patient-response questionnaire that included foot position, boot type, mechanism of injury, demographic information, and a physician's diagnosis. Data were collected from injured snowboarders who sought medical attention at 1 of over 30 hospitals and clinics that participated in the study. All injuries were diagnosed by emergency department physicians, family practice physicians, or orthopaedic surgeons. The data collection forms were available to these doctors in each of the facilities.

During this 7-year period a total of 3213 snowboard injuries were documented. Of these, there were 491 ankle injuries and 58 foot injuries, for a total of 549 injuries that are included in this study. Information on the number and types of injuries was compiled by diagnosis and subjected to statistical analysis by a biostatistician. For boot type, specified pairs of injury categories were compared for statistical significance based on the percentage use of the three boot types using chi-square test for contingency tables. If the chi-square test was in question because of small sample sizes, then a two-tailed Fisher's exact test was used. To identify which boot types were significantly different, a two-tailed Fisher's exact test was used for analysis stratified by boot type. For all other analyses, a two-tailed Fisher's exact test was used. All calculations were completed using SAS statistical software (Release 6.03, SAS Institute Inc., Cary, North Carolina). Specific patterns of injury were noted and compared with existing studies for validation of injury patterns.

RESULTS

Using our data collection instrument, 3213 snowboarder injuries were recorded. Average age of the injured snowboarder was 21.3 years (range, 7 to 71). Snowboarders with foot or ankle injuries were slightly older, at 23.2 years (range, 7 to 61). There were 2410 (75%) men among the injured population and 803 (25%) women. The distribution of foot and ankle injuries among men and women was similar to the sex distribution in the entire injury population, suggesting that there was no predisposition to injury by sex.

Ankle injuries accounted for 491 (15.3%) of the injuries recorded. Foot injuries (all structures distal to the talus) accounted for 58 (1.8%) of the injuries recorded. Ankle injuries consisted of 216 (44%) fractures and 255 (52%) sprains, and foot injuries consisted of 33 (57%) fractures and 16 (28%) sprains. The remainder of the injuries to the

foot and ankle were assorted injuries to the soft tissues, contusions, and abrasions (Table 1).

Of the 33 fractures of the foot, 29 (88%) were metatarsal fractures (0.9% of all snowboard injuries in this study). The remainder of the fractures of the foot were tarsal and calcaneus fractures. The 16 sprains of the foot were non-specific in location.

Among the ankle fractures, 138 (64%) were on the proximal side of the joint (medial or lateral malleolus or both). Of these, 68 (49%) were isolated fractures of the lateral malleolus and 47 (34%) were isolated fractures of the medial malleolus. Seventy-eight (36%) ankle fractures involved the talus. Of all talus fractures, 74 (95%) were fractures of the lateral process (2.3% of all snowboarding injuries, 34% of all ankle fractures, and 15% of all ankle injuries in this study).

The occurrence of foot or ankle injury involving the leading foot was found to be 343 (62.5%). Although injured more than twice as often as the trailing foot, the leading foot demonstrated no significant differences in injury pattern when compared with the trailing foot. Releasable bindings were found to have no effect on the occurrence or type of injury (Table 2).

Falling was the most common mechanism of foot and ankle injury, resulting in 410 injuries (74.7%). Twisting and collisions with trees were second and third, resulting in 64 (11.6%) and 45 (8.2%) injuries, respectively. No significant correlation could be made between specific injury type and mechanism of injury (Fig. 1).

In the total injury population, 2515 (78.26%) of the snowboarders used soft boots, 230 (7.17%) used hybrid boots, and 468 (14.57%) used hard boots. The foot and

TABLE 1
Distribution of Foot and Ankle Injuries

Injury	Percent of ankle injuries	Percent of all snowboard injuries
All ankle diagnoses	100	15.3
Ankle sprain	52.3	8.0
All ankle fractures	44.4	6.7
Lateral process fractures	15.3	2.3
	Percent of foot injuries	Percent of all snowboard injuries
All foot diagnoses	100	1.8
Foot sprain	27.6	0.5
All foot fractures	56.9	1.0
All metatarsal fractures	50.0	0.09

TABLE 2
Binding Type and Injury Rates

Injury type	Releasable bindings (%)	Nonreleasable bindings (%)
All injuries (1988–1995)	7.9	92.1
All foot and ankle injuries	6.8	93.2

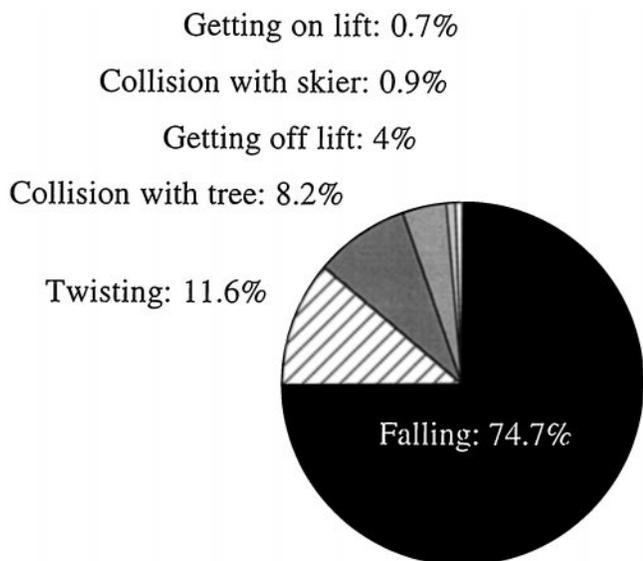


Figure 1. Mechanism of foot and ankle injuries.

ankle injury subset showed no significant differences in boot type used compared with the entire injury population (Fig. 2). However, some interesting relationships between specific foot and ankle injuries in the three boot types compared with all foot and ankle injuries in the three boot types were noted. The percentages of snowboarders who had ankle sprains in soft and hard boots did not differ from the percentages of snowboarders who had any type of foot and ankle injury in soft and hard boots, respectively. However, hybrid boots seemed to protect the ankle from sprains, with a smaller percentage of ankle sprains than all foot and ankle injuries occurring in hybrid boots ($P = 0.0013$). Compared with the incidence of all foot and ankle

injuries in soft boots, there was a slightly increased incidence of nontalus ankle fractures in soft boots (5.8%); however, this increase in ankle fractures was not statistically significant. There was a significant decrease in the injury rate for fractures of the lateral process of the talus compared with all foot and ankle injuries in soft boots ($P = 0.003$). There was a trend toward an increase of lateral process fractures compared with all foot and ankle injuries in hybrid boots, but this was not found to be statistically significant because of the small numbers in this group. However, there was a significant increase of lateral process fractures over all foot and ankle injuries in hard boots ($P = 0.004$) (Table 3).

DISCUSSION

The average age of our injury cohort was 21.3 years, which compares favorably with that found in other reports in the literature (Refs. 1, 7-10, 16, 19, 26, 34, 42; M. Curt and E. Lars-Gunnar, unpublished data, 1995; B. Huber et al., unpublished data, 1995). The average age of our foot and ankle injury subgroup was 23.3 years.

Our findings of 343 (62.4%) leading foot injuries is low when compared with that reported in the literature. Studies have quoted a leading foot injury rate of 77% to 91%.^{7,19,42} Our findings of a lower incidence of foot and ankle injury in the leading leg is more consistent with the findings of Bally and Taverney,³ which showed that the ankle of the trailing foot experienced loads similar to those experienced by the leading ankle during snowboarding. The determination of leading foot may be unreliable given the fact that the leading foot may or may not be forward on the board at the time of injury. The boarder may be riding "fakie" at the time of injury, thus negating the leading foot versus trailing foot comparison. Fakie refers to riding the

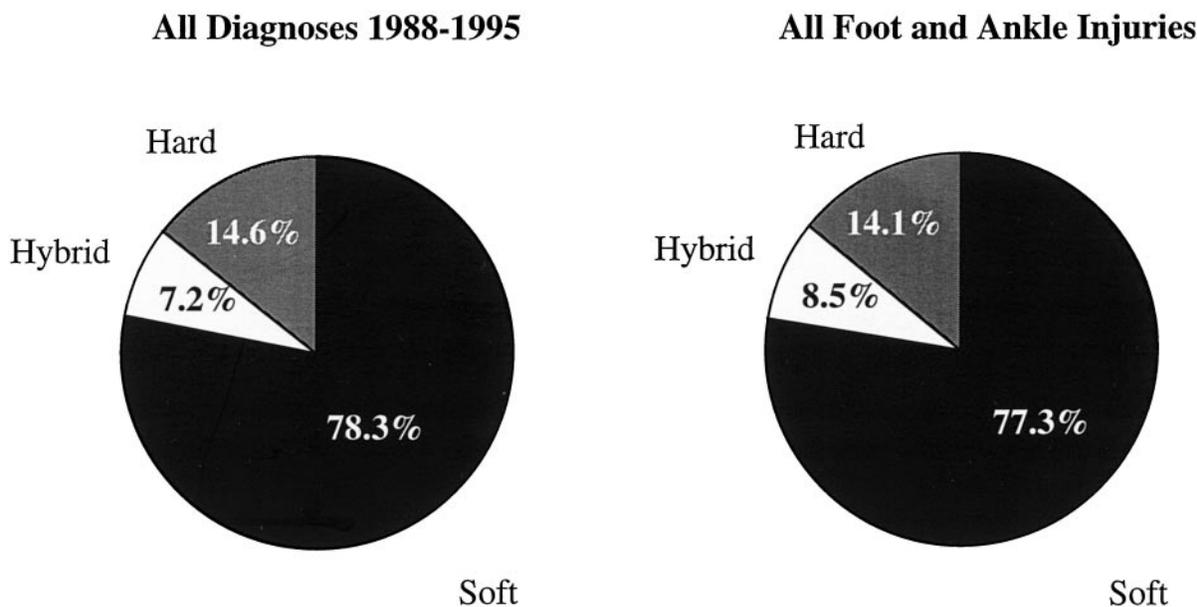


Figure 2. Use of boot type for all diagnoses and for foot and ankle injuries.

TABLE 3
Percentage of Use by Boot Type for Pairs of Injury Categories^a

Injury category	Boot type		
	Hard	Hybrid	Soft
Foot and ankle	14.14	8.52	77.34
All snowboard injuries	14.57	7.17	78.26
Ankle sprains	14.53	5.13 ^b	80.34
All foot and ankle	13.36	11.80	74.49
Ankle fractures (nontalus)	10.83	7.50	81.67
All foot and ankle	15.24	8.86	75.90
Lateral process fractures	22.86 ^c	14.29	62.86 ^d
All foot and ankle	12.65	7.54	79.81
Foot sprains	7.14	7.14	85.71
All foot and ankle	14.35	8.57	77.09
Foot fractures	9.68	12.90	77.42
All foot and ankle	14.44	8.22	77.33
Metatarsal fractures	7.41	11.11	81.48
All foot and ankle	14.54	8.37	77.09

^a All comparisons were made between an overall group and one of its subgroups. Percentages for the overall group were recalculated for each test to preserve comparisons between independent observations.

^b Statistically significant ($P = 0.0013$).

^c Statistically significant ($P = 0.004$).

^d Statistically significant ($P = 0.003$).

snowboard with the tail end of the board forward, that is, the trailing foot is in the lead position (down the fall line) rather than the leading foot, which normally faces down the fall line.

Our finding that falling was the most common mechanism of injury (74.7%) is consistent with the literature (74% to 80%).^{5,16} No correlation was found in the literature or our study between mechanism of injury and specific injury type.

Foot injuries constituted 1.8% of the injury cohort. This is consistent with previous reports that document an incidence of 1.2% to 3% for foot injuries.¹⁻⁹ The foot injuries in our cohort were nearly equally divided between soft tissue injuries and fractures. Of the fractures of the foot, 29 (88%) were metatarsal fractures and 2 (6%) were calcaneus fractures. The types of fractures strongly suggest impact as opposed to rotation (valgus-varus or internal-external) as the mechanism of injury and is consistent with the findings that 31 (96.7%) of the foot fractures in this study were the result of a fall.

Early anecdotal reports and lack of good injury reporting resulted in concerns that snowboarding had a much higher injury rate than alpine skiing. Questions of liability and the danger of the sport itself prompted many resorts to ban snowboards in the late 1970s. Since then several studies have shown no statistical difference between the injury rate for snowboarders and that for alpine skiers (Refs. 5, 36, 37; M. H. Binet et al., unpublished data, 1995; B. Huber et al., unpublished data, 1995). The 491 snowboarder ankle injuries were 15.3% of the injuries in our cohort. This compares favorably with a reported incidence of between 12% and 28% in other studies (Refs. 1, 7, 9, 16, 19, 31, 36-38; P. C. Janes and R. Nicholas, unpublished data, 1995). This represents a significant

increase over the percentage of ankle injuries seen in the skiing population, which ranges from 5% to 6.1% in various studies.^{1,7,16,36} The 216 ankle fractures in our study constituted 6.7% of the injury population. This compares favorably with a reported range of 3% to 8% in the snowboarding literature.^{1,16,19,26}

Among the ankle fractures, 74 (34%) were lateral process talus fractures. The overall rate for this fracture was 2.3%, which is comparable with the rate of 1.2% to 6.3% reported in the literature (Refs. 2, 7, 16, 19, 33, 34; P. C. Janes and R. Nicholas, unpublished data, 1995). Of the snowboard studies that recognized the occurrence of fracture of the lateral process, each noted the difficulty in diagnosis (Refs. 7, 16, 19, 33, 34; P. C. Janes and R. Nicholas, unpublished data, 1995). This difficulty in diagnosis is reflected in the literature and points out the importance of accurate and thorough imaging techniques and a high suspicion of fracture of the lateral process of the talus (Fig. 3).^{2,4,6,11-15,17,18,20,22-25,28-30,32,35,39,41}

Dimon¹³ believed the best radiographic view of the fracture of the lateral process of the talus was an AP of the ankle with 45° of internal rotation and 30° of plantar flexion. However, Mukherjee et al.³⁰ believed that the best view was an AP with 20° of internal rotation and neutral plantar flexion. Most authors concluded that if the radiograph or examination is suspicious, a CT scan is the study of choice (Fig. 3c) (Refs. 6, 12, 14, 19, 21, 24, 32, 33, 35; P.C. Janes and R. Nicholas, unpublished data, 1995).

Many authors believe that a common mechanism for fracture of the lateral process of the talus is dorsiflexion of the ankle and inversion of the hindfoot.^{7,15,17,18,22,30,31,33} This is consistent with the work of Fjeldborg,¹⁵ which demonstrates that when the hindfoot is placed in inversion, the subtalar joint loses its congruence and pressure is concentrated on the lateral process. Given the many degrees of freedom that the snowboard boot allows, it is feasible that this mechanism may apply to the fracture of the lateral process of the talus among snowboarders as well.

Several studies evaluated outcomes of lateral process of the talus fractures treated with casting only. They demonstrated significant disability when these fractures were treated conservatively, unless anatomic alignment could be maintained.^{13,15,17,18,25,28,29,32,33,35,39} Other studies have demonstrated the significant disability caused by lateral process fractures that are misdiagnosed as ankle sprains and seen late.^{13,18,30,35} Successful management of lateral process fractures requires accurate diagnosis including the degree of displacement and comminution. The literature favors CT over magnetic resonance imaging or tomograms as the study of choice (Refs. 6, 12, 14, 19, 20, 24, 32, 33, 35; P.C. Janes and R. Nicholas, unpublished data, 1995).

If small displaced fragments or significant comminution of the fracture is found, most authors favor early excision with weightbearing as tolerated.^{11,12,30,33} If CT demonstrates a large displaced fracture, open reduction and internal fixation is the recommended treatment (Fig. 4).^{2,4,11-13,17,30,33} Paul and Janes³³ recommend that after open reduction and internal fixation, weightbearing not be



Figure 3. Anteroposterior (A) and lateral (B) ankle radiographs. Note how subtle the lateral talus fracture findings are on the standard radiograph. A CT scan of the ankle (C) shows a displaced interarticular fracture of the lateral processes (arrow); the opposite foot shows normal anatomy.

allowed for 4 to 6 weeks. If a nondisplaced fracture of the lateral process is demonstrated and nonoperative treatment is selected, these authors recommend nonweight-bearing with a below-the-knee cast for 4 weeks, then 2 weeks of progressive weightbearing as tolerated in a walking cast.

Soft boots were used by 424 (77.3%) snowboarders in our foot and ankle injury cohort. This is comparable with

the 70% to 87.6% seen in the literature.^{7,16} There are conflicting data in the literature with regard to the occurrence of ankle or knee injury with different boot types. Ganong et al.¹⁶ showed an increase in knee injuries and decreased ankle injuries with hard boots. Conversely, they found ankle injuries were more prevalent in soft boots. While this observation makes sense intuitively, a large study by Shealy et al.³⁷ showed no statistical difference



Figure 4. Lateral process talus fracture after open reduction and internal fixation.

between foot and ankle injuries in relation to boot type. Although our study does not identify the entire population at risk, our findings are consistent with those of Shealy et al.

The use of soft or hard boots resulted in no significant increases in ankle sprains, while the use of hybrid boots resulted in a significant decrease. However, hard boots appeared to be protective for ankle fractures not involving the lateral process of the talus. The significantly lower rate of lateral process fractures in patients wearing soft boots and the higher rate among those wearing hard boots is more difficult to explain. Given the fixed foot and ankle position in the hard boot, extremes of inversion or eversion of the hindfoot are unlikely. Further basic science research should focus on foot and ankle alignment and the effect of rotation and axial loads on the talus to determine whether there is a good explanation for this observation.

Foot and ankle injuries represent a significant subset of the injuries seen in the snowboarder. Injury patterns, such as the fracture of the lateral process of the talus must be suspected so as to properly diagnose and treat the injury. Injury types, such as ankle sprains and fractures, can be associated with variables such as boot type. Awareness of these variables and how they affect injury patterns is essential in the care of the injured snowboarder.

Because of the significant morbidity associated with late or missed diagnoses of fractures of the lateral process

of the talus, physicians must suspect this fracture in a snowboarder with lateral ankle pain. Aggressive surgical treatment is recommended in the displaced fracture of the lateral process of the talus.

ACKNOWLEDGMENTS

The authors thank Leslie Ruff, RN (High Country Health Care, P.C.), who coordinates the ongoing Colorado Snowboarding Injury Study. We also thank the many health care providers at the more than 30 hospitals and clinics who participated in this study. We also thank Howard Shapiro, PhD, for conducting the statistical analysis.

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