

# Incidence of Oral and Maxillofacial Skiing Injuries Due to Different Injury Mechanisms

Robert Gassner, MD, DMD,\* Hanno Ulmer, PhD,†  
Tarkan Tuli, MD,‡ and Rüdiger Emsboff, MD, DMD§

**Purpose:** This study emphasizes the significance of maxillofacial injuries in skiing accidents, correlating injury mechanisms and patterns, by evaluating a large population of maxillofacial injuries over a 6-year period.

**Patients and Methods:** Between 1991 and 1996, of 5,623 patients showing oral and maxillofacial injuries, 1,859 were sports-related. Records of 579 patients with 882 incidents of oral and maxillofacial injury due to skiing were reviewed and analyzed according to age, sex, type of injury, cause of accident, location, and frequency of fractures. Additionally, the five main injury mechanisms were analyzed.

**Results:** The oral and maxillofacial injuries in 10.3% of all trauma patients, or 33% of all sports-related trauma patients, were due to skiing. A total of 310 patients (53.5%) had facial bone fractures, 236 patients (40.8%) suffered from dentoalveolar trauma, and 336 patients (58%) showed soft tissue injuries. Five major causes and mechanisms of injury existed, namely, 263 falls (45%); 135 collisions with other skiers (23%); 70 individuals struck by their own ski equipment (12%); 46 collisions against stationary objects (8%); and 34 lift-track accidents (6%). Sex distribution showed an overall male-to-female ratio of 1.9:1.0, but varied depending on the injury mechanism. The age distribution ranged from 2 to 81 years.

**Conclusion:** The results of this study show the high incidence of oral and maxillofacial injuries due to skiing accidents. Depending on the mechanism of injury, different patterns occur. Facial bone fractures are more likely in collisions with other persons, falls, and collisions with stationary objects, whereas dentoalveolar trauma is more common when persons are struck by their own ski equipment, or when accidents on lift-tracks occur.

Reports evaluating the epidemiology and trends of skiing accidents during the last 30 years<sup>1-5</sup> have indicated a shift of injuries from the ankle and lower leg to the knee, upper extremities, trunk, and head. However, they have not reflected the diversity and severity of facial trauma. This article reviews the skiing injuries treated in the Department of Oral and Maxillofacial Surgery at the University of Innsbruck, Austria, with specific attention to the mechanism of injury patterns.

## Patients and Methods

From January 1, 1991 to December 31, 1996, 1,859 of the 5,623 patients with oral and maxillofacial

injuries registered at the Department of Oral and Maxillofacial Surgery of the University of Innsbruck, Austria, had sports-related injuries. The records of 579 of the former patients injured during skiing were reviewed and analyzed according to age, sex distribution, cause of injury, type and location of injury, and frequency of fractures. The 882 injuries were divided into the following 3 categories: maxillofacial fractures, dentoalveolar trauma, and soft tissue injuries. The 5 main causes for ski accidents were falls, collisions with other skiers, being struck by one's own ski equipment, collisions against stationary objects, and lift-track accidents. Statistical analyses performed included descriptive analysis, the chi-squared test, the Fisher's exact test, and the Mann-Whitney *U*-test. This was followed by logistic regression analyses for the 3 injury types to determine the impact of the 5 main injury mechanisms on the type of injury at different ages in male and female skiers.

## Results

In the 6-year period of this study, 579 patients with 882 incidents of skiing-related oral and maxillofacial injuries were referred to the Department of Oral and Maxillofacial Surgery at the University of Innsbruck,

---

Received from the University of Innsbruck, Austria.

\*Assistant Professor, Department of Oral and Maxillofacial Surgery.

†Assistant Professor, Department of Biostatistics.

‡Resident, Department of Oral and Maxillofacial Surgery.

§Assistant Professor, Department of Oral and Maxillofacial Surgery.

Address correspondence and reprint requests to Dr Gassner: Department of Oral and Maxillofacial Surgery, University of Innsbruck, Maximilianstrasse 10, A6020 Innsbruck, Austria; e-mail: Maxillofaziale-Chirurgie@uibk.ac.at

© 1999 American Association of Oral and Maxillofacial Surgeons  
0278-2391/99/5709-0006\$3.00/0

**Table 1. DESCRIPTION OF THE SAMPLE**

Variable	579 Skiers/ 882 Incidents
<b>Age</b>	
Mean	28.35
SD	15.78
Min	2
10th percentile	10
25th percentile	16
Median	26
75th percentile	38
90th percentile	51
Maximum	81
<b>Gender</b>	
Male	378
Female	201
<b>Injury type</b>	
Facial bone fractures	310
Dentoalveolar trauma	236
Soft tissue injuries	336
<b>Mechanism of injury</b>	
Falls	263
Collision with others	135
Collision with objects	46
Struck by equipment	70
Lift accidents	34
Others	31

Austria (Table 1). The injured skiers ranged from 2 to 81 years of age, with a mean age of 28.3 years and an average age of 26 years. Fifty percent of the skiers were between 16 and 38 years of age; 90% were between 10 and 51 years. The age-groups with the highest rates of injury were children between 7 and 12 years, and young adults between 17 and 33 years (Fig 1).

Males accounted for 65.3% of the cases, and 34.7% of injured skiers were female (Table 1). In all age-groups, males had more injuries than females, except women aged 40 to 49 years, resulting in an overall male-to-female ratio of 1.9:1.0. Sixty-nine percent of injured skiers were from abroad; 31% were from Austria.

## TYPE OF INJURY

Facial bone fractures were seen in 310 patients. Dentoalveolar trauma, mainly affecting the permanent dentition, was seen in 236 patients mainly in the age-group 6 to 28 years, and 336 patients had soft tissue lesions of the face (Tables 1,2). Eight patients (1.4%) had injuries at other sites, such as the skull. Males showed a 5:3:1 ratio of facial bone fractures to dentoalveolar trauma and soft tissue injuries, whereas females had a 3:2:1 ratio of fractures to dentoalveolar trauma and soft tissue injuries. Table 2 shows the combinations of injuries.

## LOCATION AND FREQUENCY OF FRACTURES

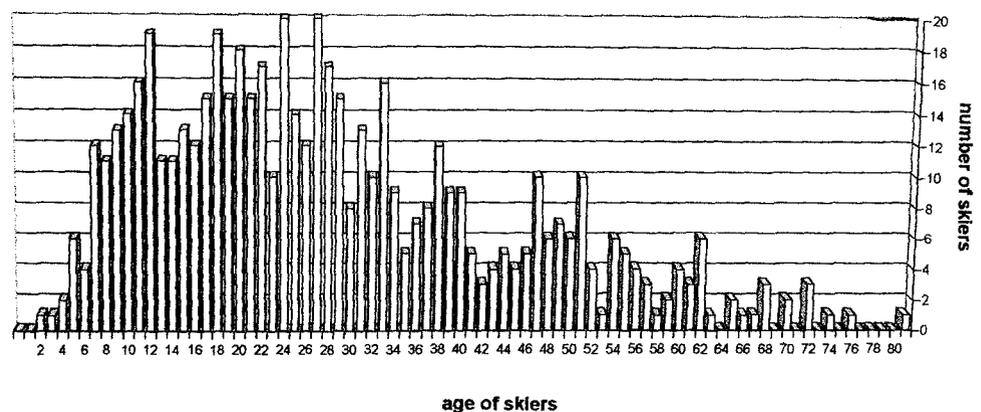
Three hundred ten patients had a total of 540 facial bone fractures. Of these, 72.3% were midfacial fractures and 27.7% were fractures of the mandible. The type of fractures (24 sites), the number of facial bone fractures, and their percentage of the total are listed in Table 3.

## MECHANISM OF INJURY

An analysis of the mechanisms of injury (Table 1) showed five major causes. These are 263 falls (45%); 135 collisions with other skiers (23%); 70 persons struck by their own ski equipment (12%); 46 collisions against stationary objects (8%); and 34 lift-track accidents (6%). In 1 case, a man accidentally skied into a snow-preparing machine that he did not see behind a hill. Five people suffered a stroke or heart attack while skiing, resulting in maxillofacial injuries. Four people died in the emergency room or within the first few days without maxillofacial intervention because of severe brain or trunk injuries.

## FALLS

Two hundred sixty-three skiers (45.5%) were injured in a fall, with an overall sex distribution of 69.2% males and 30.8% females, resulting in a male-to-female ratio of 2.2:1. Of the 132 patients who had facial



**FIGURE 1.** All injured skiers 1991 to 1996 (n = 579).

**Table 2. TYPES OF SKIING INJURIES**

	Number	Percentage
Soft tissue injuries	72	12.5
Dentoalveolar trauma	90	15.5
Facial bone fractures	128	22.1
Soft tissue + dentoalveolar trauma	99	17.1
Soft tissue + bone fractures	135	23.3
Dentoalveolar + bone fractures	17	2.9
Soft tissue + dentoalveolar + bone fractures	30	5.2
Injury outside of face	8	1.4
Total	579	100

bone fractures (50.2%), there was an even higher male-to-female ratio of 2.5:1. The highest incidence was in men approximately 25 years of age. There were six Le Fort II fractures and 4 Le Fort III fractures. Eighty patients suffered predominantly from dentoalveolar trauma. Of these, 68.7% were males and 31.3% were females, for a male-to-female ratio of 2.2:1.0. The overall ratio of facial bone fractures to dentoalveolar trauma was 1.6:1.0. Fifty-one patients had isolated soft tissue injuries (19.4%) with a male-to-female ratio of 1.75:1.

**Table 3. NUMBER AND PERCENTAGE OF FACIAL BONE FRACTURES CAUSED BY SKIING ACCIDENTS**

Type of Fracture	Number (Male/ Female)	Percentage
Le Fort I	4 (4/0)	0.7
Le Fort II	11 (7/4)	2.0
Le Fort III	9 (7/2)	1.7
Right zygoma	62 (41/21)	11.0
Left zygoma	60 (38/22)	10.9
Zygomatic arch, right	14 (10/4)	2.7
Zygomatic arch, left	11 (5/6)	2.0
Floor of the right orbit	60 (38/22)	10.9
Floor of the left orbit	70 (50/20)	13.1
Right orbit	8 (5/3)	1.6
Left orbit	9 (6/3)	1.8
Right upper jaw	13 (9/4)	2.5
Left upper jaw	11 (8/3)	2.1
Right upper alveolar	7 (3/4)	1.4
Left upper alveolar	9 (4/5)	1.8
Nose	32 (22/10)	6.1
Mandible symphysis	11 (7/4)	2.1
Right mandible	38 (24/14)	7.0
Left mandible	39 (29/10)	7.0
Right condylar neck	21 (15/6)	4.1
Left condylar neck	18 (13/5)	3.3
Right lower alveolar	9 (7/2)	1.8
Left lower alveolar	9 (8/1)	1.8
Condyle	5 (3/2)	0.8
Total	540 (363/177)	100

NOTE. Patients, 310; fractures, 540; fracture of midface, 72.3%; fracture of mandible, 27.7%.

### COLLISION WITH OTHER PERSONS

One hundred thirty-five skiers (23.3%) were injured during collisions with other people, 57% were men and 43% were women. Most notably, the analysis showed 100 skiers with facial bone fractures compared with 26 skiers with predominantly dentoalveolar trauma, resulting in a ratio of 4:1. Among these cases, there were 2 Le Fort I fractures, 4 Le Fort II fractures, and 1 Le Fort III fracture. Only 9 patients (5 men and 4 women) had isolated soft tissue injuries.

### HIT BY OWN SKI EQUIPMENT

Seventy skiers were injured by their own skis or ski poles, with a male-to-female ratio of 2.5:1. Although there was a high rate of dentoalveolar trauma, with 37 cases, the total number of facial bone fractures was also high, with 22 cases. The ratio of facial bone fractures to dentoalveolar trauma was 1.0:1.7. Eleven patients with isolated soft tissue injuries were recorded.

### COLLISIONS WITH STATIONARY OBJECTS

Eight percent of all skiing-related facial trauma (46 skiers) was due to collision with stationary objects (eg, trees), with a male-to-female ratio of 2.3:1.0, mainly affecting the age-group 10 to 40 years. Twenty-eight cases with facial bone fractures and 13 cases with predominantly dentoalveolar trauma were recorded, resulting in a ratio of 2.1:1.0. This included one Le Fort I fracture. Four patients (1 man and 3 women) had isolated soft tissue injuries.

### LIFT-TRACK ACCIDENTS

Thirty-four skiers (6%) were injured in the lift area. Fifteen of the injured skiers were male, and 19 were female. There were 7 cases with facial bone fractures and 25 cases with predominantly dentoalveolar trauma, for a ratio of 1.0:3.6. Two female skiers had isolated soft tissue injuries.

Among the 579 patients, the mechanism of injury was not available in 21 cases. In these cases, there were one each of Le Fort I, II, and III fractures.

### LOGISTIC REGRESSION ANALYSES

The results of logistic regression analyses for dentoalveolar trauma and facial bone fractures are shown in Tables 4 and 5, respectively. Relations between injury mechanism and the injury type for soft tissue injuries were not sufficient to estimate a statistical significant regression model. Older skiers had significantly more facial bone fractures (mean age, 32.2 years;  $P < .001$ ) whereas younger skiers were more prone to dentoalveolar trauma (23.3 years;  $P < .001$ ). However, the mean age of skiers with soft tissue injuries (28.4 years) was not statistically significant. Furthermore, no statis-

**Table 4. RELATION OF DENTOALVEOLAR TRAUMA MECHANISM OF INJURY**

	Dentoalveolar Trauma		Significance Crude	Odds Ratio Adjusted	Odds Ratio 95% CI	Significance Adjusted
	Yes	No				
Age	23.26 ± 14.20	31.84 ± 15.89	<i>P</i> < .001	0.9647	0.9516-0.9779	<i>P</i> < .001
Sex						
Female	80/201 (39.8%)	121/201 (60.2%)	<i>P</i> = .790	1.8337	0.8208-4.0966	<i>P</i> = .1393
Male	156/378 (41.3%)	222/378 (58.7%)				
Fall						
Yes	97/263 (36.9%)	166/263 (63.1%)	<i>P</i> = .090	1.6670	0.6981-3.9810	<i>P</i> = .2499
No	139/316 (44.0%)	177/316 (56.0%)				
Collision with objects						
Yes	24/46 (52.2%)	22/46 (47.8%)	<i>P</i> = .118	2.9281	1.0462-8.1951	<i>P</i> = .0408
No	212/533 (39.8%)	321/533 (60.2%)				
Collision with others						
Yes	36/135 (26.7%)	99/135 (73.3%)	<i>P</i> < .001	1.2956	0.5142-3.2643	<i>P</i> = .5828
No	200/444 (45.0%)	244/444 (55.0%)				
Struck by equipment						
Yes	43/70 (61.4%)	27/70 (38.6%)	<i>P</i> < .001	4.7244	1.7885-12.4800	<i>P</i> = .0017
No	193/509 (37.9%)	316/509 (62.1%)				
Lift accidents						
Yes	28/34 (82.4%)	6/34 (17.6%)	<i>P</i> < .001	16.8901	4.8647-58.6427	<i>P</i> < .001
No	208/545 (38.2%)	337/545 (61.8%)				

tical significant differences were found for male and female skiers in terms of the three injury types.

The results of logistic regression for injury mechanisms presented in the right columns of Table 4 and 5 indicate that lift accidents, being struck by one's own ski equipment, and collisions with objects were associated with the occurrence of dentoalveolar trauma and only being struck by own skiing equipment was unlikely to result in a facial bone fracture.

The probability of suffering dentoalveolar trauma during skiing varied depending on the injury mecha-

nism. There was a 3-fold risk for dentoalveolar trauma when colliding with objects, a 5-fold risk when hit by one's own equipment, and a 17-fold risk during lift accidents. The probability of suffering facial bone fractures during collision with other persons was a 3-fold risk.

## Discussion

Previous reports<sup>1-8</sup> on the epidemiology of skiing injuries have only rarely included information on

**Table 5. RELATION OF FACIAL BONES FRACTURES TO MECHANISM OF INJURY**

	Fracture		Significance Crude	Odds Ratio Adjusted	Odds Ratio 95% CI	Significance Adjusted
	Yes	No				
Age	32.19 ± 15.33	23.91 ± 15.15	<i>P</i> < .001	1.0072	0.9753-1.0402	<i>P</i> = .6607
Sex						
Female	102/201 (50.7%)	99/201 (49.3%)	<i>P</i> = .021	1.2107	0.8270-1.7723	<i>P</i> = .3255
Male	208/378 (55.0%)	170/378 (45.0%)				
Fall						
Yes	132/263 (50.2%)	131/263 (49.8%)	<i>P</i> = .0824	1.0226	0.3132-3.3387	<i>P</i> = .9705
No	178/316 (56.3%)	138/316 (43.7%)				
Collision with objects						
Yes	28/46 (60.9%)	18/46 (39.1%)	<i>P</i> = .188	0.9547	0.3379-2.6973	<i>P</i> = .9303
No	282/533 (52.9%)	251/533 (47.1%)				
Collision with others						
Yes	100/135 (74.1%)	35/135 (25.9%)	<i>P</i> < .001	3.1738	0.8149-12.3612	<i>P</i> = .0959
No	210/444 (47.3%)	234/444 (52.7%)				
Struck by equipment						
Yes	22/70 (31.4%)	48/70 (68.6%)	<i>P</i> < .001	0.2005	0.0751-0.5356	<i>P</i> = .0013
No	288/509 (56.6%)	221/509 (43.4%)				
Lift accidents						
Yes	7/34 (20.6%)	27/34 (79.4%)	<i>P</i> < .001	0.3394	0.0448-2.5699	<i>P</i> = .2955
No	303/545 (55.6%)	242/545 (44.4%)				

maxillofacial injuries. Studies of the causes of death among skiers have reported on the relationship of sudden cardiac death (25%) to traumatic death (75%)<sup>9</sup> in Austria, whereas others have reported an estimated traumatic death rate of 2.67 per million skiers,<sup>10</sup> which increases with age. Yet, skiing is assumed to be 7 times safer than driving a car.<sup>10</sup> The estimated traumatic death rate among bicyclists is 10 times higher than among skiers.<sup>11</sup>

Other studies on skiing injury rates<sup>1,4,5,7,8</sup> have shown that they range from 2.5 to 6.5 injuries per 1,000 skier-days, with a shift of such injuries from the lower leg to the knee, upper extremity, trunk, and head during the past 30 years. This has been attributed to various developments, such as new technologies in boot and binding construction, the higher speed of skiers, and overcrowded ski slopes.

In the area around Innsbruck, approximately 35,000 people ski on Sundays in the winter.<sup>5</sup> Fourteen local hospitals and the Department of Traumatology, University of Innsbruck refer patients with maxillofacial trauma to the Department of Oral and Maxillofacial Surgery at the University of Innsbruck. More than 10.3% of all oral and maxillofacial trauma cases treated in the department are skiing-related, and this is therefore the most common cause of sports-related facial trauma (33%). The high percentage of facial trauma seen is mainly due to the location of the hospital in the midst of the Alps, where skiing is one of the favorite holiday and spare-time activities. The high percentage also supports reports of other authors<sup>12-14</sup> that sports-related injuries are becoming increasingly more common (up to 33%), in contrast to reports with fewer numbers (11%).<sup>15</sup>

The age distribution of the injured skiers ranged from 2 to 81 years. Between 6 and 30 years of age, dentoalveolar trauma was most frequent, and between 10 and 50 years of age, facial bone fractures were more common, supporting the findings of Tanaka.<sup>16</sup>

The overall male to female distribution in the series was 1.9:1.0, showing a higher percentage of female skiers involved in these accidents than that reported by others,<sup>16</sup> with a male-to-female ratio of 5:1. Interestingly, women aged 40 to 49 years were at a higher risk than men in this age-group. An increasing percentage of females (40%) has also been noted in bicycle accidents, resulting in mandibular fractures.<sup>17</sup> It is known that inexperienced skiers have more falls and therefore might suffer more facial injuries. This is supported by the fact that 69% of skiers with facial injuries were foreigners.

More than half of the skiers with facial injuries had fractures, and one third suffered predominantly from dentoalveolar trauma, contrary to findings among injured bicyclists that showed a reverse distribution.<sup>17</sup>

Among the patients with facial bone fractures, more than two thirds (72.3%) had injuries of the midface, and fewer than one-third (27.7%) had injuries of the mandible. The number of the fractures of Le Fort I, II, and III types was identical to the number of these fractures reported between 1963 and 1969<sup>18,19</sup> yet the total number of midfacial fractures had increased 6-fold. The most commonly affected bones were the zygoma and floor of the orbit, confirming the data of a previous 2-year survey.<sup>20</sup> The 12.5% incidence of isolated soft tissue injuries does not adequately account for all such injuries sustained while skiing, because most of these soft tissue injuries were treated in local hospitals.

Falls, mostly occurring when speed was out of control or in cases of imbalance, accounted for the greatest number of injuries (45%), whereas collisions with stationary objects (trees) accounted for only 8% of all cases. The most underestimated cause might be that 23% of all injuries are due to collision with other people; 80% of these resulted in facial bone fracture, and only 20% resulted in dentoalveolar trauma. The most likely cause for these collisions was overcrowded slopes. Nevertheless, being struck by one's own ski equipment is a frequent injury mechanism and would be even greater without the safety improvements in boot and binding construction.

Six percent of all facial injuries occurred on lift-tracks. Collision with other skiers at a crossing of the ski slope and lift-tracks, T-bars striking skiers on the head at the entrance or exit of the lift, and skiers going up colliding with other people who accidentally dropped off the T-bar lift and who could not immediately clear the lift, were the main causes for these accidents.

Besides the possibility of using a helmet that protects the head, including the face, and a mouthguard to protect the teeth, there are several measures that may also minimize the risk of becoming a trauma patient while skiing.<sup>21</sup> To prevent injury, including facial trauma while skiing, it is highly recommended to control one's speed at all times, to be in proper physical condition and to ski only after sufficient preseason training, to look for well-prepared slopes, to avoid bad weather and difficult snow conditions, and to avoid overcrowded slopes and T-bar lifts, especially when an inexperienced skier.

## References

1. Johnson RJ, Ettlinger CF, Campbell RJ: Trends in skiing injuries: Analysis of 6-year study (1972-1978). *Am J Sports Med* 8:106, 1980
2. Deibert MC, Aronsson DD, Johnson RJ, et al: Skiing injuries in children, adolescents, and adults. *J Bone Joint Surg Am* 80:25, 1998
3. Sacco DE, Sartorelli DH, Vane DW: Evaluation of Alpine skiing and snowboarding injury in a Northeastern state. *J Trauma* 44:654, 1998

4. Johnson RJ, Ettlinger CF, Shealy JE: Skier injury trends 1972 to 1994, *in* Johnson RJ, Mote CD Jr, Ekeland A (eds): *Skiing Trauma and Safety*, vol 11. ASTM STP 1289, American Society for Testing and Materials, 1997, pp 37-48
5. Benedetto KP, Wambacher B, Genelin A, et al: Skisport-typische Verletzungen. *Langenbecks Arch Chir* 376:460, 1991 (suppl)
6. Shorter NA, Jensen PE, Harmon BJ, et al: Skiing injuries in children and adolescents. *J Trauma* 40:997, 1996
7. Warne WJ, Feagin JA, King P, et al: Ski injury statistics 1982 to 1993, Jackson Hole ski resort. *Am J Sports Med* 23:597, 1995
8. Johnson RJ (ed): *Symposium on Skiing Injuries*. *Clin Sports Med* 1:179, 1982
9. Burtscher M, Likar R, Philadelphia M: Sudden cardiac death during mountain hiking and downhill skiing. *N Engl J Med* 329:1738, 1993
10. Shealy JE: Deaths in downhill skiing 1976-1992: A retrospective view, *in* Johnson RJ (ed): *Skiing Trauma and Safety: Tenth International Symposium*, ASTM STP 1266. American Society for Testing and Materials, 1996, pp 66-72
11. Kraus JF, Conroy C: Mortality and morbidity from injuries in sports and recreation. *Annu Rev Public Health* 5:163, 1984
12. Afzelius LE, Rosen C: Facial fractures: A review of 368 cases. *Int J Oral Surg* 9:25, 1980
13. Hill CM, Crosber RF, Carrol MF, et al: Facial fractures: The results of a prospective four year study. *J Oral Maxillofac Surg* 12:267, 1984
14. Linn EW, Vrijhoef MMA, De Wijn JR, et al: Facial injuries sustained during sports and games. *J Craniomaxillofac Surg* 14:83, 1986
15. Posnick JC, Wells M, Pron GE: Pediatric facial fractures: Evolving patterns of treatment. *J Oral Maxillofac Surg* 51:836, 1993
16. Tanaka N, Hayashi S, Amagasa T, et al: Maxillofacial fractures sustained during sports. *J Oral Maxillofac Surg* 54:715, 1996
17. Emshoff R, Schöning H, Röhler G, et al: Trends in the incidence and cause of sport-related mandibular fractures: A retrospective analysis. *J Oral Maxillofac Surg* 55:585, 1997
18. Waldhart E, Burrer G: Kiefer- und Gesichtsverletzungen im Wintersport. *Zahnärztl. Welt Rundschau* Vol 20, 1970, pp 882-886
19. Waldhart E, Röhler G: Verletzungen im Kiefer- und Gesichtsbereich beim Wintersport. *Zeitschrift für Allgemeinmedizin*. 52: 1413, 1976
20. Gassner R, Traugott D, Röhler G, et al: Epidemiology of facial injuries sustained in Alpine skiing, *in* Mote CD Jr, Johnson RJ, Hauser W, Schaff PS (eds): *Skiing Trauma and Safety*, ASTM STP 1266, Vol 10. American Society for Testing and Materials, 1996, pp 77-81
21. Wray RC: From the other side of the bed sheets: The physician as patient. *Plast Reconstr Surg* 97:1466, 1997 (editorial)