DEPRESSED SKULL FRACTURE IN SKIING AND ITS PREVENTION- AN EXPERIMENTAL STUDY

by

S.Oh*., M.Rüedi**

* Department of Neurosurgery, Kantonsspital Chur, Switzerland

**Federal Laboratories for Materials Testing and Research, St. Gallen, Switzerland

SUMMARY

During the last 7 years, 57 patients were treated surgically for head injuries caused by skiing accidents. In 49(84%) cases depressed skull fractures were observed with or without brain damage-bleeding. Clinically the mechanisms of the fractures were analysed and depressed skull fractures were studied experimentally. A depressed fracture is caused by direct small local impact energy, of which in the present study a tolerance threshold of about 1 to 2 kN was observed for a depressed fracture in the temporal region. From these studies it can be shown very clearly that only the wearing of helmets offer in fact an effective possibility for the prevention of head accidents in the ski sport.

INTRODUCTION

In Switzerland skiing has become a national sport, due to its optimal geographical location. After all, who does not feel physically fit on beautiful snow slopes in fresh air and wintery sunshine for reason of health. Skiing is growing more popular from year to year, so that the number of skiiers increased steadily. According to UNO-experts, by 1982 they should amount to about 55 millions skiiers in the world. Skiing is associated with more or less speed. The speed brings about greater accidents risks, however. Modern ski-bindings lead to on increasing percentage of head injuries. The prevention of head injuries in skiing is nowadays of great importance just like in automobile accidents. Among the surgical treatment of the patients, we have observed impressively more depressed skull fractures with or without brain damages. The cause of the fracture is studied clinically and experimentally. The possibilities of accident prevention are discussed.

CAUSES OF ACCIDENTS

Excessive speed or speed not adjusted to prevailing conditions often lead to loss of ski control, and then accidents occur. - Collision with various obstacles such as trees, wooden or wire, fences, protruding rocks, walls etc. occurred. - At times of heavy skiing activity all kinds of collisions between two skiiers occur also.

- Another reason for accidents are injuries caused by own or other peoples'ski equipment(fig.1) as well as by ski-lifts etc.

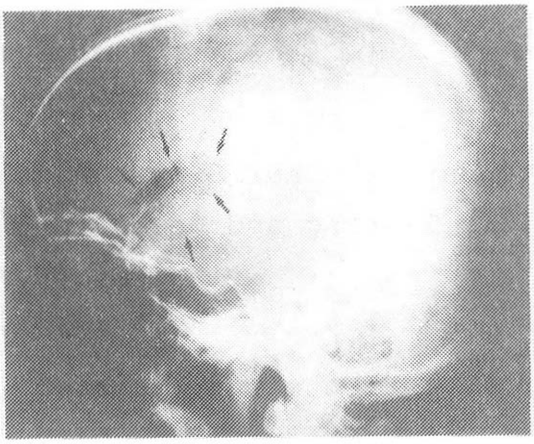


Fig:1

Depressed fracture in the temporal region through ski-point.

EXPERIMENTAL STUDY

The present study was performed on the human skull, whereby the fractures in the temporal areas were considered, because (a) Clinically ,the severe depressed fractures were most frequently observed in this region. (b) Anatomically ,the bone is very thin in this area and contrary to other regions,important brain function and many brain vessels are located here.
The study concentrated mainly on the direct local small force, resulting in depressed fracture. In a free fall,a cylindrical body of steel with spherical impact surface with a curvature radius of 14 mm was dropped on the skull. Additional weights could be screwed on the body of steel,and an acceleration indicator was mounted in it,which showed a charge proportionate to the acceleration. By means of a charge-amplifier this was transformed into a tension signal and stored digitally on a transient-recorder. Slowed down 1000-fold the acceleration-time-curve was registered on a X-Y-recorder.

Test Nr.	Fall-Height in m	Fall-Weight in kg	Energy in J	Speed in km/h	Acceleration in g	Force in kN	Skull Nr.	Fracture
1	2	3	4	5	6	7	8	9
2	2.7	1.39	37	26.2	>100	>1.4	2	+++
3	2.7	1.39	37	26.2	>100	>1.4	2	+++
4	1.0	1.39	14	15.9	>100	>1.4	2	++
11	.7	1.39	10	13.3	~130	~1.8	1	0
12	1.0	1.39	14	15.9	~110	~1.5	1	+
13	.8	1.39	11	14.3	120	1.6	1	++
14	.9	1.39	12	15.1	0	0.0	1	+
15	.9	1.39	12	15.1	~150	~2.0	1	+
24	.8	1.39	11	14.3	65	.9	3	0
25	1.0	1.39	14	15.9	0	0.0	3	+++
26	.8	1.39	11	14.4	55	.7	3	+++
27	1.0	1.39	14	15.9	80	1.1	3	++
28	.8	1.39	11	14.3	80	1.1	4	++
29	.8	1.39	11	14.3	85	1.2	4	++
33	.8	1.39	11	14.3	~120	~1.6	5	++
34	.8	1.39	11	14.3	90	1.2	5	++
38	.8	1.39	11	14.3	75	1.0	6	+++
39	.7	1.39	10	13.3	70	1.0	6	++
40	.8	1.39	11	14.3	130	1.8	7	+
41	.8	1.39	11	14.3	105	1.4	7	0
42	.8	1.39	11	14.3	90	1.2	7	+
43	1.0	1.39	14	15.9	125	1.7	8	++
44	1.0	1.39	14	15.9	100	1.4	8	++

The fractures were listed in the following categories: (column9 in table 1)

0	:	no fracture
+	:	slight fracture
++	:	depressed fracture
+++	:	total depressed fracture

Table. 1 Reaction of the fractures in the temporal area.

We worked in the temporal area(bothsides). Through macroscopic inspection the fractures were established and documented: photographicaly, cinematographicaly,. All in all nine skulls were tested,with a total of 52 dynamic tests,of which 23 were performedin the temporal region(table 1).

In some individual tests the acceleration lies outside the fixed measuring limits(test 2 in table 1). For other measurings the acceleration could not be determined exactly because of self-vibrations of the system(test 11,12 etc in table 1). Tests for which the acceleration was not measured are entered in column 6 and 7 by "0"(test 14,25 in table 1).

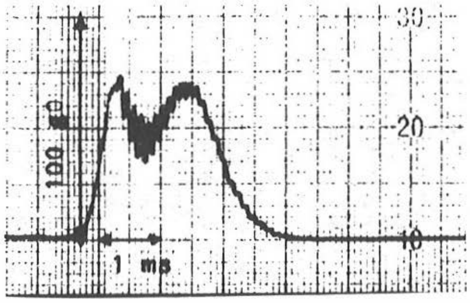
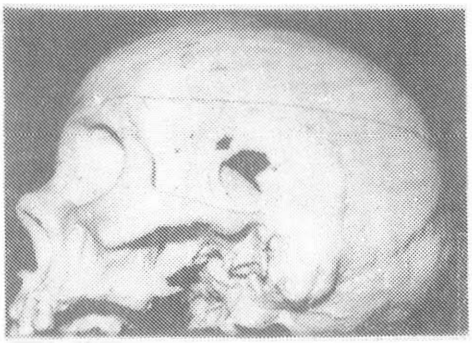
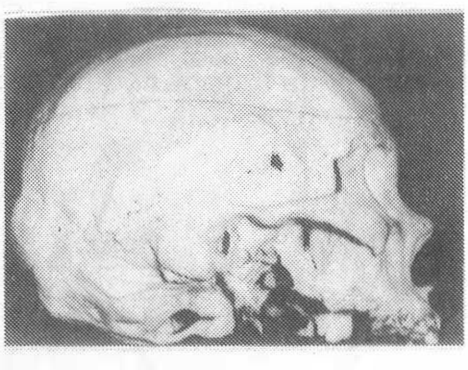


Fig.2

Acceleration-time-curve and the total depressed fracture(test no 38 in table 1)



The acceleration-time-curves from test 38 and 40(fig 2,3)are demonstrated. Test 38 resulted in a total depressed fracture(fig. 2),whereas test 40 yielded only a slight depression(fig.3). Generally the tendency was observed that in cases of fractures the measured accelerations(resp-forces) are smaller than when the skull remains intact.



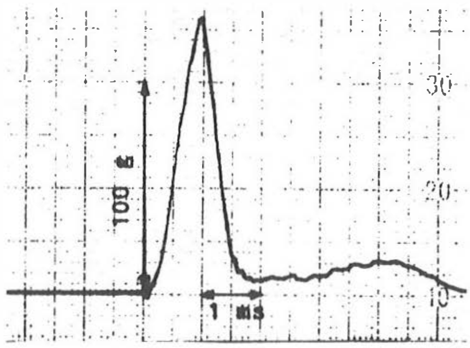


Fig. 3 Acceleration-time-curve and the slight depressed fracture(test no 40 in table 1)

Of course this is true only for comparable energies. The reason for this is that in the case of a fracture the falling-body is slowed down less than on other impacts.

DISCUSSION

The accidents frequency connected with skiing is, as explained, often due to excessive speed or not adequately adjusted speed, as it also often is the case with automobile accidents (1,6,8,9,10,11). The head injuries which in our presentation required surgical treatment were due to very characteristic injuries, namely foremost "depressed fracture" in 84% (children 92%) of the cases, with or without accompanied by brain contusions or hematomas (8). A depressed fracture caused by direct local small force application is often the result of speed (fig. 4). Penetrating injuries like a depressed fracture in skiing, most frequency necessitate an operation.

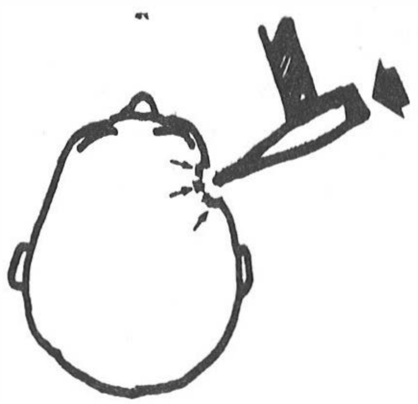


Fig. 4

Direct small local impact energy occurred a depressed fracture.

Generally, the impact energy grows with the square to the speed, that is double a speed results in four-fold an energy, etc. Due to the ever-increasing speed this same effect is true in the various types of sport and in traffic.

The damage to the object by the impact energy depends upon: (a) The direction of the energy (vertical or oblique) and the form (blut or sharp). (b) The circumstances of the objects (flat or arched (fig. 5), smooth or rough). During the experimental study, we were observed by cinematography, by oblique impact-energy no depressed fracture occurred as compared to vertical impact-energy (fig. 6).

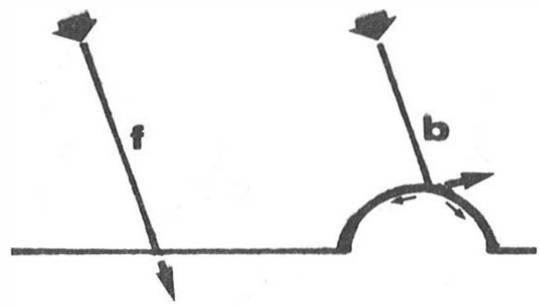


Fig. 5

Different reaction of the impact-energy: flat (f) compared to arched (a).

Also, if the object was arched no damage happened compared to flat objects, because most of the energy slipped off by the arched forms. An arched helmet in the temporal region protects against penetrating-perforating skull injuries, for example(8,9,10,11).

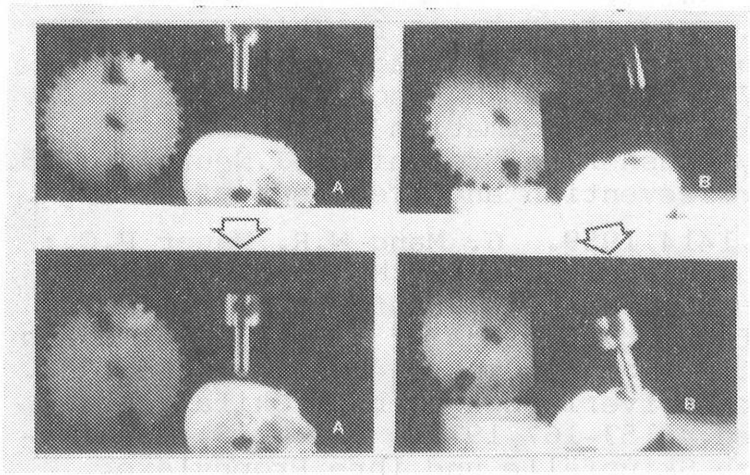


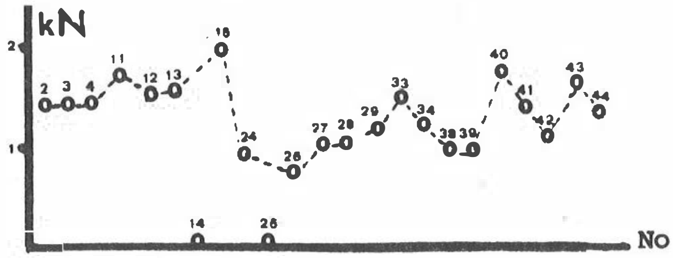
Fig. 6

Cinematographical observation:
A - vertical impact with fracture
B - oblique impact without fracture

In the present study a tolerance threshold of about 1 to 2 kN(with an impact speed of about 16 km/h and an impact energy of about 11 joule) was observed for a depressed fracture in the temporal region(fig.7), which happens often in skiing.

Fig. 7

The forces in the temporal region (column 7 in table 1)



A skiier drives an average of about 30-50 km/h. Upon impact at this speed is a great risk of skull injuries. Based on this study, a proper head-protection gear must be demanded for the prevention of head injuries in sports that are performed at speed of more than 20 km/h, especially for children and young skiiers(fig.8).

Fig. 8

Smart head protects themselves

and

Helmet protects life

REFERENCES

1. Baumgartner W.: Die Sicherheit der Skiabfahrt.Münchn. Med.Wschr.102,2220,196o. 2. Gosch H.H.,Gooding E.,Schneider R.G.: Distortion and displacement of the brain in experimental head injuries.Surgical Form.20,425-426,1969. 3. Gurdjian E.S.,Hodgson V.R.,Thomas L.M,Patrick L.M.: Significance of relative movements of scalp,skull and intracranial contents during impact injury of the head.J.Neurosurg.29,70-72,1968. 4. Hodgson V.R.,Gurdjian E. S.,Thomas L.M.: Experimental skull deformation and brain displacement demonstrated by flash X-ray technique.J.Neurosurg.25, 549-552,1966. 5. Kraus H.: Prevention and treatment of skiing injuries.J.Amer.Med.Ass.169,1414,1959. 6. Mang W.R.,Mauer P.C.: Der tödliche Skiunfall.Orthop.Klin.Techn.Univ.München.94/3,107, 1976. 7. Nahum A.M.,Gatts J.D.,Gadd C.W.,Danforth J.: Impact tolerance of the skull and face.Proceedings of 12 stapp car coach conference,P-26,New York.Society of automotive enginners Inc,1968. 8. Oh S.: Die Verhütung der Kopfverletzungen beim Skifahren. Scheiz.Zeitschrift f.Sportmed.4,157-167,1979. 9. Oh S.:Zunehmende Schädelhirn-Traumen durch Skiunfälle und ihre Prophylaxe. Schweiz.Aerztezeitung.62/3,132-135,1981. 10. Oh S.,Nisoli M.: Schwere Kollisionsverletzung beim Skifahren und ihre Prävention. Schweiz.Rundschau f.Med."Praxis"10,408-413,1981. 11. Oh S., Balmer K.,Tok S.: Tödliche Schädelhirnverletzung durch Skiunfälle und ihre Prophylaxe.Schweiz.Zeitschrift f. Sportmed.4,137-141,1981.

Author's address: S. Oh,M.D.
Department of Neurosurgery
Kantonsspital Chur
7000 Chur,Switzerland