Analysis of Belaying Techniques: *A Typical UIAA Activity*

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A joint effort in the analysis and discussion of the belaying techniques used in the Member Countries is a typical task of the UIAA. It was proposed by the Safety Commission during its 1996 Plenary Session: it was felt that the right time had come for a discussion on a subject which had caused endless debates between the mountaineers of the Member Countries. It was suggested that a joint publication, supported by multimedial documents, would provide climbers and mountaineers with an updated view of the pros and cons of several methods in various circumstances. Techniques and equipment have indeed improved to such an extent as to make it clear that no method is *the best* for any circumstance.

Since then, the progress in the proposed activity was, understandably, rather slow: a lot of field-work, documentation and theoretical analysis is necessary to support debates and conclusions in this context. The present note concerns the steps that the Italian Alpine Club Safety Commission (**CMT**) has made in order to contribute to the joint effort. In this paper only a brief and qualitative summary is possible. Our colleagues of the UIAA Safety Commission and the Member Associations are warmly invited to join in our future work.

A brief look into the past

The Italian Alpine Club "Safety Commission" (CMT) started its work on belaying techniques during the late '60s. The writer of this note was a new member of the CMT when the problem of belaying was discussed by the UIAA Safety Commission during its Plenary Session at Andermatt, 1974. Several practical demonstrations took place on that occasion; I regret that I was not present, since I could have witnessed the somersault of Pit Schubert, who was attached to a too long safety rope when he demonstrated holding the fall of an 80 kg mass by means of the traditional shoulder-belay. He came out of that experience with only slight body injuries, far less serious than those experienced by Dietrich Hasse at the and of the '50s, when he tried to hold a long fall with the Kreuzsicherung (ropes crossed around the chest) method.

Those were the times when the CMT was studying the belay system called Mezzo Barcaiolo (MB), developed by Mario Bisaccia, Franco Garda e Pietro Gilardoni. I have pleasure in mentioning those friends (who are no longer with us), since the MB has proved to be a very valuable braking system, a great contribution to mountaineers' safety.

A great progress has been made since then, related to the development of the MB and of the Sticht Plate:

- The Sticht Plate (a small plate provided with a slot, through which the rope is passed before clamping it into a karabiner) had been developed during the late '60s by Fritz Sticht and had soon become the favourite belaying device of British and American climbers. It is a very *dynamic* device, therefore it has evolved into the presently more popular TUBER "family" (the same basic concept, but with a more pronounced U-shaped path of the rope within the device).

- The MB (Mezzo Barcaiolo = Demi Capstan = Halbmastwurf) is such a simple tool that the only possible development concerned the kind of karabiner used with it; this karabiner is now called HMS (Halbmastwurf-Sicherung) in UIAA standards. The MB name means "a half of the knot which is used by the sailors to secure a boat to a bollard in a harbour". The fact that the Britons call it the "Italian Hitch" does not suggest, I am afraid, any particular consideration for its inventors but, rather, lack of interest for the device, such as to lead to no particular name for it. The "English Speaking" climbers have indeed always consistently opposed the MB, basically because in their opinion it is too "static" for their body-belay system. The Americans did even worse than the Britons: they called it Munter Hitch, referring to a Swiss guide of name Munter who demonstrated the MB, or a similar braking device, during his visit to mountaineering circles in the USA, sometime during the '70s. I wonder how the UIAA Safety Commission was able to agree to call the MB "UIAA knot"! I regret I was not a member of the Commission at that time.

Why such a long discussion about names? Because it is a reminder of the difficulties that mountaineers belonging to a certain "area" have in accepting foreign methods. Now the regional differences are fading away, I hope; therefore it can be accepted that all presently available methods are useful and the mountaineers should be put in a position to choose the best method, depending on circumstances. This is why the UIAA action in this field should be pursued, in order to avoid misconceptions.

The past work of the Italian Alpine Club Safety Commission (CMT)

We were convinced from the beginning that it was imperative to be equipped with a "playground" where it was possible to obtain long free falls without friction: the presence of a large amount of friction in practically all real falls is a great advantage in mountaineering, but it conceals a number of basic factors which are fundamental for the analysis of the dynamic belay process. Friction can be easily introduced when necessary, the difficulties are in avoiding it.

Our first demonstration occurred on occasion of the UIAA Safety Commission plenary session in Venice, 1979. The CMT and the Padova Moun-

taineering School had equipped a high climbing wall, where it was possible to get free falls of an 80 kg mass up to 45-m height, with additional space for rope sliding. I had the privilege (!) of demonstrating how to hold a 30-meter free fall without intermediate runners by means of the MB technique. I was wearing a glove, which was necessary to let the rope slide in my hand about 15 m! That was the first demonstration of the "slip ratio" (length of rope slipping in the belayer's hand, divided by the total free fall height), which is the single parameter determining the average belaying forces. This ratio was subsequently used by the CMT as a characteristic parameter for any belaying device, though the slip ratio depends to some extent also upon other factors, such as belayer's hand strength and rope type.

On 1980 "The Tower", as we call it, was built in Padova: a 16-meter high tower, where a steel mass can fall, without friction, along two columns; on the tower a large number of tests can be performed in a short time, due to the electrically operated lifting of the mass.

The work on the tower was focussed for a long time on the analysis of belaying devices and related techniques. Particular attention was put on teaching the climbers that slippage of the rope is inevitable, if friction of the rope against the rock doesn't help. Many features of the belaying action were demonstrated; e. g. it was clearly shown that the maximum and average value of the braking forces occurring during dynamic belay (not their duration!), and consequently the load on the last runner, are practically independent of the free fall height.

At the beginning, we had to devote most of our efforts to convincing the climbers that in the large majority of real cases the friction between rope and rock is determinant in holding the falling climber; consequently, testing belay at the tower was essential to appreciate what can really happen in a bad (though unlikely) case, i. e. when there is no friction. In more recent years, the CMT has started producing films, aimed at analysing the facts occurring during the belaying action. Two films were shown during UIAA meetings:

- 1996: a film concerning the comparison of rock-belay against body-belay on a real rock face, with real people falling with a fall-factor 2 up to a 14-m height from over an overhang: by using or not using runners, cases with and without friction were compared. The attention of the audience was focussed on the need to optimise the belayer's attachment to the stance, in order to avoid being thrown into the air or against the rock.

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Fig. 2: Classical stance arrangement, with MB (HMS) belaying device

◀
Fig. 1: The rock face equipped with runners. The overhang is essential to obtain a clean free fall of the mass.

▶
Fig. 3: Stance arrangement for body-belay, with figure-of-eight belaying device

photos: C. Zanantoni

- 1998: a film concerning the comparison between combined (chest + seat) and seat harnesses. The comparison was extended to the progression on glacier, in order to confirm the results of ENSA, previously published by J. F. Charlet: the seat harness is definitely better in this case.

Recent work of the CMT

During 1998 and 1999, a few hundred tests were conducted on rock and on the Tower, comparing belay devices and belay systems, use of single rope and twin ropes, rock-belay and body-belay.

Representatives of the Italian Guides participate in our exercises; one of the major points in our discussion is the different opinion of Guides and CMT concerning body-belay. The Guides use it in any case, the CMT position is more diversified and presently under discussion. It would be very interesting for us to have UIAA colleagues participating in our debate.

At the moment, the CMT attention is focussed on improving the understanding of the belaying process by means of an analysis of its basic parameters, such as: type of device, position and weight of the belayer, length of slipping rope, amount of friction along the rope. The major aim is at the moment the evaluation of the load on the anchor points and on the last runner, which is pulled by the joint action of two strands of rope.

During 1999, two experimental sessions were held at Passo Rolle (Dolomites region). A rock face was equipped with runners up to a height of 12 meters (Fig. 1). An 80-kg steel mass was raised 2 m from the last runner above an overhang, thus providing a 4-m free fall.

Peak forces and, more recently, full plots of the forces occurring in two or three points of the belay chain were recorded. In the two sessions, about 100 cases were studied. Other sessions will follow shortly, probably at Padova next June: the Tower has been equipped with a dummy rock face; the parameters will be analysed more carefully than was possible at Passo Rolle. A computer model is being used to evaluate the results.

Notes on the results

Our set of tests is not completed; the CMT wants to perform more work before our results are published. However, a couple of points are mentioned here in order to stimulate discussion.

Use of twin or half ropes to reduce the load on the last runner

This topic is generating a lot of discussions, in relation to the doubtful strength of runners placed on lousy rock faces or on ice walls. The load on the last runner, it is alleged, is very much reduced if two twin or half ropes are used and they slide on two "parallel" lines, alternatively clamped into different runners.

[Let us confine the discussion on this single statement, leaving aside the critiques of those who, like the writer of this note, maintain that -a) clamping the two ropes into different connectors is not a good practice from the point of view of safety because it reduces the advantage of using two ropes, particularly in view of the danger caused by sharp edges -b) the rope-drag force increases if the two ropes run on aligned runners: in this case the karabiner must indeed often act as separator of the two ropes, which are usually twisted].

Our tests have confirmed that reductions of the order of 30–40 % can be reached, compared to the use of a single rope. However, the cause of the difference is only to a minor extent the larger deformation of the "thinner" rope. A simple calculation shows that this larger deformation can only lead to a maximum reduction of the order of 10 %. The major part of the difference is due to the fact that the belayer's hand is less effective in holding the ropes when only one of the two is slipping. This is clearly shown by measurements of the slippage. From these remarks it appears that the advantages of this technique are more appreciable in case of ice climbing. Indeed in this case the cutting edges are less frequent and very "dynamic" devices can and must be used: the reliability of the runners is doubtful and the slippage of the rope is made easier by the use of gloves.

Fig. 4: The belayer is lifted up by the rope.

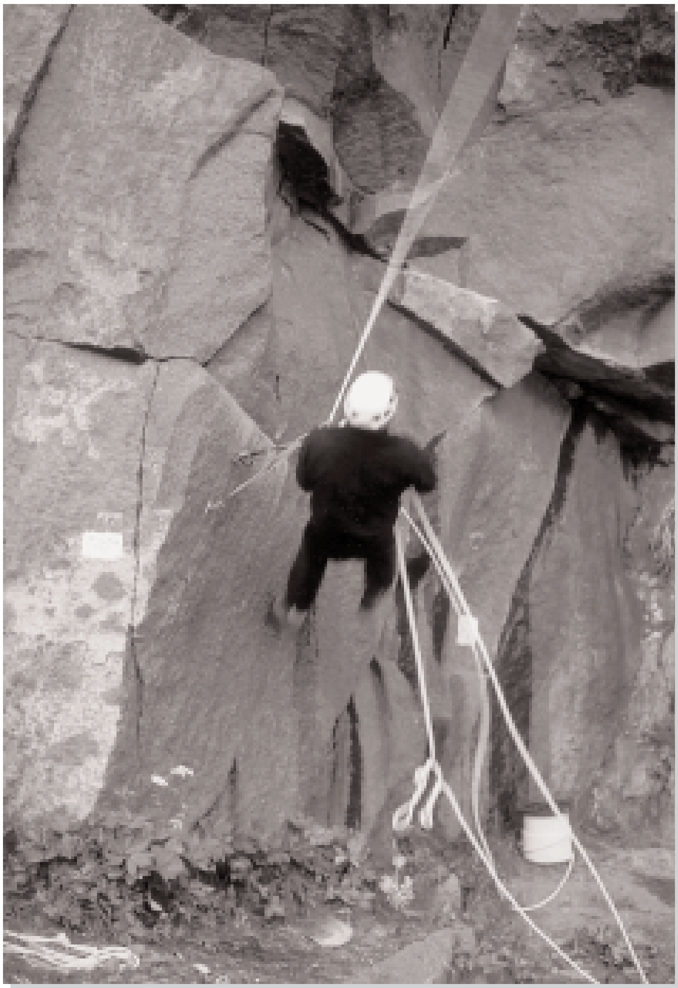

Fig. 5: Final position of the belayer.

photos: C. Zanantoni

Remarks on body-belay

Figs. 2 and 3 show the stance arrangements.

Figs. 4 and 5 show how the belayer is pulled up by the rope.

The CMT recognises that body-belay is often the best choice when the stance is bad; it is also a necessary solution when certain types of belaying devices (say a Sticht plate) are used. But are we really sure that using the belayer's body as a counterweight always leads to a reduction of the load on the last runner?

Our experimental results, confirmed by computer simulations, show that this is not always the case, depending on the circumstances. In the body-belay process the first phase is "inertial", i. e. the inertia of the belayer's body prevails over the braking action; it is followed by a "frictional" phase, where the braking action of the device prevails. The inertia of the belayer's body can lead to a higher peak load on the last runner, compared to the load caused by the regular slippage of the rope in a device attached to the stance. The role of the inertia is tricky; e. g. it is not always true that the load on the last runner is lower when the friction along the runner's chain is lower: the pull on the belayer's body is stronger in this case, so that his inertia can be the prevailing effect in determining the forces on the last runner. Depending on the circumstances, an increase in the belayer's mass can lead to a reduction or an increase of the load on the last runner or on the stance.

It would not be right to insist on these tricky details without quantitative explanations. I just made these few remarks to stimulate collaboration within UIAA: I hope I didn't produce the opposite effect.

Conclusions

Our work leads us to a better understanding of the factors affecting the various belaying techniques. We believe that each has its own advantages and the choice of the optimum method varies with circumstances. We are still investigating details of the belaying process and would welcome to join a broader UIAA effort in this field.

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