SOMETIMES THE LEADER DOES FALL...
A LOOK INTO THE EXPERIENCES OF ICE CLIMBERS WHO HAVE FALLEN ON ICE SCREWS

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INTRODUCTION/BACKGROUND

Last winter a climber with Adventure Spirit Rock+Ice+Alpine was asking me about the holding power of ice screws. We discussed the various lab studies that have been done (a list of links to some interesting ones can be found at the bottom of this paper) then he said, "That's great, but has anyone ever specifically done research into how they actually perform in the field?" He had a point. While the dictum in ice climbing is that "the leader never falls," in the end, they sometimes do. So presumably there was an ample population from which to sample—but I was unaware of any actual field research done with this population. So, fueled by that question, I decided to explore the topic. The results of this inquiry appear below.

Though I have a background in research, make no mistake: This presentation of findings should not be viewed through the same lens as academic research. Aside from running it by a few academic-climber friends there has been only an informal peer review, there are significant short-comings in the methodology (noted below), and ideas are put forth that don't necessarily build directly on prior research (largely because—as noted—there really hasn't been much research on the topic and much less field research).

In addition, this write up is not done in the typical "5 Part" research format of Introduction, Methodology, Results, Analysis, and Conclusion. Moreover, the tone and style of the presentation is hardly formal. It is meant to serve more as a data point for discussion among practitioners than as an iron-clad academic addition to the body of research on ice protection.

IMPORTANT INFORMATION: This is paper is presented as a useful piece of information for climbers to add to their decision-making toolbox more than any kind of definitive evaluation of the effectiveness of ice screws in the field. Each and every climber must make his/her own decisions regarding risk management and safety and this author and any people associated with aiding in this study or in its dissemination bear no responsibility for accidents or injuries that may occur to people after reading this information. Each and every climber must make his/her own decision about the ice conditions and screw placements and take responsibility for the decisions made and the consequences wrought. This is not only the duty of the climber—indeed it is the essence of climbing, its appeal and allure.

Based on initial reactions to my survey (you can find one thread HERE), I can only imagine the reaction this paper may elicit among those with plenty of time for critiquing but seemingly very little for mounting research of their own. While some online commenters raised important questions regarding the methodology (the survey originally omitted a question about fall factor), the tone of some people's comments points sadly to the deficit of civility that occurs in the relative anonymity of online forums. We would never interact with each other in this way at the cliffside, why should it be any different online? **Anyone reading this paper who has constructive comments to make is encouraged to own his/her comments and connect with me directly at tkrossiterclimb@gmail.com. For those who only seek to complain or point out various shortcomings in the research online, please direct your energy more productively and immediately set about creating a better study—there is certainly a need for it and the ice climbing community will thank you for it.**

RESEARCH DESIGN BASICS

A ten question survey was created on Survey Monkey. I would have liked to have added more questions, but Survey Monkey's free service limits surveys to this length, and since it was my first attempt at this sort of project I kept costs as minimal as possible. A link to the survey was distributed via contacts in the guiding/climbing world and via forums such as NEice.com . You can review a copy of the survey (revised mid-stream to query about fall factor) at THIS LINK. In brief, the survey asked climbers:

1. Did the screw hold?
2. How far did you fall (*and an estimation of fall factor was later added – but due to limited responses, not included in analysis)?
3. Length of the screw?
4. Steepness of the ice?
5. Method of attachment between screw and rope (quickdraw, screamer, alpine, direct)?
6. Type of rope method used (single, double, twin)?
7. Subjective estimate of ice quality?
8. Did injury result?
9. How confident are you now in ice screws?
10. Any comments regarding changes in attitude?

Questions 2-10 offered participants the opportunity to insert comments. Participants who fell on a screw that held (n=43) only filled out one survey. Participants who fell on a screw that pulled (n=3) were asked to fill out another survey; 2 of these participants filled out a second survey and none filled out a third. So, in total there were n=48 responses, with no participants in this study indicated pulling more than one screw in a single fall.

The responses were compiled using an Excel spreadsheet and the data analysis function within Excel was used to analyze the quantitative data. Special thanks go to Ben Mirkin from Lyndon State College's Mountain Recreation Management program for his work on the analysis (though any faults in the interpretation or presentation of that analysis are mine!).

KEY DATA FROM THE STUDY:

- Of the 44 respondents, 3 had their first screw pull, so 6.5% pulled or—more positively—93.5% held. No respondents indicated a second screw pulled.
- Thirty-nine percent of respondents fell 11-15'. About 35% fell less than 11' and about 20% fell more than 15'.
- Fifty-nine percent of the respondents fell on 14-16cm screws; 22% fell on shorter screws, 19% fell on longer ones.
- Forty-one percent fell on WI5, 35% on WI4, 22% on WI3, and 2% on WI2.
- Following a fall on an ice screw, most people (48%) maintained the same amount of confidence in ice screws as protection and 37% had more confidence; 9% had less confidence and 7% had much more confidence.
- Seventeen percent of the falls resulted in injury, 83% did not. Lacerations, contusions, punctures, and sprains were reported; it appears that none of the injuries were serious or involved long-term rehabilitation.

Relevant aspects related to this data are presented below.

DISCUSSION

Fall Factor

It makes the most sense to address the issue of fall factor first. The dynamic ropes that we climb on absorb force, so the more rope that is "out" the more "spring" there is in the overall system, producing less force on the anchor in question. Fall factor is an important aspect in considering the actual force put on a screw during a fall. Fall factor is determined according to the equation:

FF=L/R, where FF is "fall factor", "L" is "length of fall", and "R" is "length of rope in the system"

The first version of the survey did not include a question inquiring about fall factor. This omission was pointed out on the NEIce.com forum (you can find the thread HERE). By that point, the bulk of survey responses had come in, such that of the total respondents (n=44 respondents with n=3 filling out a second survey due to first screw pulling), there were seven that provided precise fall factor data. Given this small sample size, it wasn't possible to glean any statistically significant conclusions related to fall factor.

When discussing whether or not an anchor holds, one cannot overlook the role fall factor plays—after all, more force on the anchor leads directly to the likelihood of failure. Because of such a direct relationship, fall factor has long been a favorite point of focus when discussing climbing falls. However, over time there has been a steady stream of opinion cautioning against the use of the simple FF=L/R equation when determining actual fall factors experienced in the field. Like so many laboratory equations, the equation for determining fall factor becomes theoretical when translated into the reality of the climbing environment. There are many reasons for this:

- In the field, squishy human bodies, harness stretch, and soft catches all moderate the FF=L/R equation, making the vaunted "fall factor of 2" unlikely.

- Perhaps more importantly, as Petzl points out HERE, when a lead rope angles through a piece of protection, it essentially diminishes the dynamic capacity the rope might otherwise provide below the piece. To summarize: “The theoretical fall factor does not take into account the rope friction...if a climber does not take the necessary steps to avoid rope drag, the actual fall factor can quickly increase.” So, a theoretically low fall factor could, in fact, produce dramatic fall factors in the field.

- A final field variable that throws off theoretical fall factor computations concerns moisture in the rope. Wet ropes lose significant strength, as Mammut Hardgoods Category Manager Dave Furman explains:

  Many dry-treated ropes absorb between 15 and 50 percent of their weight in water, and this water may affect the fall factor as well. In addition, it may be important to differentiate between liquid and frozen water in a rope. Liquid water in a rope will significantly lower the number of test falls a rope can withstand before it fails. A rope that absorbs 45% of its weight in water during the UIAA dry test will only hold about 30% of its fall-rating worth of falls before it breaks, if saturated.

- That moisture can potentially be all the more damaging in a freezing environment. Dave Furman goes on to explain:

  There is some evidence that frozen ropes lose elasticity and might perform more like static ropes, increasing fall factor due to frozen water reducing the ability of individual fibers to move within the structure of the braid. Although water in a rope reduces the ropes ability to withstand repeated impacts it’s much less clear how frozen water may be different--this is quite difficult to test because no drop-towers are capable of being held at below-freezing temps over the course of a test, so the "frozen" water in a rope that is tested is always liquid after the first fall due to heat from friction within the rope caused by the fall itself and doesn't re-freeze, so the test isn't really representative.It's likely the rope will exhibit very different impact characteristics with frozen water in it than it would either dry or with liquid water, and that doesn’t even consider the difficulty handling a frozen rope.

Fall factor is a very important component when seeking to determine the impact force put on an anchor. That said, there is risk in overestimating the role fall factor plays in producing force on an anchor. Future studies on the efficacy of ice screws in the field would do well to question participants about the fall factors they experienced, but should also investigate factors such as rope moisture, icing, and drag.

Injury

Though this survey data indicates that ice screws of varying lengths, when placed in decent ice, are reliable anchors, that is only one part of the fall equation. The other part of the equation concerns the fact that ice climbers fall with many more sharp and shear points than does a rock climber. As such, even when the protection holds, substantial injury and even death could still potentially result.

Of the 44 survey respondents, 17% reported injury. While respondents noted an array of unpleasant injuries ranging from concussions to contusions, none of the injured parties reported injuries requiring assisted evacuation and most appeared to not involve medical intervention and subsequent rehabilitation (e.g., broken bones, large lacerations, internal injury, etc).

So, while there is ample evidence that ice climbing falls can kill, the statistics in this survey indicate that on average, injuries sustained in lead ice falls are moderate. Additionally, on average, there did not appear to be any significant relationship between either distance of fall and injury or steepness of ice and injury.

The Learning Curve

"The leader never falls!" is what we hear so often in the ice climbing world, but *when* the leader *does* fall, how does that affect his/her subsequent climbing attitude and experiences? No one in this study indicated hanging up his/her tools after a fall. While a few (n=4) indicated having less confidence in ice screws even after taking a fall, the majority held their confidence level (n=22). Seventeen indicated "more confidence" and three indicated "much more confidence." For this question, the subjective data may be more interesting. Several indicated that their experiences underscored the mantra at the head of this paragraph. Of those who provided subjective data on injuries sustained, respondents reported:

- *Should have [been injured], wound up hanging upside down 3' off the deck.*
- *Puncture wound on upper right thigh from left crampon's heel points. The fabric of my pants was not cut, but the skin on my thigh had a puncture wound. No medical treatment necessary.*
- *Bruised hip.*
- *[My] head struck lower angle ice below steeper section- concussion and laceration resulting.*
- *Painful contusion on my quad. I healed up completely in 3 weeks.*
- *Hematoma left hip.*
- *I vomited heavily after subsequently topping out.*

And though all the respondents in this survey seemed to walk away largely unscathed physically from the falling experience, as the final comment above indicates, the falling event did extract a heavy toll on many respondents psychologically:

- *I was spooked and have made it a goal to never again fall while leading ice.*
- *I never want to fall again, end of story. I was 100% fine, but I realize how easily it could have gone horribly worse.*
- *I'd soloed the route I fell on several times, and it made me re-think whether I'm really 100% in control while soloing.*
- *I became hesitate to climb 90 degree and WI4+ and up.*
- *Loss of confidence on the next couple of leads. That came back after I proved myself.*
- *I feel like my lead head was affected. I still lead climb but it crosses my mind more often nowadays and it has been a process feeling confident again in my ability.*
- *I am now more cautious on steep ice and work harder to get great placements.*
- *I learned not to try and punch through a crux on ice like you might on rock. Now, I try*

to ice climb with a much greater degree of control.

Perhaps, like the old adage goes, “If you're not learning, you're dying”: The respondents in this survey make it clear that they learned from the falling event and that they don't carry the same attitude to ice climbing that they might to the sport climbing crag. The subjective reports of their experiences make it clear that the experience of falling on an ice screw was not taken lightly and substantial reflection ensued for many.

WRAP-UP

Research Limitations and Recommendations

Enough has been said above about fall factor and it should be included in future research. This study may have other limitations. One primary limitation could exist in terms of 1) who falls on ice screws, 2) how that affects them, 3) how this survey was broadcast, and 4) who responded to it. Falling on ice screws is at a minimum scary (as even the respondents of this survey indicated). It can also cause severe injury and even death. It may well be the case that the psychological trauma of falling on an ice screw causes a person to decide to quit ice climbing. Others may encounter severe enough injury that they are simply unable to ice climb again. Others may be dead. This survey was broadcast through channels directed toward those who are currently ice climbing and all of the potential respondents mentioned above simply may not have reached. So, results from this study regarding amount of injury sustained, changes in attitude following a fall, and other factors, may not truly represent the entire population of climbers who have fallen on an ice screw. Future study on the topic should consider ways in which to reach those people who may have fallen on an ice screw but may no longer be climbing.

A more important limitation of this study is—happily enough—an outgrowth of one of the primary finding of this study: In field applications, ice screws typically do hold a leader fall. As a result, there was a very small data set of climbers whose first ice screw had pulled (n=3) and no climbers whose second screw had pulled. With such a small data set to work with, it wasn't possible to establish any definitive finding about the factors surrounding ice screws pulling (e.g., fall factor, screw length, ice quality, etc). Future study on the topic will need to cast a much wider net, so as to capture a larger sample of climbers who have actually had ice screws pull when falling on them.

In addition to the information collected in this study, future studies should include information on fall factor, angle of screw placement in the ice and ideally, include a much larger sample. Ideally, a ‘regression equation’ would be compiled that could enable climbers to compute different factor such as length of fall, with or without screamer, on single vs. double ropes, etc. to see what the failure point of a screw is for someone of their weight in average (if that exists…) ice conditions.

Recommendations for Field Application

Make no mistake—it's still a bad idea to fall on ice screws. Even though the research

indicated they hold over 90% of the time, you're still falling with a bunch of hard, sharp points that can puncture soft flesh and catch on soft ice. And even for the strongest of climbers, falling is a possibility. We do not control when we fall and we control even less of what happens once we fall.

There is so much in the world that we do not control and it is no different in the climbing world. But in the face of that unceasing uncertainly, climbing offers us the opportunity to take control of—and responsibility for—our actions. It is a refreshing antidote to much of modern living. You should not ice climb unless you are ready for that antidote, nor should you use any of the ideas, information, or opinions expressed in this paper unless you are ready to assume complete responsibility for your actions and the outcomes. Should you choose to use the antidote, enjoy all it offers fully.

Acknowledgments:

The strength of this research and analysis were bolstered by the statistical expertise of Ben Mirkin (Associate Professor, Lyndon State College, Mountain Recreation Management) and the technical information and analysis of Dave Furman (Hardgoods Category Manager at Mammut North America). I give them both many thanks and owe them both many belays! *But, to be clear: All of the limitations and shortcomings of this study are mine alone.*

Additional Resources/Reading:

http://www.needlesports.com/catalogue/content.aspx?con_id=095232e4-4caf-49ec-8495-9c9e00a633da

http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-622-experimental-projects-ii-fall-2003/projects/alziati_bennett.pdf

http://hmga.gr/storehouse/word-acrobat/Ice%20Climbing%20Anchor%20Strength%20-%20MRA%202009%20-%20Marc%20Beverly.pdf