Blue Ridge Mountain Rescue Group

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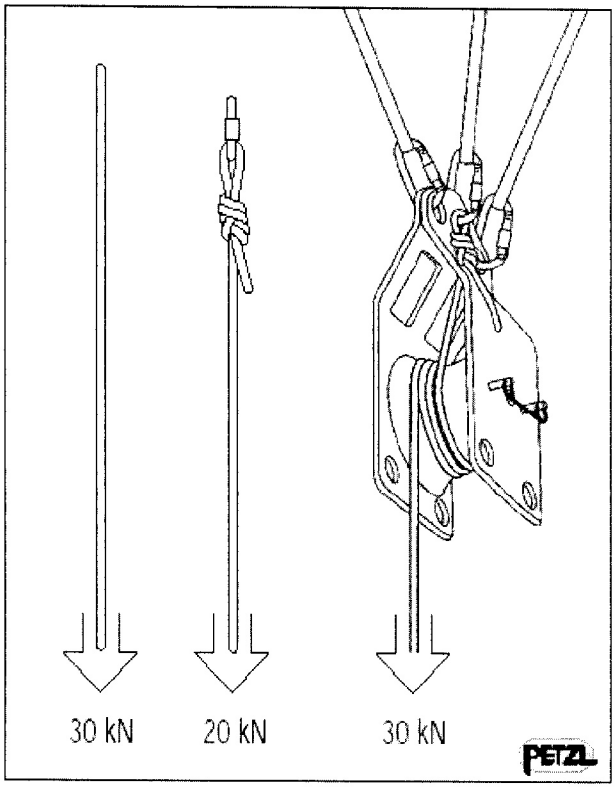

Introduction to Anchors and Technical Litter Rigging

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Task: To gain introductory knowledge on proper anchor building and technical litter handling during ropes rescue.

Conditions: Ropes, cord, webbing, carabiners, and other hardware for students to view and practice with; knowledgeable instructors and an indoor/outdoor classroom environment.

Standards:

A) Understand the basic safety aspects of a safe anchor rigging

B) Gain proficiency in constructing basic Single-Point anchors:
   (1) High-strength tie-offs;
   (2) Use of Kootenay Carriage as an anchor;
   (3) Webbing anchors;
      a. Wrap 2-Pull-1;
      b. Wrap 3-Pull-2;
      c. Slings

C) Multi-Point Anchors:
   (1) Understand advantages & disadvantages;
   (2) Understand dangers of tension in Multiple Anchor Rigging;
   (3) Demonstrate basic equalization principles;
   (4) Describe application of pre-tensioned back-ties;

D) Understand basic rigging in technical litter handling:
   (1) Rigging for lower;
   (2) Rigging for raise

Introduction

The rigging principles that follow are written for rescue and caving scenarios. Many climbing and mountaineering references recommend alternative methods. Climbers employ 'light & fast' means of vertical movement and rely on a great deal of man-made anchors. Because forces encountered in climbing are often much less than those in rescue, such techniques are acceptable for climbing but NOT for rescue use. The techniques and principles of this Introduction focus on very strong and reliable anchor-building methods suitable for rescue use.

Rigging Criteria

1. The rigging should provide for easy as well as safe access to the top of the drop.
2. The rigging should be as strong as the rope.
3. The rigging should allow the rope to hang free to avoid any unnecessary abrasion.
4. The rigging should avoid hazards such as waterfalls, loose and unstable rocks, sharp edges, mud, or curved breakovers.
5. After rigging, the rope should be long enough to reach the bottom of the drop or a step-off ledge.
6. Whenever possible, use a natural rig point to preserve our nonrenewable resources.

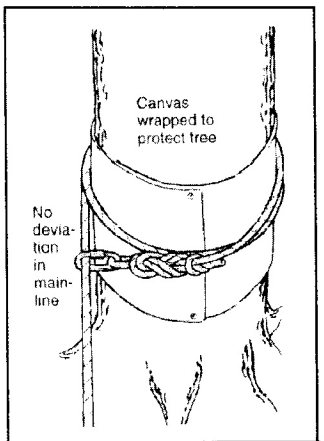
The rigging should be done in a safe, strong, and reliable manner. *RIG HIGH* (set up the anchor above the ground) whenever possible to provide better access to the rope, save on padding, and help the rope to hang free.

Single-Point Anchors

- Any rigging that relies on just one anchor point must be *bombproof.* The anchor rig point must be very strong, at least as strong as the rope itself (30 – 60 kN; 6,000 – 13,000 lbf.).
- Use *natural anchor points* first. Only after totally exhausting all natural options should you construct artificial anchors (bolts, pitons, cams, chocks, etc.).

High-Strength Tie-Off

This type of single-point anchor uses rope friction around the rig point to secure the load.



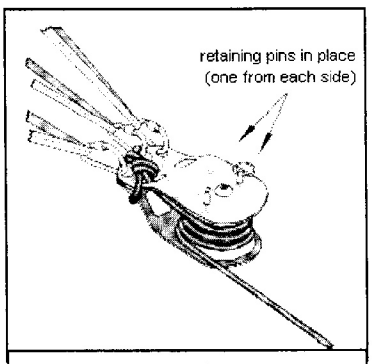
High-Strength Tie-Off

Advantages

- Probably the strongest anchor you can use.
- Can be untied while still under tension.

Construction

- Don't over-wrap the rope around the rig point using up valuable rope length. BRMRG normally recommends approximately four wraps. Some sources say only two wraps are sufficient for most anchors while three to four may be necessary for smaller diameter or smooth surfaced rig points. *"Don't just wrap the rope out of habit. Wrap the rope to accomplish a function."*
- Use a Figure-Eight on a Bite as the end knot; some references (see figure to the right) also use a carabiner to avoid the slim chance of rope rubbing and cutting.
- Tension the rope, but do not cause deviation in the main line.
- Protect rig points (trees) from damage with canvas or other padding. Many State and National Parks require bark protection prior to rigging; the padding protects the rope from tree sap, too.



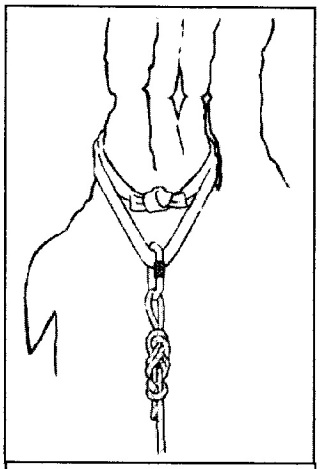
Kootenay Carriage

Kootenay Carriage

- Can be used as a High-Strength Tie-Off rig point *if the retaining pins are installed.*
- An excellent choice when connecting multi-point anchors and don't have a rigging plate to spare.
- Does not allow a knot to degrade main line rope strength (*see cover illustration).*

Webbing

Webbing is often used as an *indirect anchor* instead tying the main line around the rig point. The webbing is wrapped around the rig point and the main line is secured with a carabiner(s).



Wrap 2-Pull-1

Wrap 2-Pull-1

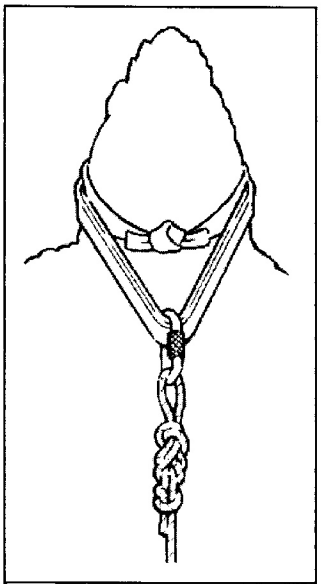
Useful when the rope will not physically slide around the rig point (a thin flake/hole) or when using a knob or boulder.

- Place the Ring Bend (Water Knot) on the point of the least tension and where it is visible for inspection.
- Remember a single piece of 1" tubular webbing is only about half the strength of ½" main line rope.

Wrap 3-Pull-2

A stronger alternative to the above method. Additional 'wraps' can be used if needed, but only two 'pulls' are generally necessary.

- Place Ring Bend as above for inspection and to facilitate de-rigging.
- Extra 'wrap' and 'pull' theoretically yields almost 77kN (18,000lbf.) of available anchor strength.

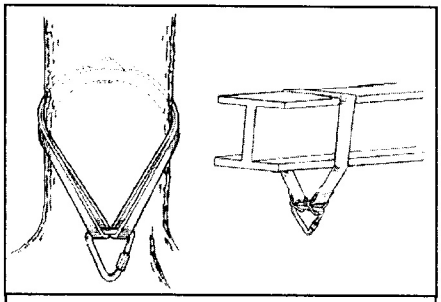


Wrap 3-Pull-2

Slings & Runners

The sling or runner is wrapped around the rig point and the ends are attached by a carabiner.

- The carabiner can be damaged or destroyed if multi-directional forces are applied off the long axis.
- Use a Delta Rapide or Tri-link if forces are three-dimensional.
- Never use a Girth Hitch in a rescue anchor. The knot applies 2-to-1 stress factors on the cordage.



Slings & Runners used; note Tri-Links to better distribute 3-D forces

Multi-Point Anchors

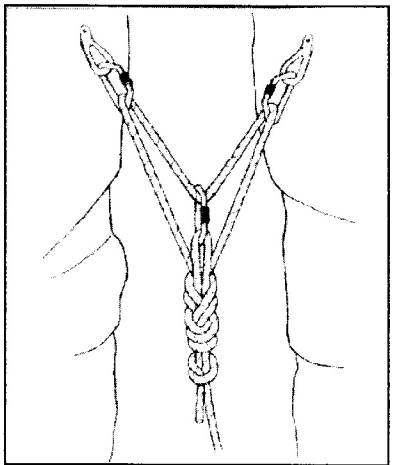
Multi-Point anchors come in all shapes and sizes. Designs can vary widely given different conditions present at the rig points. There is no 'one way' to build a multi-point anchor other than safely, and this takes knowledge and experience.

Disadvantages

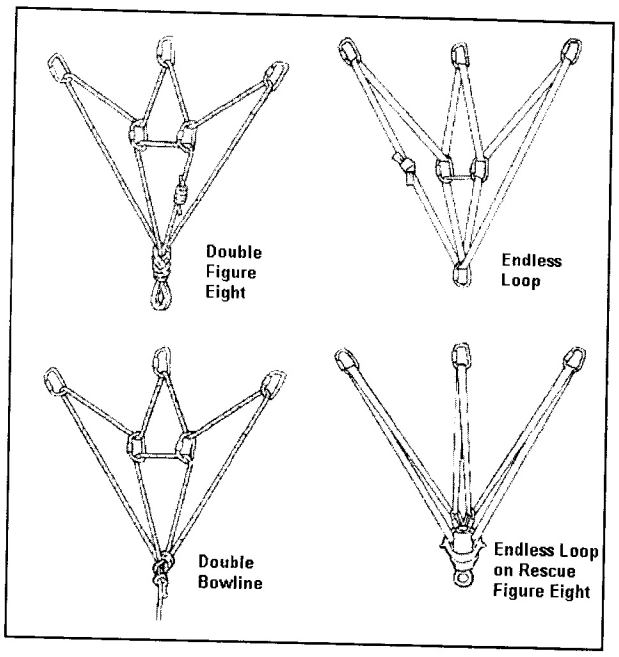
- Takes a long time to set up.
- Takes an excessive amount of hardware and software.
- Has potential for catastrophic failure resulting in injury or death.
- Takes above-average rigging knowledge.

Advantages

- Can turn two or three marginal anchors into an acceptable, usable anchor system.
- Tends to stabilize the point of attachment.



Multi-Point anchor using a Double Figure-Eight on a Bite for equalization

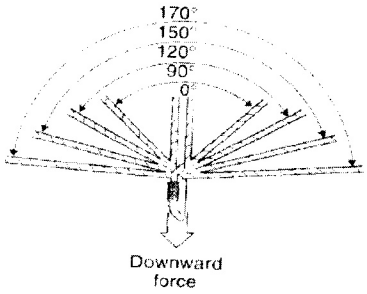


- Looks impressive (just kidding).

The Multi-Point anchor examples (left) demonstrate the wide varieties of options available. These four examples show four different ways to rig an *equalized* anchor from the same three rig points. The Double Figure-Eight method uses a length of rope or cord, the Double Bowline uses the main line itself, and the Endless Loop anchors demonstrate webbing to build the anchor.

Dangers of Tension

Rigging Multi-Point anchors presents a unique danger as angles between the downward force vector and multiple anchor rig points are created. The force exerted on a rope or a sling approaches infinity the closer the angle between the downward force and the anchor gets to 180°. A good rule of thumb is to never build an anchor with angles exceeding 90°. An anchor with two legs 150° apart puts 2x the force of the load on *each* leg.

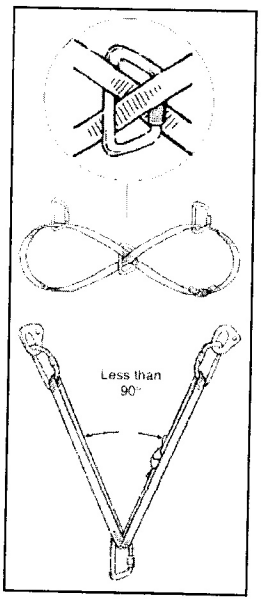


Tension in Multiple Anchor Rigging	
Angle	**Resulting Leg Tension***
170°	1150%
150°	200%
120°	100%
90°	70%
0°	50%
*on each leg relative to downward force	

Equalization

Equalization is used when the downward force needs to be distributed among two or more rig points. In rescue use, this is not often needed since each anchor should be bombproof. Equalizing marginal anchors is only the last resort.

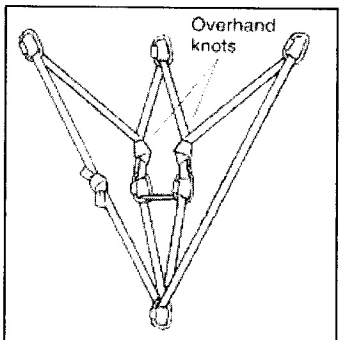
- Angle tension is critical.
- Cross the sling and clip carabiner through the X in a two-point suspension.
- Avoid anchor extension (place protective Overhand knots in sling/rope); failure of any leg may cause catastrophic failure of others.



A primary concern in equalization is avoiding tension that would overstress a rig point. If one rig point fails, the entire anchor system shifts and redistributes the load to the remaining rig points. Poorly constructed equalized Multi-Point anchors may not be able to handle the redistribution of force and all the remaining rig points may also fail.

An equalized anchor built from a sling between two rig points (right) should utilize a cross-clip technique with the central rigging carabiner for the load. This is done to avoid having the main line slip off the end of the sling should a single rig point fail. If one rig point fails, the carabiner will slide to the end of the sling and stop.

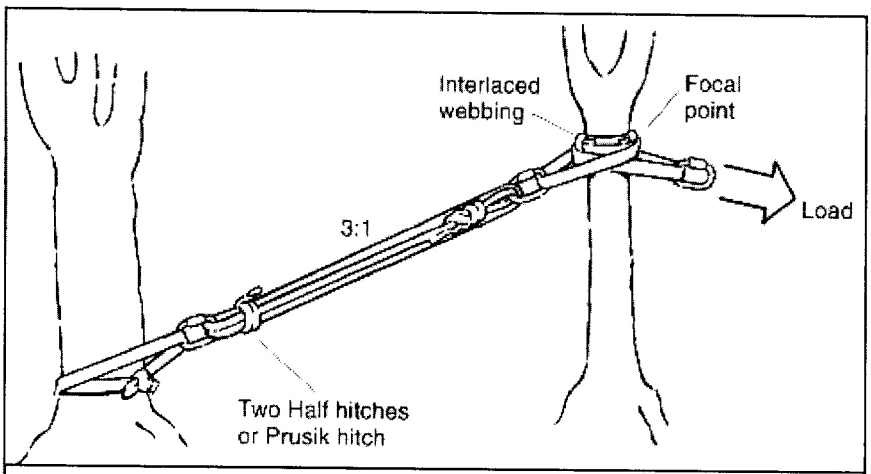
When one rig point fails in a Multi-Point anchor, a rigger can minimize the amount of force shifted to other rig-points when the sling or rope extends by placing overhand knots between equalization points. The equalized Endless Loop anchor shown earlier is made safer in the example to the right.



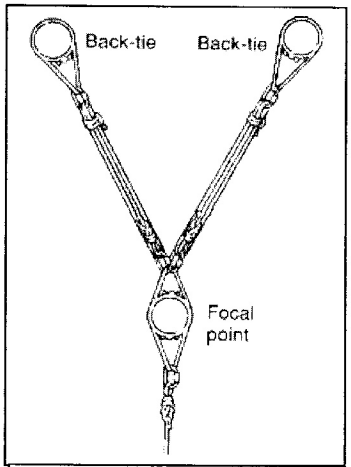
Equalized anchor using Overhand knots to minimize extension should a rig point fail

Pre-Tensioned Back-Ties

Marginal anchors can also be strengthened by backing them up with additional anchors. A second or third anchor is found and a back-tie to the main anchor is built. Be sure to readjust the back-tie after use to remove any slack introduced by creep when the anchors are loaded. This concept is similar to the tightening of a highline or Tyrolean.



Pre-tensioned back-tie built with three Wrap 2-Pull-1 anchors. Note how two webbing anchors at focal point are interlaced for security.



One anchor using two pre-tensioned back-ties

Rigging for Technical Litter Handling

Technical evacuations require more than one rope to control and secure the rescue load. One (or two) Working Lines run from the pre-constructed anchor point. A Belay Line runs from a second bombproof anchor down to the rescuers and patient. The Belay Line is a safety line while the Working Line(s) controls the movement of the litter, either up or down. *The Working Line(s) and Belay Line must be on separate anchors!*

The litter is fitted with a 'spider' harness of several long legs of webbing connected to each corner of the litter frame. These legs can be controlled by two Working Lines (head and foot) or a single line if all four legs meet at a single central rig point above the litter.

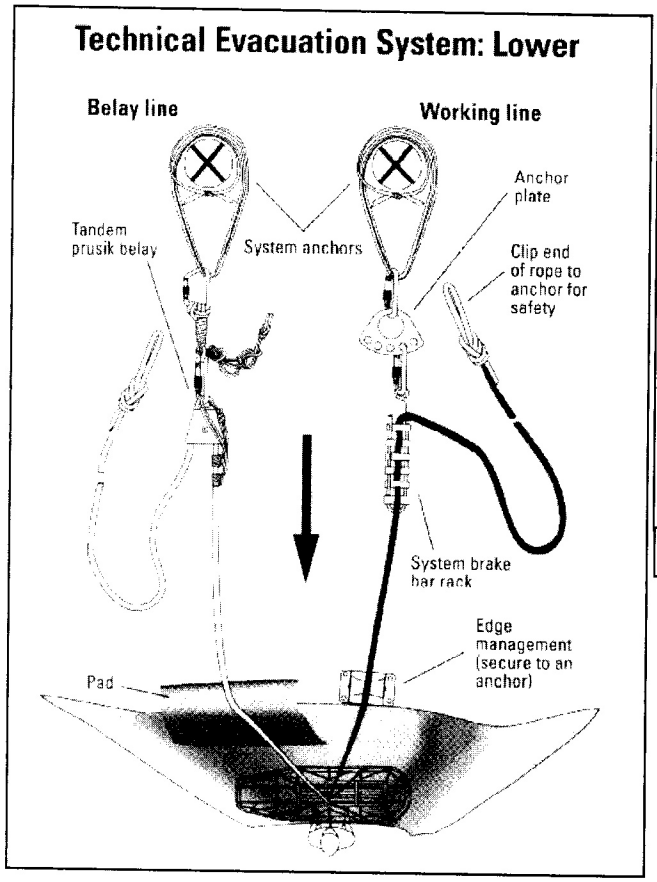
A Load-Releasing Hitch (or equivalent) is attached on the Belay Line between the anchor point and controlling device, either a PMP (Prusik-Minding Pulley) with prusiks or a belay device.

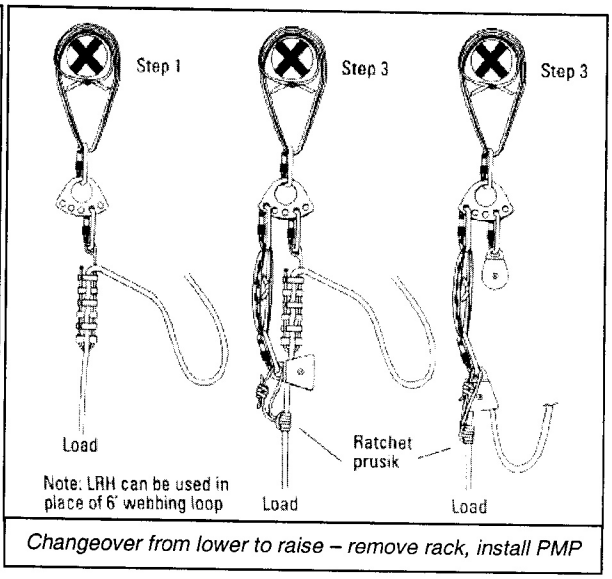
Litter Lowering

Belayers on the working line(s) control descent with a rappel rack connected to the anchor point with a rigging plate. PMPs can be pre-installed during a lower to make transitioning to a litter raise faster. Use one rack per working line. The belayer on the Belay line feeds out rope through a PMP backed up with

prusik knots or another rappel rack. If a rappel rack is used on the Belay Line, rig the line with an anchor plate between the rack and Load-Releasing Hitch (LRH).

Litter Raising
All belayers, on the Working Line(s) and Belay Line, simply reverse the direction of the ropes and use PMPs instead of rappel racks. The changeover from lower to raise on the Working line is shown as a three step process in the last figure below. This is where the rigging plate shows its use. All lines are backed up with prusiks.





Changeover from lower to raise – remove rack, install PMP

References:

Lipke, Rick. Technical Rescue Riggers Guide, Revised Edition. Conterra Inc., Bellingham, Washnigton. 1997.

Pendley, Tom. The Essential Technical Rescue Field Operations Guide, Second Edition. Desert Rescue Research. July 2000

Smith, Bruce and Allen Padgett. On Rope, North American Vertical Rope Techniques. New Revised Edition. National Speleological Society, Huntsville, Alabama. 1996. Chapter 4, Rigging.