PA3DJS

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Distel-Offset friction hitch (DO-hitch)

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Additional disclaimer

Climbing, lifting, working at height and related activities are dangerous. Friction hitches don’t have anti-panic features that are present on several mechanical devices. The use of friction hitches may be prohibited or discouraged in your industry sector, or community.

Good operation of friction hitches depends on many factors, not limited to; hitch type, weather conditions, rope/cord thickness, rope/cord construction and tightness of the hitch. You should be well trained/instructed before using friction hitches in situations where expected and unexpected behavior can lead to loss or damage. You need to be your own devil’s advocate. The information shown in this document is not a substitute for good training.

Wim Telkamp, PA3DJS

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1. Introduction

This document discusses modifications to the Distel hitch to improve locking when using standard Nylon (PA) or Polyester (PES) accessory cord (to Std. EN 564). The modification creates distance (offset) between the rope and the load to improve locking/grabbing. 5 versions are discussed.

Adding static friction to overcome the effects of diameter change due to load onto the rope below the friction hitch is also discussed.

The goal of the document is to encourage experimenting with friction hitches. Testing must be part of experimenting as lot of things can go wrong. The focus is on climbing use of friction hitches.

1.1. Friction hitches in general

Friction hitches can be used for many purposes:

- as temporary or permanent connection to rope and solid objects
- as means of adjustment in work positioning lines
- for binding things together, similar to using cable ties.
- as anchor points during climbing on solid objects (choking anchors)
- as ascending/descending aid (with a foot loop, or foot ascender)
- rigging for lifting loads

A friction hitch enables to connect a rope to the main rope without tying a knot in the main rope. When the rope is not loaded, the friction hitch can be moved along the main rope. Once loaded, the hitch can't be moved in most cases (it is "locked" onto the main rope). When the load is removed, or sufficiently reduced, the hitch can be released and moved to another position on the main rope.

> In this document "**Rope**" is used for the main rope, "**cord**" is used for the rope that you use to tie the friction hitch. In most cases "cord" is so called "accessory cord", "prusik cord" or "hitch cord". Both are designed for climbing applications.

Lock and release behavior is less important for static applications. As long as it holds when locked onto the rope, and it is not too difficult to release, it is fine. Nearly every friction hitch works in that case, as long as it has sufficient turns and doesn't slide down when the load is (temporary) removed.

There are applications that require frequent locking, releasing and moving. There is a tradeoff between good locking, easy releasing and easy moving. You can't have all three at the same time. A hitch that moves very easy after release may not lock when it should, and that can be really dangerous.

For some applications backlash is also of importance. During the transition from an unlocked hitch to a locked hitch, part of the hitch moves in the direction of the load. This effect is called backlash, or sit back.

1.2. Locking and holding power

A friction hitch must grab the line when it should. Whether or not a hitch grabs depends on many factors. Important factors are:

- Hitch cord over (climbing) rope diameter ratio (large ratio increases risk of not locking)
- Surface finish of rope and hitch cord (affects friction, especially glazing can be dangerous)
- flexibility (knotability) of the hitch cord (the more flexible, the better it locks)
- tightness of the hitch (improves locking, but also increases no-load friction and may increase holding power)
- Wet or dry rope (as this affects friction)
- Rope diameter variation of (climbing) rope (for example due to sheath slippage or heavy load onto the rope below the hitch)
- of course the type of friction hitch, especially the number of top turns (more turns increase holding power)

Locking is not the same as holding power. A hitch may lock (that is grab the rope). However, when increasing the load, it may (temporary) slip at some load. Slippage limits the holding power of the hitch. Slipping may occur at relative small load, and when it doesn't stop, Nylon or Polyester accessory cord will melt. Factors affecting holding power:

- there are insufficient top turns,
- using relative large hitch cord over rope diameter ratio (increases slippage),
- using double cord for the hitch (larger advance per turn gives higher slipping risk),
- rope or hitch cord is contaminated with a greasy substance.
- The hitch is loose, resulting in deformation of the turns pattern
- Excessive cord stretch, resulting in deformation of the turns pattern (Polyester stretches less compared to Nylon (Polyamide))
- Glazing of the surface of the hitch/prusik cord (reduces friction).

Slipping is not always problematic. As long as it happens well beyond the intended load, and it doesn't result in fusion between rope and cord fibers (due to melting), it is fine. It will only slip shortly in case of an unforeseen shock load. When it slips, it reduces the peak load.

> Your operation should never rely on slippage to reduce shock load, as the weight where slippage occurs shows large variation.

1.3. *Long term effects, locking and holding power*

There are some things that may affect both locking and holding power. These effects occur when a friction hitch is used several times, without retying the hitch.

- Change of cross section of the cord.
- Glazing of the surface of the cord that is in contact with the rope.

Change of cross section

The first effect occurs relatively fast. Initially a cord or rope has circular cross section. However when you wrap it around an object, its cross section becomes more or less oval. This is shown in figure 1.1A.

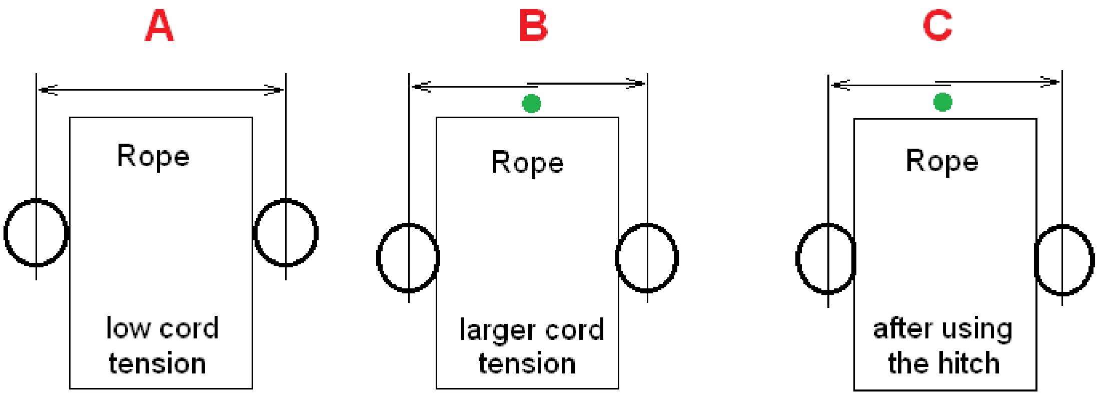


Figure 1.1; Change of cross section of prusik cord

When you wrap it more tightly (or load a friction hitch) the cord's cross section becomes more oval, and it bites somewhat into the rope. This is shown in figure 1.1B. The average cord diameter reduces as can be seen by the overlapping ends of the arrows at the green dot. Thin rope protrudes into the rope relatively better, as its contact pressure is higher. This increases the friction due to the deformation of the rope at the contact area. It is one of the reasons that friction hitches out of thin rope grab and hold better. It is also said they "bite" better.

After some use of a friction hitch, the cross section becomes even more oval, so the average diameter reduces. This can be seen above the green dot in figure 1.1C. Smaller diameter creates excess cord (slack) inside the hitch.

The cord area that is in contact with the rope flattens, see figure 1.1C. You can see this when untying a friction hitch out of regular accessory cord. A flat surface bites less into the rope so has less friction.

> Both effects (flattening of the contact surface and average diameter reduction) reduce locking behavior, and reduce holding power of a friction hitch.

Glazing of the cord surface

After some use, especially when the hitch slips (can be on purpose), there will be plastic (permanent) deformation in the cord fibers, due to heat. The cord fibers that make contact with the rope will stick to each other and deform forming a compact surface that may be even somewhat glossy. This effect is called glazing.

A glazed cord surface has lower friction coefficient towards the rope. This will negatively affect locking, and reduces the holding power. When the holding power reduces below the rated load, the hitch will slide and keeps sliding.

Polymer cord (such as PA (Nylon) or PES (Polyester)) will melt completely. This can be fatal in case of human load. Cord with an Aramid sheath (Kevlar, Technora, etc) will not glaze as aramids don't melt, but just disintegrate (blacken, carbonize) like many natural fibers. Disintegration of Aramids happens at a temperature where all polymer rope is molten completely. That is why Aramid hitch cords are used by arborists.

Friction of Aramid sheathed cord may reduce when rope fibers from the Nylon (PA) climbing rope transfer to the cord and seep into the space between the Aramid fibers.

Conclusion regarding long term effects
Hitches that use a double rope (loop) such as the Autoblock hitch (Marchad hitch) are more friendly to the climbing rope, but have less holding power given the same number of turns. So this is also valid for the double rope Distel or DO-hitch as discussed here.

In the beginning, a friction hitch may lock very well and has good holding power. Holding power can be checked by jumping onto a foot loop that is connected to the hitch. Breaking the hitch under load and see how it slides may give you an idea of its holding power due to further flattening of the cord and deformation/reorientation of turns.

After using the hitch for certain time, locking may be less reliable and holding power may reduce over time. This is potentially dangerous as you may not notice this. Deformation of cord cross section goes relatively fast, however glazing may occur slower, depending on the use of the hitch. Making many short descents may give you a good idea about the influence of glazing when using PA or PES cord.

It is therefore recommended to experiment with the rope-cord combination you want to use. Holding power can more then halve referenced to the initial holding power just after tying. Test your hitches close to the ground so that you can handle unexpected hitch behavior. See chapter 11 for testing your hitches.

1.4. Improving locking behavior using lateral force

Easiest way to improve locking is to force the cord turns onto the rope by having a tight hitch. The downside of a very tight hitch is that it moves difficult when not loaded. This is acceptable for several applications (think of rigging). For applications where the hitch has to be repositioned frequently, this is at least annoying.

There is another way to improve the locking behavior (not holding power) of a friction hitch without increasing its no-load friction: having the load bearing strands offset from the rope so that a diagonal cord section appears. This introduces lateral forces in the top turns. When a small force (F_{load}) is applied, additional friction appears proportionally. This helps locking of the hitch.

The effect of offset is shown in figure 1.3.

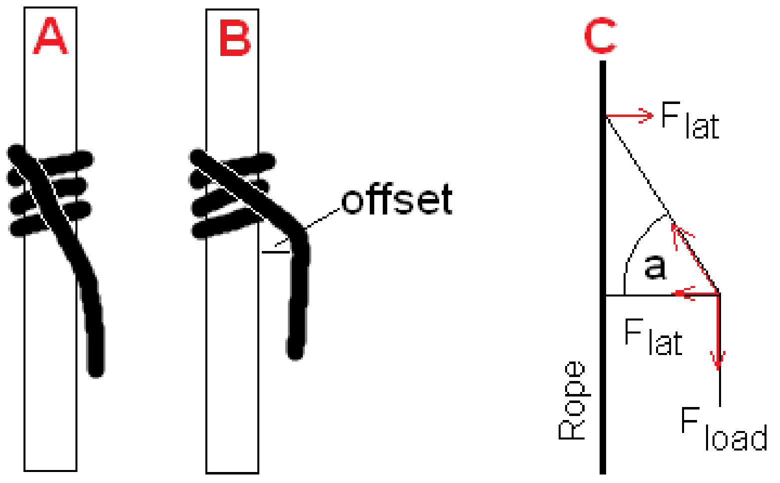


Figure 1.3; Relation between Lateral force and offset

There is always some friction between the hitch cord and the rope. That must be there to avoid that a friction hitch slides down due to its own weight (yes, this can happen with a loose hitch, or stiff accessory cord in combination with climbing rope with greasy contamination on it, or climbing rope that is loaded below the hitch).

Due to hitch cord and rope thickness, F_{load} does not work pure vertically on the turns. This is shown in figure 1.3A. When F_{load} starts to increase, two opposing lateral forces are generated. This is shown in figure 1.3C. The load bearing strand is pulled to the left, and the cord section that comes from the top turn is pulled to the right. These sideways acting forces add friction to the already present rope to hitch cord friction. This additional friction should avoid that the turns slide down along the rope during constricting of the turns that happens when F_{load} is applied.

With certain pretention in the turns, rope and hitch cord combination, increase of friction force due to F_{lat}, may not be sufficient to counteract F_{load}. If so, the hitch doesn't lock and slides down. This risk increases when using relative stiff / bouncy accessory cord.

When F_{load} gets additional offset, angle “a” reduces, see figure 1.3B. This increases the lateral force (F_{lat}) due to F_{load}. Larger F_{lat}, gives more friction between the rope and the hitch cord. This reduces the risk of not locking.

Example

Angle “a” = 45 degrees, and friction coefficient between the rope and the friction cord is 0.4.

When you do the math, $F_{lat} = F_{load}$.

F_{lat} acts twice onto the rope: in the top as “pull” force, and in the bottom as a “push” force. The maximum vertical friction force ($0.4 \cdot F_{lat}$) also acts twice. Therefore $F_{fric.lat} = 0.8 \cdot F_{load}$.

When $(1-0.8) \cdot F_{load}$ exceeds the no-load friction minus hitch weight, the hitch will slide.

As an example, the no load friction of the hitch minus its own weight is say 0.1 kg. That means when you add >0.1 kg of weight at the hitch near the rope (so that is sure doesn’t lock), the hitch will slide.

F_{load} can be 0.1/(1-0.8) = 0.4 kg before the hitch slides. This is because of the “free” additional friction of 80% of F_{load}.

Note that for “a” = 75 degrees, F_{load} > 0.13 kg will cause the hitch to slide. This shows the effect of angle “a”.

The trick of a friction hitch is that the 0.4 kg load transfers to the top turns as 0.4·1.414 = 0.56 kg. This cord force should be sufficient to constrict the turns so that additional friction occurs that is well beyond the applied load, and then the hitch is in its locked state. Creating offset “provokes” locking of the friction hitch.

1.4.1. Creating offset

Offset can be created using rope/cord, or additional hardware. First experiments were done with a carabiner between the rope and the hitch cord. This gives about 10 mm additional offset, and that is large given a rope diameter of 10…13 mm.

During these experiments it became clear that the bottom turn, that is present in nearly all hitches, avoids spiraling/bulging of the rope when the hitch is heavy loaded. That bottom turn adds tension in the rope just below the top turns (4 top turns and 1 bottom turn in figure 3.1). Spiraling/bulging of the rope can reduce the holding power of the hitch, due to severe deformation of the layout of the top turns. This also happens when a hitch is loose tightened. Spiraling may introduce jamming, or difficult releasing.

Spiraling/bulging of the rope can happen with (for example) an Autoblock or VT/XT hitch, as they don't have a bottom turn.

Over the years various hitches were designed with mixed success. Some knots were difficult to tie, to remember, or to inspect. That is not what you want at the end of the day in a situation where you trust your life onto a friction hitch.

A design based on a Distel hitch seems to work well, and is very easy to tie. When you know the clove hitch, the transition to a Distel hitch is not that difficult. The transition to the "Distel-Offset hitch" is even simpler, where the Distel-Offset hitch with retraced load bearing ends is the most difficult one.

1.5. Taking in or giving out cord

During its use, a friction hitch may take in some cord. This means that there will be more cord in the hitch, resulting in loosening of the turns. This reduces the static friction, thereby increasing the risk of not locking and/or slipping at certain load.

When there is slack inside the hitch, the hitch may still lock when having very flexible cord. It may however slip under load as the advance of the turns increases with more slack. So just checking a hitch by checking whether it grabs/locks is <u>not</u> sufficient.

Whether a hitch takes in cord, or gives out cord depends on many factors and on how you use the hitch. Giving out cord causes the hitch to release or move more difficult, but that is better then a hitch that slides/slips, or doesn't lock at all.

1.6. Rope tension, diameter and locking

The diameter of (climbing) rope as mentioned on the label is measured with certain tension in the rope. Ropes for climbing are measured with a 10 kg load on a new, unused rope. Other specification uses a preload of a certain percentage of the breaking strength.

Without any load it is thicker. With your body weight the diameter reduces below the size on the label.

When using a part of your rope frequently, especially with friction hitches, the sheath may move a bit (milking) and that reduces the diameter further, and increases the no-load diameter where the sheath accumulates. A 1..1.5 mm diameter change is not uncommon. That means you can have a slack of 3..4.5 mm per turn of hitch cord that is around the rope.

When a rope is tightened, its surface changes, as fibers become more compact (air is squeezed out). This changes the friction (especially on new rope), thereby increasing the risk of sliding down under its own weight.

Figure 1.4 shows what can happen.

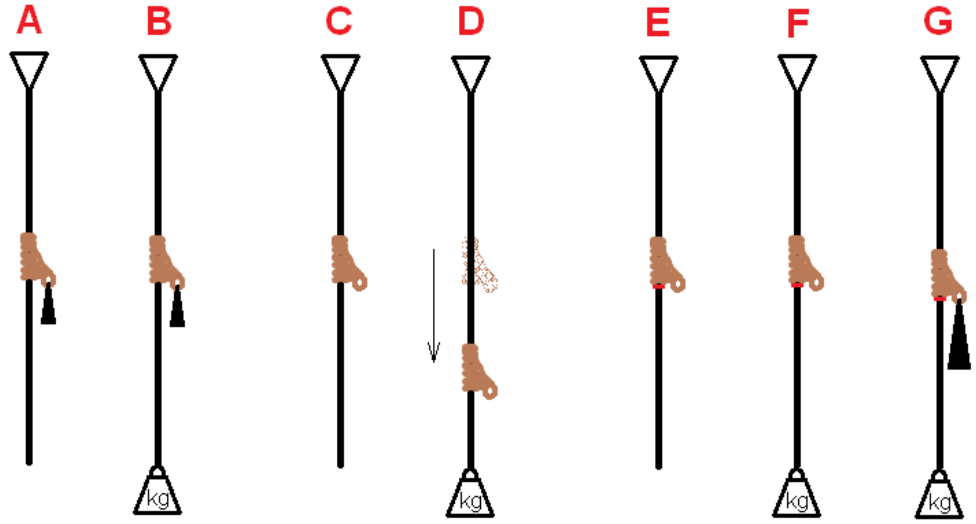


Figure 1.4; sliding of a hitch due to rope diameter change

The A-figure shows a hitch with a small weight, so that it is locked. That weight can be one or two steel carabiners. The weight (force) to move the hitch up or down is well below the weight of the small weight, so you know it is locked. The rope is moved a lot, so that there is no stress in the rope from previous loading.

In the B-figure the rope is loaded (for example with your weight). It becomes 1 mm thinner and nothing happens (the hitch may slide a few cm). The hitch remains locked due to the small weight.

The C-figure shows a hitch without any load that moves relatively easy along the rope. It doesn't slide down due to its own weight. The eyes are not loaded, so that it is in its unlocked state.

Now in the D-figure weight is added to the rope, the diameter reduces, and the hitch slides down due to its own weight! The D-situation is easy to replicate with both dynamic rope and semi-static (low stretch) rope with hitches using regular accessory cord. When you remove the weight, the sliding stops.

When there would be some load, but not sufficient to lock the hitch in the beginning, the hitch will slide down, but may likely lock at some irregularity in the rope.

The hitch will also lock when you pull it down with a speed higher then the own weight slide speed. In all cases, a sliding hitch is not what you want. You cannot use such a hitch as a backup or other serious application.

Avoiding unintentional sliding of the hitch

You need certain friction, otherwise you can't get force in the diagonal rope section that goes to the top turn (figure 1.3C). Some force in that section is required to start the constriction process of the rope turns that provides the friction to carry the load.

There is a way to solve this problem. Make sure to have some friction that is independent of the rope diameter.

Best would be a friction that acts at or under the top turns. The provision providing the friction may reach between the rope and the top turns and that is not desired. Second best is to have the friction below the hitch, so that the bottom turn doesn't slide down. It does work, but isn't optimal compared to adding friction in the top turns.

The E-figure shows the situation. The friction can be made using elastic cord (shock cord), shown in red.

In the F-figure the rope is loaded, the diameter reduces, but nothing happens. The non-diameter dependent friction avoids that the hitch slides down.

The G-figure shows the situation when a weight is added slowly. The hitch may move a few cm, but then it locks. Moving slowly takes out acceleration forces that help locking.

When you move the hitch up and down with the eyes, it won't slide down, only up (in case of a self-tending hitch).

Experimentation showed that the friction can be added directly under the top turns using the "shock cord friction loop". The advantage is that it doesn't interfere with tending devices below the hitch, and the hinge function is not negatively affected. It works better then adding friction below the hitch. See chapter 8 for details.

2. The Distel-Offset hitch (DO-hitch) in general

The Distel hitch is a good candidate to add offset to improve its locking behavior. It is assumed that you are familiar with the Distel hitch.

The normal Distel hitch is a relative short hitch that works pretty well with a pulley or ring as tending device and it is easy to inspect.

When failure is because of the cord, the cord breaks at the half hitch that is part of the bottom turn. The bend radius is smallest at that point. This happens also when using a figure 8 on a bight to make the eyes: the half hitch fails mostly. The weak point of the Distel hitch is therefore the half hitch that makes the bottom section.

4 versions of the Distel-Offset hitch are discussed:

1. Single cord DO-hitch
2. Single cord DO-hitch with retraced load bearing ends, with and without auxiliary cord
3. Double cord DO hitch (using a loop)
4. Double cord DO-hitch (using a loop) and short piece of auxiliary cord

Versions 1 and 2 use a single cord and behave more or less like a normal Distal hitch.

Versions 3 and 4 use a double cord (endless loop). Because of the double cord, they share properties with the Autoblock hitch (French Prusik hitch). That means: it has a higher risk of slipping, is significantly stronger than a standard Distel hitch, and descending using the hitch shows less (but still high) wear on the cord.

Because of the higher slippage risk of the double cord versions, testing is very important (see chapter 11).

The 4 DO-hitch versions are discussed in the next four chapters.

3. Distel-Offset hitch, single cord version

This is the version that you use when having a cord with eyes, and correct length. For most reliable operation, you need to avoid that the hitch takes in cord as this reduces both good locking and holding power. It is only slightly stronger than a normal Distel hitch. Failure is not at the eyes (when using figure 8 on a bight), but in the half hitch that makes the lower turn.

It is the least recommended of the 4 version that are discussed.

3.1. How to tie the hitch

Figure 3.1 shows how to tie the hitch with 4 top turns.

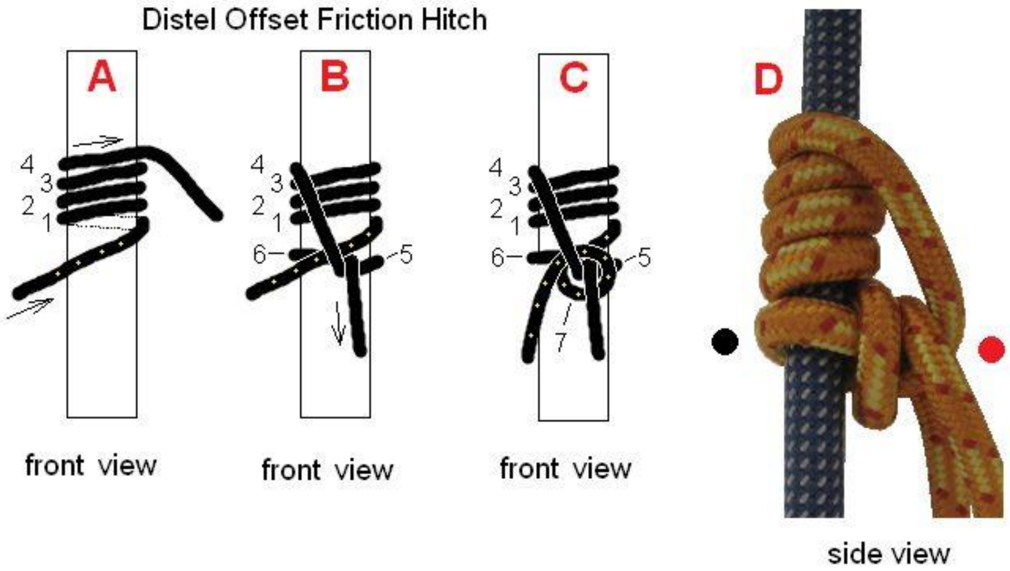


Figure 3.1; Tying the Distel-Offset hitch using single cord

It should look as shown in the D-figure. The two load bearing ends and the diagonal section are now offset from the rope. The turn around the two cord sections (between the black and red dot) acts more or less as a hinge that can swivel a bit in the vertical plane. When loaded, the right side (at the red dot) is pulled down. This generates tension in the diagonal section that comes from the top turn.

For body weight support, at least 5 (instead of 4) top turns are required.

4. Distel-Offset hitch, single cord, retrace version

The single cord DO-hitch of chapter 3 is good when you have a cord with the right length having two eyes (knotted or sewn). Sewn is best, as knots have efficiency in the range of 25..60% depending on cord type and cord material. You lose strength, as the load connects via the knots. It should be noted that the standard Distel hitch and the single cord DO-hitch fail mostly in the hitch itself, at the bottom turn.

When you have only a piece of accessory cord it is time consuming to make a good working hitch, because of the eye termination knots, and you can't test it when at height.

There is a solution for that, without needing eye terminations: wrapping the load bearing ends around the carabiner and retracing them back into the hitch. It has a knot, but that carries just maximum 30% of the load, so the strength reduction is less compared to using a cord with knotted eye terminations.

When the cord fails, the load at failure is significantly higher than for the normal Distel hitch. Because of the retracing of the load bearing ends, the bend radius of the section that comes down from the top of the hitch increases (at the bottom of the hitch). It should be noted that in many applications the hitch may slip or damage the sheath of the rope before the cord breaks.

When tying it, the carabiner is automatically as close as possible to the hitch. The carabiner may touch the underside of the hitch.

The offset can be increased by adding auxiliary rope turns, similar to the hitch of paragraph 6. It is discussed in paragraph 4.3.

Tying requires more actions compared to a double cord hitch when using a premade cord. The risk of human error is therefore larger.

4.1. How to tie the single cord, retraced version

Figure 4.1 shows how to tie the single cord, retraced DO-hitch.

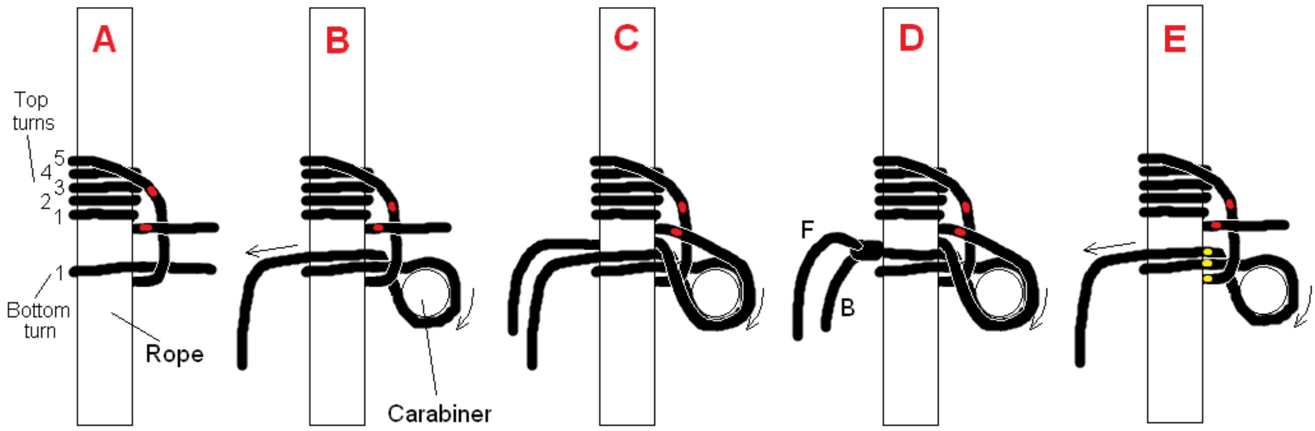


Figure 4.1; single cord, retraced DO-hitch

Figure-A

You start with a standard 5 top turns Distel Hitch around the rope. Wrap the turns tight, add tension on the cord during wrapping. Wiggle the turns, so that they settle nice around the rope. When you look from the right sight to the hitch, the end from the top turns is on your left and the end from the bottom turn is on your right.

Figure-B

Wrap the end from the bottom turn around the carabiner and retrace it back through the hitch. Note the direction of the arrows. You go over the carabiner first.

Figure-C

Wrap the end from the top turn around the carabiner and retrace it back through the hitch. Note the direction of the arrows.

Check that both retraced ends are below the sections that arrive from the top turns (marked with red).

Figure-D

Pull tight the two cord ends that are on the back (left side in the figure) of the hitch and tie a tight square knot. Put some load onto the hitch so that the turns settle around the rope.

You very likely need to untighten the square knot. Take the slack out of the hitch and tie a square knot again.

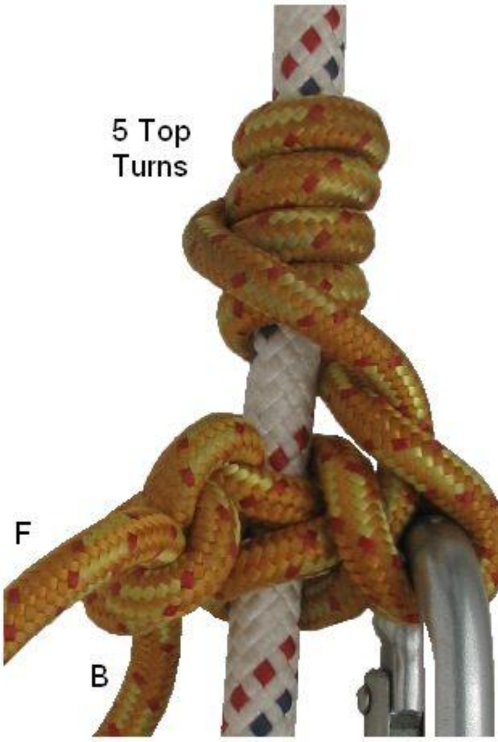
When the hitch works fine, add a securing knot (overhand using both cord ends, or make a triple square knot when you need the hitch just very short time).

Figure-E

Figure E shows the B-figure again, but 3 cord sections are yellow marked. When you want more offset (to increase locking behavior) you may wrap an auxiliary cord around these 3 sections. See paragraph 4.3.

It is not recommended to tie the hitch with large eyes. Due to the force distribution across all rope strands, the hitch may take in cord. If there is a reason to do so, you need to test for that. You may add auxiliary turns and add the shock cord friction loop. Loose hitches generally have less holding power.

Figure 4.2 shows a DO-hitch, single cord, retraced.



The rope is 10.5 mm Semi-Static (SLK to Std EN 1891, Type A). The accessory cord is 7 mm Nylon (sheath and core). The hitch has 5 top turns. The knot is a triple square knot.

After loading with body weight (80 kg), the square knot is untied, en retightened to take slack out of the knot due to the first stretch and settling of the turns.

Though this hitch isn't designed for descending, it does work over > 4m. Test is done with interruptions, moving and jumping into the foot loop, but without retying. Use descent in an emergency only.

So with 5 top turns there is sufficient margin for reliable operation. With 6 turns descending goes easier.

Figure 4.2; Single cord, retrace DO-hitch

Increasing the offset without using another cord section.
You can increase the offset by feeding the loose ends F (Front) and B (Back) through the hitch. See figure 4.2 for the F and B markings.

The cord ends need to pass over the 3 strands that are yellow marked in figure 4.1E. The F section you push into the paper, below the visible eye that goes around the carabiner. The B strands goes first behind the rope and then passes over the three yellow marked sections, but below the visible eye. The B strand points out of the paper.

Further increase of offset can be created using auxiliary cord, see paragraph 4.3.

Checks:

1. Count the number of top turns on the back of hitch (that is opposite to the carabiner. In the example hitch there are 5 turns where the last turn overlaps other turns.
2. The highest of the top turns must go all the way down and goes below the bottom turn
3. The cord end from the lowest turn of the top turns goes first over the carabiner and then through it.
4. The cord end from the bottom turn first goes over the carabiner and then through it.
5. Retracing of the cord end from the bottom turn goes back over itself.
6. Retracing of the cord end from the top turns goes back under itself.
7. The knot on the back of the hitch does pass around the rope only
8. Hitch must be tight, clearance above carabiner less then 10 mm.
9. The knot on the back must have a backup knot.

4.2. Features

You can tie this version just hanging onto the rope in your sit harness. You don’t have to adjust eye terminations. You need to tie it tight, as due to rope stretch and settling of the turns, it loosens a bit (and that is as expected).

When tightened (easy to do), the eyes are tight/snug around the carabiner. Therefore the hitch can’t take in cord. After loading, the hitch becomes somewhat less tight due to settling of the turns. When it is not too tight, it is self-tending when using it on Semi-static rope (to Std. EN 1891). You just pull the carabiner upwards and the hitch moves. The friction however is more compared to a tending device, or compared to pushing onto the sweet spot.

This DO-hitch version is easy to adjust as the knot carries maximum 30% of the load. The knot (with backup) is therefore easy to untie.

Its strength is about 150% of cord MBS. The hitch may fail in the knot, or at the half hitch that makes the bottom turn.

4.3. Single cord, retrace version with auxiliary cord

Increasing offset with auxiliary cord is discussed in chapter 6. It adds offset with very minor increase of no load friction. It is advised to read that chapter first. Due the significantly larger offset, tying is less critical.

2 Turns around the yellow marked rope sections (figure 4.1E) are mostly sufficient for a single cord, retraced hitch. Do not use the auxiliary cord together with the cord ends passing through the hitch. Use same accessory cord as for the hitch.

The example hitch is shown in figure 4.3 with 2 auxiliary turns.

First wrap the 5 top turns with high tension. Press on them so that they settle nice around the rope. Then tie the complete hitch as shown in figure 4.1D. Tie it loose and don't apply large tension when tying the square knot (as you need to untie it later in the process).

Open the carabiner and take it out of the eye that goes to the top turns. That is the eye closest to you in figure 4.3. This eases adding the auxiliary turns. Then add the auxiliary turns as shown in figure 6.1B and C.

Figure 4.3; Single cord, retrace DO-hitch
With auxiliary cord

Note that now the turns pass around 3 rope sections. Figure 6.1 shows 3 auxiliary turns, but 2 turns are used in figure 4.3. 2..3 turns are generally sufficient.

Push the carabiner back through the eye and terminate the auxiliary turns with an overhand knot.

Untie the square knot tighten the DO-hitch and tie the square knot again. Now you can test the hitch and retie the square knot if required. Don't forget a backup knot.

Note

> If you (by accident) wrap the auxiliary turns around all cord sections (4 in total) that go from the rope to the carabiner, it is fine. They may not go around the cord sections that go to the top turns (red marked in figure 4.1),
>
> So it doesn't make a big difference when the auxiliary turns are around three or for cord sections. Wrapping over 4 cord sections gives little more offset but slightly limits vertical hinge swivel.

The larger offset is clearly visible when comparing it to the rope diameter in figure 4.2.

The auxiliary cord (red) that goes around the rope, does only go around the rope, there is no orange/yellow cord between the auxiliary turn and the rope. If so, you tied it wrong. The top turns can nicely sit onto the red auxiliary turn that goes around the rope. Do not tighten it much as that may mask a loose hitch and it interferes with the vertical swivel movement of the “hinge”. The auxiliary turns should just be tight enough so that the turns do not collapse onto each other.

The auxiliary turn increases the friction when self-tending, especially when the hitch is very tight. A tending device is recommended in such case. Tending on the sweet spot (under the auxiliary cord turns) goes very well.

5. Distel-Offset hitch, double cord version

The double cord version uses a cord loop so you don't need eye terminations. Its behavior is similar to that of an Autoblock hitch (French Prusik hitch). They are stronger, but need more turns to hold well and put less stress onto the rope.

The strength is because of the hitch is tied with a double rope, so roughly strength is twice that of a normal Distel hitch. You may also use cord that is 40% thinner. Minimum cord thickness must be 5 mm to compare with 7 mm for a normal Distel hitch.

Though the double cord DO-hitch is not designed for descending, it will break when you are able to transfer a part of the load to the top of the hitch. You could use this in case of a real emergency. You should be well trained to carry out this operation, as your natural reflex will result in sliding down. Friction hitches don't have anti-panic function and when using Polyester or Nylon cord, glazing may significantly reduce the holding power.

The double cord Distel-Offset hitch using cord only, is shown in figure 5.1. It has 4 top turns consisting of two cord sections per turn. There is 1 bottom turn consisting of two rope sections.

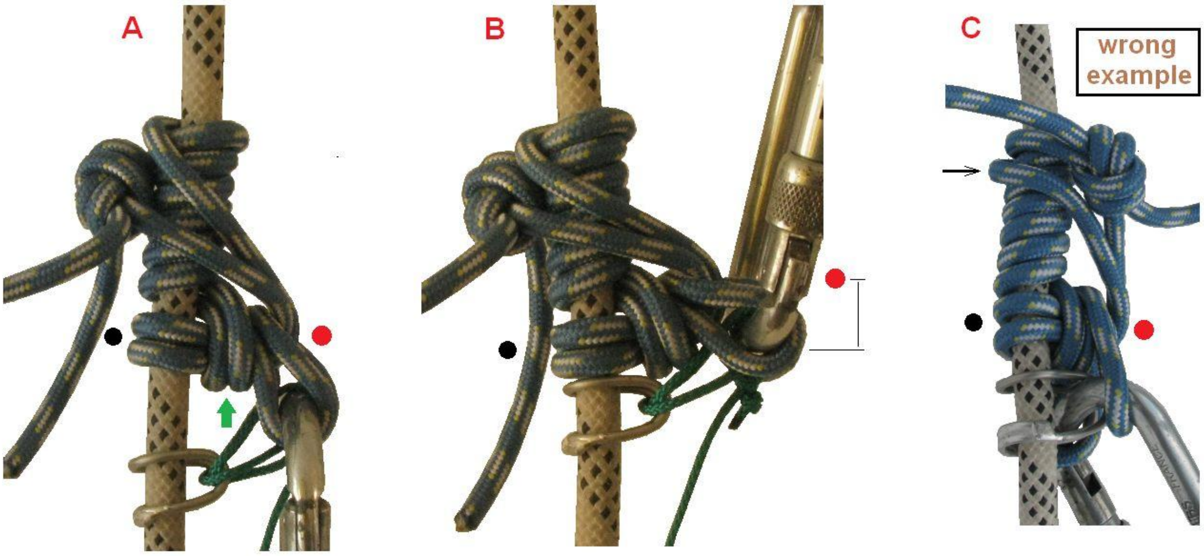


Figure 5.1; Double cord Distel-Offset hitch

The loop is made using a follow through overhand knot / water knot. This is not an offset overhand bend.

There is less then 8 mm space between the top of the carabiner and the cord above. Small distance is required for reliable operation (to avoid cord eating).

5.1. How to tie it?

Start by making an endless loop using a follow through overhand knot. A loop length of about 0.53 m (inner side) is a good starting point when using 11..12 mm climbing rope, 4 top turns and 6 mm prusik cord. Use a 57 cm loop for a 5 top turns hitch. Check that there are no twists in the cord after making the loop. when using 5 top turns, you may use a fisherman's bend.

Tie a normal Distel hitch. Wind the top turns as tight as you can. You need to experiment with the position of the bend knot as that must be near the top of the top turns.

Load the hitch (use a carabiner) to allow the turns to nicely sit around the rope. Readjust the hitch so that the eye that comes from the lowest turn of the top turns is about 5 cm longer.

Add the additional turn as in figure 3.1C and push the carabiner through the eyes (that may be difficult). Load the hitch and readjust the hitch so that there is no slack in the top turns. Load it again.

The slack in the eyes around the carabiner should be less then 10 mm. Readjust the length of the loop when required. When you want the eyes to be 10 mm smaller, you need to take out 40 mm of cord length out of your loop. So the loop must be 20 mm smaller.

Mark one of the eyes when the hitch functions well. This saves you from finding the position of the bend knot again.

The wrong example (figure 5.1C)
It is important that the hinge can move up and down to enable locking and releasing of the top turns. The tending device is too tight. The hinge is continuously squeezed down to the rope, making the hitch difficult to move.

The user tried to solve this by making the cord loop larger. This can be seen at the arrow in figure 5.1C. There is lots of slack in the hitch while the hinge is pulled down. The result is a hitch that didn't lock well. Here we have a combination of both wrong use and a wrong tied hitch.

6. DO-hitch with double cord and auxiliary cord

The DO-hitch with auxiliary cord is a standard Distel hitch with a double rope (loop). In fact it is an Autoblock with a Distel hitch finish. The offset is now created using a ring, or using a separate cord section. This has some advantages.

The concept is shown in figure 6.1 (4 top turns). As there is no additional turn with this version, start with a loop inside length of about 47 cm when using 11 mm rope with 6 mm accessory cord. For 5 top turns (recommended) start with a 54 cm long loop.

The properties and adjustments are virtually the same as for the double cord only hitch, but easier.

6.1. How to tie the hitch

The DO-hitch with double cord and auxiliary cord is shown in figure 6.1. Basically you tie a Distel hitch with the double cord. Load the hitch several times to get some stretch out of the rope. Now you can add the auxiliary cord turns to increase its locking performance.

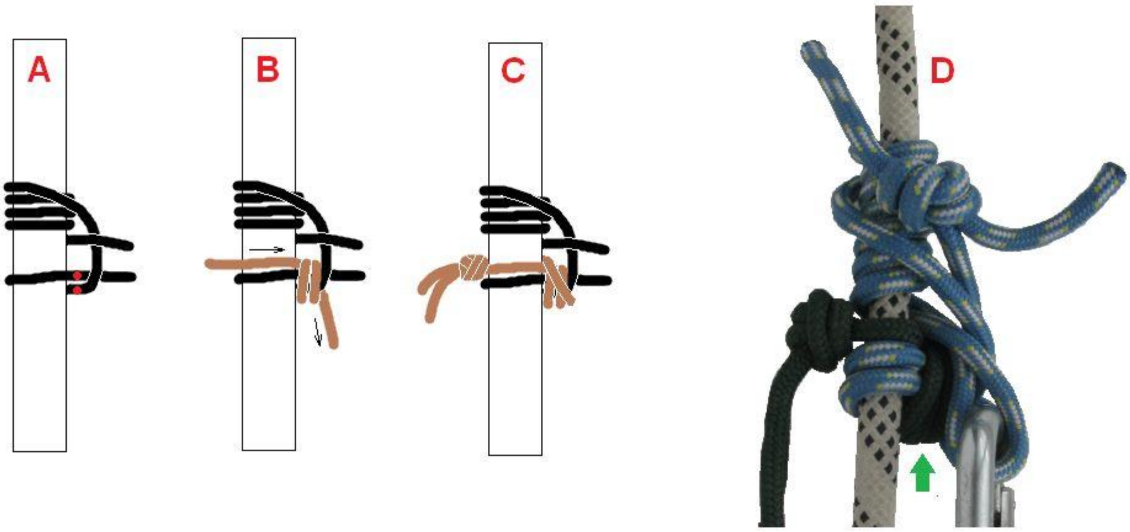


Figure 6.1; Double cord Distel-Offset hitch with auxiliary rope

A-figure

The A-figure shows a single cord Distel hitch with intentional large distance between the 4 upper turns and the bottom turn. In real world the loop should be used. Showing a single cord is just for clarity. When you add an about 6 to10 mm thick ring around the red marked cord sections when tying the lower turn, you have the offset.

Check that the cord section of the upper turn of the top turns goes all the way down. The hinge indicated with the red dots must act on the top turn.

Push a carabiner through the eyes and load the hitch. This takes out some of the stretch and creates some space to add the auxiliary cord.

B-, C-figure

Wrap about 2 or 3 turns of accessory cord around the red marked cord sections. Tie them off around the rope using your favorite knot. This creates the offset. The figure shows 3 auxiliary cord turns. An overhand knot using both cord ends is recommended over a square knot.

D-figure

The D-figure shows its appearance using a double cord (loop). The climbing rope is 11 mm, the accessory cord is 6 mm, the loop length is 48 cm, and there are 4 top turns. The loop knot is a follow through overhand bend (water knot).

The green cord is just utility cord (here Paracord). This contrasts with the accessory cord for clarity. It is however recommended to use a same diameter piece of accessory cord, or 1 mm larger.

6.2. Tips

The auxiliary cord enables experimenting with the offset by varying the number of turns. The main reason for tying the auxiliary cord around the rope is to ease release of the hitch. The lowest of the top turn can sit onto the auxiliary turn.

It is recommended to use same cord for the auxiliary turns as you used to tie the hitch, or 1 mm thicker when you need very large offset.

When using 7 mm cord for a hitch onto 10…12 mm rope, you need at least 5 top turns. So test well using both the short and long descent test (chapter 11). You can use a fisherman's bend to make the loop when using 5 top turns or more. When using 5 top turns, you may also need 3 auxiliary cord turns to increase the offset.

Adding more auxiliary turns, increases cord length inside the hitch. This increases backlash / sit back, and increases risk of slipping.

The slack in the eyes (after loading of the hitch) should be less than 10 mm. If more, reduce the loop length.

The hitch can be tended as described in chapter 7.

6.3. *Example of a 5 turns DO-hitch with auxiliary cord*

Figure 6.2; 5 turns DO-hitch

Figure 6.2 shows a DO-hitch using a cord loop with auxiliary cord. It is not a side view, so you can't assess the offset. The cord is 7 mm Nylon (sheath and core), the rope is 12 mm. It should be noted that the actual cord diameter is about 7.5 mm.

The auxiliary cord (7 mm) has yellow markings to distinguish it from the load carrying cord. It has two turns, but 3 turns would be better.

Inside Loop length is 59 cm and a double fisherman's bend is used to make the loop.

Holding power tests

4 turns (so 8 in total) seems to grab and hold well (body weight with gear, 80 kg). But when doing about 3 short descents (full body weight), the margin is insufficient.

After the third descent, the hitch doesn't lock immediately when removing the pressure from the top of the hitch. Very low force is required to break the hitch. That is not what you want.

Therefore <u>at least 5 turns</u> are required, making it a relative long hitch. For 5 top turns, 3 auxiliary rope turns are recommended with same diameter cord, as this improves locking. The no-load friction is more compared to a 4 turns hitch using 6 mm cord.

The carabiner sits very close to the hitch, avoiding loosening of the hitch. This also requires good adjustment of the black/gray colored loop cord loop that tends the U-shaped ring. Despite its length, it has low sit back / backlash.

The hitch is also tested over >10 m vertical descent with full body weight onto the hitch. This 10 m descent is divided over about 16 sessions of 0.7 m, without removing the hitch from the rope. After the session, locking and holding power is sufficient (one person with gear).

Same hitch with 5 turns of 6 mm nylon accessory cord (inside loop length is 54 cm) onto 11 mm rope and 3 auxiliary cord turns works also fine. Descending is more elaborate as more force onto the top of the hitch is required. After descending about 10 m, descending doesn't go easier (even more difficult), so glazing does not affect the reliability when using a human load. Jumping into the foot loop (after the descent test) doesn't induce sliding.

When using 4 turns (47 cm cord length), descending goes very easy after 10 m of descending. Jumping showed dangerous slippage the first times after descending, so 4 turns for the tested cord-rope combination is not reliable. 5 turns works well.

Using more turns (say 6) increases the holding power, eases breaking the hirtch (descending), gives more sit back / backlash, and increases the no load friction.

7. Friction hitch tending methods

7.1. Introduction

Tending a hitch, is to move the hitch in the desired direction. In virtually all cases the hitch is not loaded, and the tending direction is mostly upwards (as gravity acts downwards).

You can tend with your hand, mostly by wrapping your hand around the rope below the hitch, and push the hitch upwards. People may also grab the whole hitch and push it upwards. Some hitch designs can be tend by just pulling the carabiner upwards.

Tending can also be done by using a device, a so called “tender” or “tending device”. The reason is simple; you don’t want to “spend” your hand to move a hitch upwards. When it goes automatically, you have your both hands free to do your things.

Some examples where tending makes working easier:

- Adjusting a work positioning lanyard around your back, or between the waist D-rings (on your harness). When you pull the loose end, the hitch should release and move in the desired direction (to get a shorter lanyard).
- Adjusting a vertical work positioning lanyard to raise your vertical work position
- Climbing a rope using two friction hitches and a foot loop. The hitch should automatically move upwards as your body moves upwards along the rope.
- “let go” prevention when lifting objects.

Tending devices can be: pulley, ring, piece of rope, very small carabiner, etc.

A tending device has two functions:

1. Removing any load from the hitch so that it can move up or down
2. Pushing the hitch in the desired direction.

The load must be taken off the eyes to enable the hitch to release (unlock) or to avoid high no-load friction.

Both the standard Distel hitch and the DO-hitch move very difficult (or not at all) upwards when using the load bearing cord ends. The text in the next paragraphs is limited to the double cord DO-hitch, single cord, retraced DO-hitch or double cord Distel hitch, but is applicable to many other friction hitches.

7.2. Manual tending

Pushing up the hitch manually goes easiest by grabbing the rope under the hitch with one hand and moving your hand upwards. Of course there must be tension in the rope below your hand; otherwise you lift the rope also.

When there is tension in the rope above the hitch, there is a sweet spot. You only need to push at the sweet spot to raise/lift the hitch. See the green upwards pointing arrow in figure. 5.1D or 6.2B. When there is slack in the rope above you, you also need to push upwards the bottom turn to avoid tipping over of the hitch.

When there is still some load onto the eyes, there will be higher no-load friction. You may need to lift the carabiner also. You have to take care that you don't squeeze the carabiner onto the rope as than the hinge is pulled down, introducing tension in the diagonal cord section. When you put your thumb through the carabiner just below the two cord eyes of the hitch, you can both lift the hitch and the carabiner with one hand.

7.3. Basic tending device operation

Figure 7.1 shows the basic tending operation when using the carabiner and a piece of thin cord.

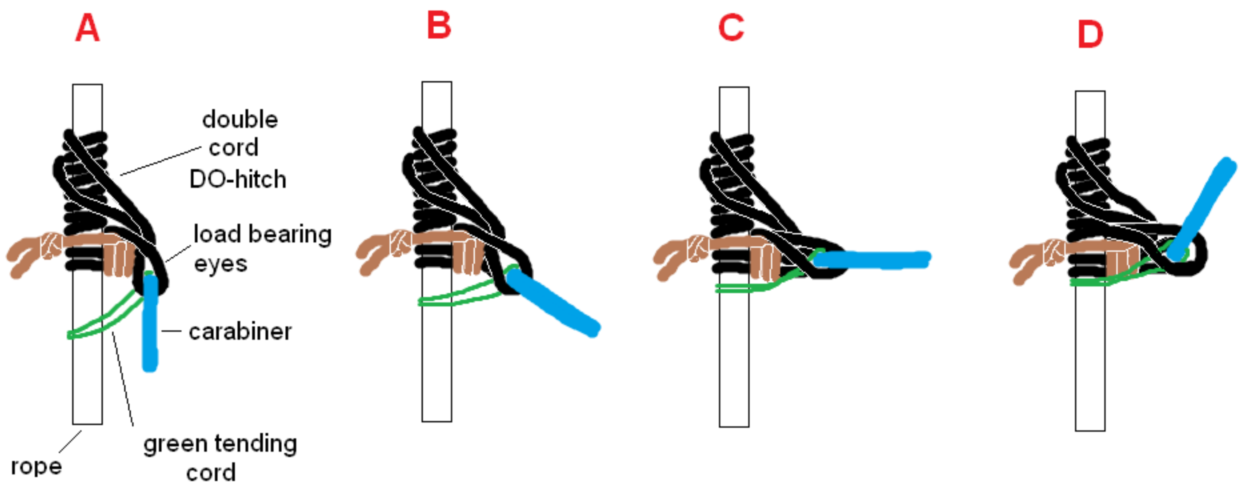


Figure 7.1; 5 turns DO-hitch with tending device

A DO-hitch is shown in figure 6.1A with a blue carabiner and a green cord loop (as tending device) that goes around the carabiner and the rope. The green cord loop should be adjustable. A simple adjustable loop hitch works well for that. See Annex 1 for a simple loop friction hitch. You may have a ring around the rope that connects to the green loop.

The rope below and above the hitch has tension. The green cord doesn't interfere with the hitch when the carabiner is pulled down. When you pull a bit sideways, you arrive in the B-figure. The green cord still has slack so doesn't interfere with the hitch or rope.

In the C-figure the carabiner is pulled fully sideways. There is zero vertical force component. Now the situation changes, as the force onto the carabiner transfers partly to the green cord and partly to the two eyes of the hitch. Theoretically the green cord interferes with the hitch, as it takes over some of the carabiner load.

In the D figure the force is transferred fully onto the green cord. The two eyes are loose around the carabiner. When the force onto the carabiner is large enough to overcome the friction of the now non-tensioned hitch, the hitch will move upwards. The hitch is only pushed upwards by the green cord loop. The eyes are loose around the carabiner.

A well-adjusted green cord length assures that the eyes are tensioned as long as possible. This reduces taking in rope, increasing the reliability of the hitch.

The green cord has friction with the rope. When using a ring as shown in figure 4.1A, the force to raise the hitch will be less.

- When the green cord loop is too long, not all force is transferred to the rope and that increases the friction while raising the hitch
- When the green cord loop is too shot, there will be more risk of non-locking and/or the carabiner pushes onto the auxiliary ropes, and this also increases friction.

7.4. Tending a hitch without lifting the carabiner.

One can tend the hitch by looping a cord around the carabiner as shown in figure 7.2A. That cord is in between the eyes of the hitch. The carabiner goes (for example) to the ventral (belly button, Rope Access) D-ring on your harness. The red cord (shock/elastic cord) goes to your neck or sternal (chest) D-ring. This reduces slack when “falling” into the DO-hitch (or other hitch).

This method does not reduce taking in the eyes, so the loop length should be right.

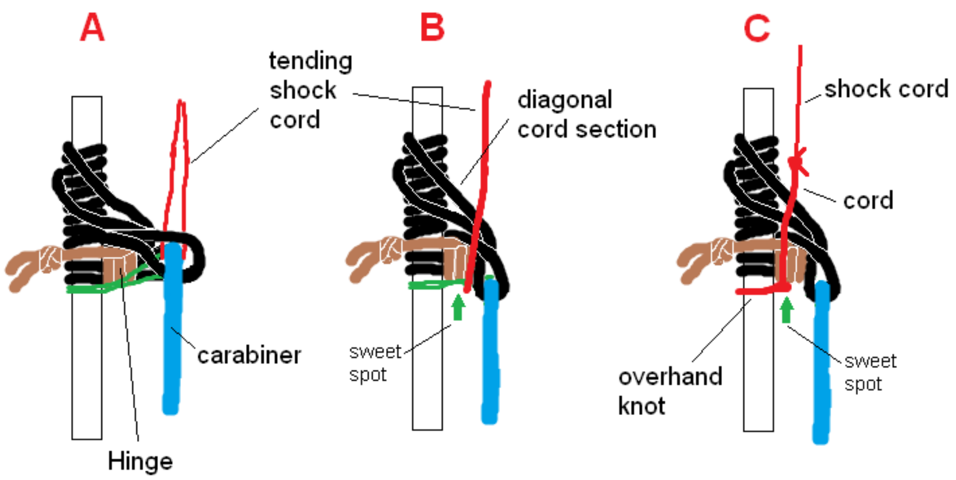


Figure 7.2; 5 turns DO-hitch with other ways of tending

You can also loop a cord around the hitch with green cord, as shown in figure 7.2B. this goes faster. You may need to reduce the green loop cord length a bit.

When ascending, there will be weight onto the carabiner. Due to the green cord, in combination with the tending (red) cord, there will be minor force onto the eyes. The red (shock) cord also acts very close to the sweet spot.

Due to the weight of the carabiner and the weight onto the carabiner, the hinge (that is where the three auxiliary cord turns are) may rotate clockwise. This increases the non-loaded friction somewhat, but improves the locking behavior significantly when load is applied to the carabiner. That load will further rotate the hinge clockwise increasing the force onto the diagonal cord sections.

7.5. Tending a hitch without a tending device

Figure 7.2A and B use the green cord as tending device. When tending the hitch with near zero load onto the eyes, lifting can be done with a piece of cord directly, without any other cord. This is shown in figure 7.2.C. this method introduces the least risk of taking in cord by the hitch (cord eating), as some load at the eyes is maintained by the shock cord.

A non-tightened overhand knot is tied around the rope. A cord with 3…4 mm thickness is recommended. Thin cord increases the friction between the cord and the rope.

The two ends go upwards and connect to shock cord that goes around your neck (in case of ascending a rope). The shock cord provides always some force onto the sweet spot (green upwards pointing arrow) that is large enough to overcome the no-load friction of the hitch.

As soon as the force is removed from the carabiner, the hinge rotates somewhat counter clockwise, reducing the tension onto the diagonal cord section. This releases / unlocks the hitch and the hitch is lifted by the cord / shock cord combination. The loose overhand knot avoids that the cord moves away from the sweet spot to the right.

When load is applied, the hinge rotates clockwise, and that locks the hitch. Due to the upwards pulling of the red cord, (some) cord may be pulled out of the hitch. When using this system, you can mostly use a standard Distel hitch, as long as the cord / shock combination is present, and operates well. The load bearing eyes can be larger as this system avoids taking in cord.

This method works very well when used in a hoisting operation (let go protection) or ascender setup.

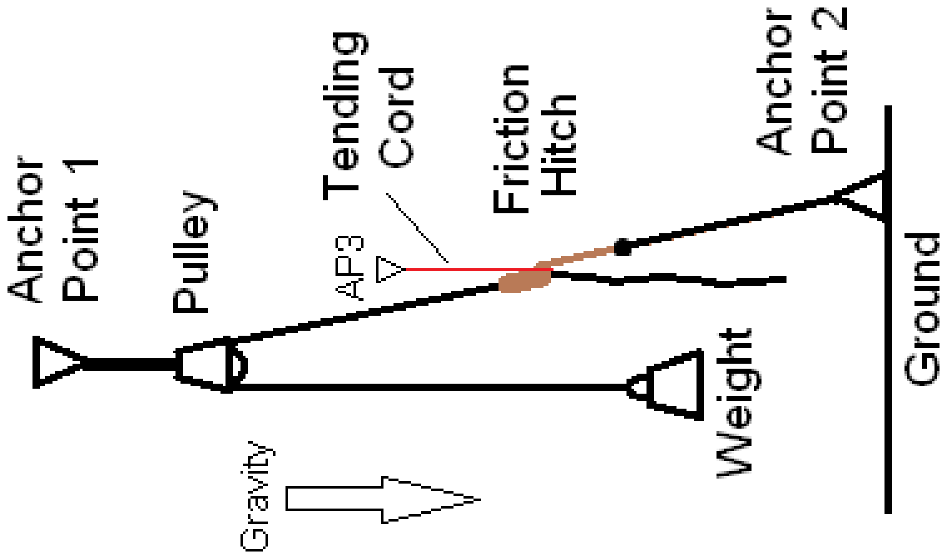


Figure 7.3; Let go prevention in a hoisting application

Example “let go” prevention (figure 7.3)

In this example a friction hitch catches the lifting rope when one would let go the rope. Note that gravity works to the right.

Anchor Point 1 (AP2) and 2 are strong points, where AP2 bears greater then twice the load (depending on pulley energetic efficiency). AP3 is a very weak one. As shown in figure 7.3, the load is fully supported by the friction hitch. AP2 carries the weight now. The red tending cord has slight slack (just a cm).

When you pull the loose rope, the weight is gradually transferred from the hitch to you, as you pull the rope. When all weight is onto the rope the hitch moves a bit down, but is caught by the tending cord at the sweet spot. Now there is no slack in the red tending cord and very small slack in the rope section between AP2 and the hitch. That small slack releases the hitch.

When further lifting the weight, the lifting rope moves through the hitch. When you led go the rope, the hitch catches the rope and moves a bit upwards until the slack is out of the black rope section between AP2 and the hitch.

When using strong enough shock cord as tending cord, the system works without any slack. The only slack that is in the system is because of the backlash in the friction hitch. As this system avoids taking in cord (see figure 7.2C), the backlash of the hitch is just a few cm (for a Distel or DO-hitch).

Disadvantage of this system is that you need a third hand to release the hitch when you want to lower the weight.

An ascender setup is virtually the same as the hoisting setup of figure 7.3.

- The hitch goes to your belly button D-ring instead of AP2.
- The red tending cord goes to you neck or sternal D-ring instead of AP3.

When using shock cord, the setup provides a progress capture with very low slack, as the cord / shock cord combination always provides a lifting force onto the hitch. This prevents taking in cord (the eyes).

The disadvantage is that when the cord / shock cord combination isn't present, you can't lift the hitch by pulling the carabiner (or soft shackle) upwards, as you don't have a tending device. You need to do it manually.

Of course you can have the green cord loop present, but you should enlarge it, so that when tending according to figure 7.2C, the green cord doesn't interfere with the hitch. When you want to switch to another tending method, you just need to adjust the green cord loop.

7.6. Other methods

The next step to make hitch tending easier is to reduce the friction by using a ring. The ring is connected to the hitch via an adjustable (green cord) loop as shown in figure 5.1. Further improvement can be made by using a micro pulley. You lose the adjustment possibility with the green cord loop. So adjustment for good operation has to be done by varying the accessory cord loop length. That means you always need to use the same loop-pulley combination.

Remember that when having 4 cm more cord in the loop, the loop becomes 2 cm longer and the two eyes become 1 cm larger.

8. Solving unintended sliding of a friction hitch

8.1. The problem

You have a hitch that works well. It has acceptable no-load friction and it works perfectly in an ascending setup with a piece of shock cord around your neck. It also works fine as a hitch for a foot loop below the ascender hitch, or in a work positioning line.

However when using the hitch in situations where the rope is loaded below the hitch, without tending the hitch, the hitch slides down and locks not well. When it slides down under its own weight, it can't lock (unless pulling down fast). The reason is the instantaneous reduction of the rope diameter because of the load. It can reduce over >1 mm. This effect is discussed in chapter 1.7.

If you don't want this, you should tie the hitch so tight, that it moves very difficult along non-loaded rope sections, or sections that are a bit thicker (for example due to sheath slippage over time).

When you use the hitch above you as a backup on a single rope, sliding down is not desired. When you get a full failure of your primary hitch, your body is off the rope, the rope jumps upwards and that will for sure lock the backup hitch.

But when you get a partial failure that results in (slowly) sliding down, there will be still tension in the rope. This may result in sliding down of the backup hitch. In virtually all cases it will lock in the end, and take over your weight, but you want to be 100% sure that it locks immediately, no discussion. Initial sliding will also introduce shock load.

The backup hitch is normally above your ascending hitch, or better on a second rope. You need to reposition it every time so that it is above you to limit your fall distance. This is most important when you are close to an anchor point above you, as then there isn't sufficient rope above you to spread out the shock load in time (so that the peak force is limited).

> Do evaluate the peak load that will occur when your main hitch fails abruptly. You may arrive in a situation where you need a shock absorber. When that is an industrial 6 kN screamer, it is not advised to use a friction hitch.

8.2. Adding static friction

8.2.1. Introduction

The trick to avoid sliding down due to rope diameter reduction is adding some friction at the right spot that is near independent of rope diameter.

Before using the added friction trick

- use a hitch that is tighten such, that the no-load friction is acceptable. You should not use this trick to “correct” a loose hitch.
- use the maximum offset, that is around 3 auxiliary turn of same cord thickness, or 1 mm thicker. An exception is the single cord retraced hitch. As it provides offset already, it may be used without auxiliary turns.
- Use it on a hitch that passed the short descent and long descent (glazing) test).
- The trick works on all DO-hitches, with double or single cord.

The reason for the above points is that using the trick on an unreliable hitch is not the way to go. The trick only improves locking, but doesn’t increase holding power.

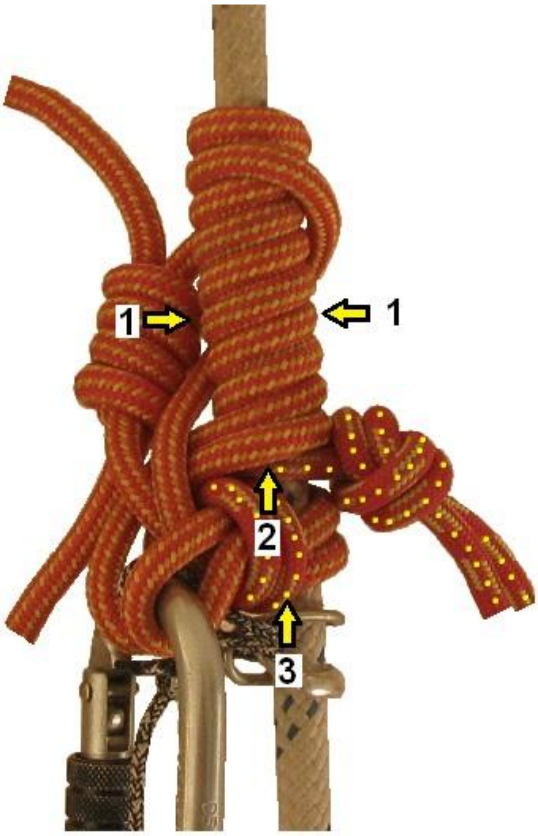


Figure 8.1; DO-hitch with markings for friction positions

Adding static friction nearly independent of rope diameter can be done in several ways.

Figure 8.1 shows a 5 turn double rope DO-Hitch with 2 auxiliary turns.

The best position to add friction is directly onto the top turns, as that directly translates to force in the rope sections that go to the top turns.

It can be done via a constant compression force on a top cord turn, indicated with “1”, or via friction around the rope that tries to push up the top turns, indicated with “2”.

Other option is by adding friction around the rope just below the bottom turns, indicated with “3”.

Options 1 and 2 work with a loose hitch, where option 1 does lock even a very loose (unhealthy) hitch. The bottom turns with eyes (the hinge) slides down while the top turns do not and receive more force that is used to constrict the turns. To get option 1 to work, mechanical provisions are required with spring action.

Option 2 requires something around the rope (for example shock cord). A piece of shock cord got into the top turns during testing, so that wasn’t a success.

Option 3 can just be a short shock cord loop that is routed exactly the same as the green cord loop in figure 7.2. It does work, but it pulls the carabiner towards the rope, and that interferes with hinge operation. The result is significant increase of no-load friction. It is hard to work with.

Option 3 does not work well with a somewhat loose hitch, as the amount of vertical swivel of the hinge is limited. Therefore the hitch should be tied well.

8.2.2. The “shock cord friction loop”

After experimenting, there is a very simple way to add friction in the lowest turn of the top turns: a shock cord loop that goes both around the rope (to introduce friction) and around the lowest turn of the top turns (so that it cannot get between the rope and the cord). It is shown in figure 8.2.

The shock cord is not eaten by the top turns, even under shock load and descending (intended sliding of the hitch). That piece of shock cord is called “shock cord friction loop” throughout this document.

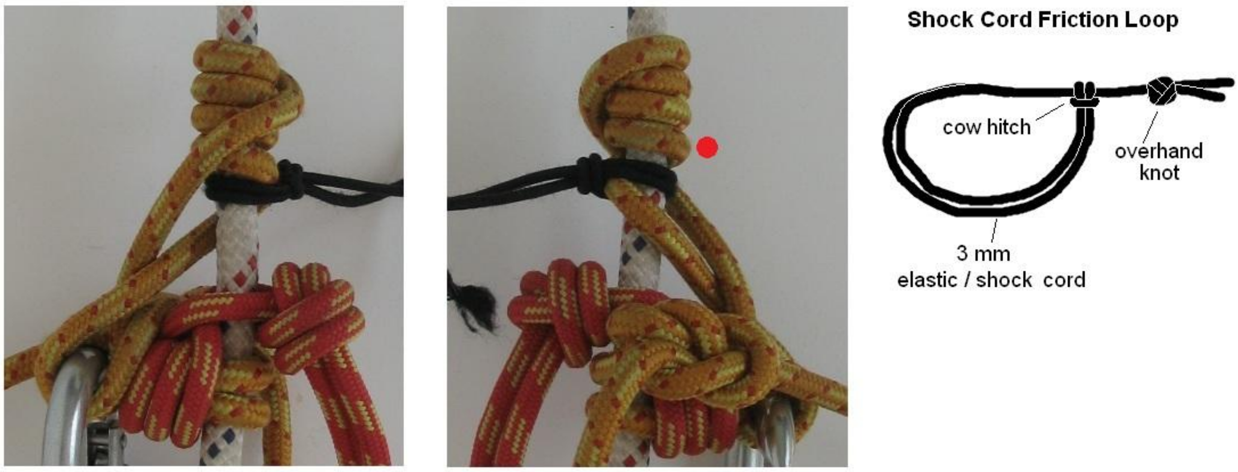


Figure 8.2; Single cord, retraced DO-hitch with shock cord friction loop

The loop is tied around the rope and the lowest of the top turns using a sliding Girth hitch loop (also called Cow Hitch loop). In this document it is called “shock cord friction loop”. The Girth hitch provides sufficient friction to avoid loosening of the loop.

The default position where the loop goes over the cord, is opposite of the eyes of the hitch, at the lowest turn. It should not be lower on the turn, as this will impede movement of the lower turn.

The position as in figure 8.2 is more or less of a compromise. It does work, there is zero risk that the loop gets between the top turns and the cord, and it doesn’t interfere with the rope section that comes down from the top.

It operates better, especially with a somewhat loose hitch, when it is somewhat higher onto the top turns. When the cow hitch doesn’t interfere with the rope section that comes down from the top, you may “rotate” the loop over about a half turn (or somewhat more) so that it arrives near the position of the red dot. The friction acts than at the top of the first turn, or slightly above.

In most cases the shock cord will not be squeezed between the top turns, or between the rope and a top turn. “most” does not mean “all”, so you need to test for your application.

When you use a double cord DO-hitch, the loop goes around two cord sections, as each turn of a double cord hitch contains two cord sections.

To tie the Girth Hitch loop, you need to start with a relative large loop. It is hard to tie with a small loop. The Girth hitch is easy to inspect and therefore recommended.

Alternative loop hitch (Buffalo hitch)
The Bull Hitch with an extra braided turn is a less known hitch (and therefore difficult to check for most people). Its non-official name is Buffalo Hitch, see figure 8.3. It is very easy to tie (in about 10 seconds or less), also when having a small loop. It is also easy to remove compared to the Girth hitch loop.

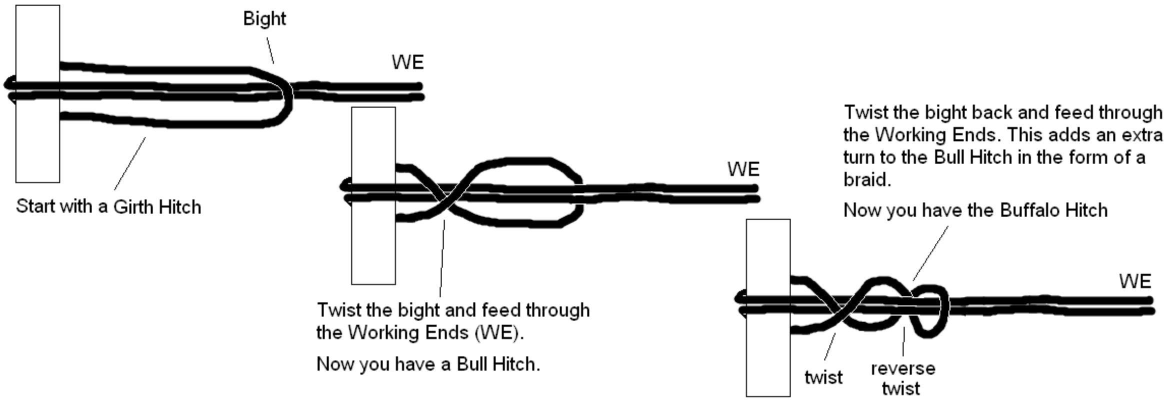


Figure 8.3; Bull Hitch with extra turn (Buffalo Hitch)

To have a reliable hitch, the second twist must be in the other direction to form the braid. When the second twist is in the same direction as the first one, you get an extra turn that may fold over the previous turn and then the Working Ends may slip.

You tension the hitch by pulling the Working Ends to the right with you right hand while grabbing the turns with your left hand and move them to the left. Though not shown, there is an overhand knot in the Working Ends to keep them together.

In the application as a “shock cord friction hitch”, you tie the Buffalo Hitch around both the rope and the lowest turn of the top turns (figure 8.2).

9. Which version to use?

With 4 versions (officially 5), it might be difficult to choose which version to use.

Single cord version

Use only when you have a premade cord with the correct length. The hitch is easy to inspect as it has a distinctive look.

Breaking Strength of hitch is 100% of cord MBS, so it is the weakest of all versions.

Single cord, retrace version

The hitch can be tied with just a straight piece of accessory cord of about 1.5 m long. The rope may be under tension. You need a carabiner, or straight piece of material to tie it. Later you can exchange that for a rope sling.

From the 4 versions, this is the only one that can be tended without a tending device (just pulling the carabiner). It has increased friction, likely too much when used in combination with Dynamic Climbing Rope. As it is a short hitch with relative low backlash, it works well when used in an adjustable lanyard that goes around your back, or connects to the waist D-rings of your harness.

You may add the auxiliary cord turns to improve locking behavior when required (see below).

The hitch can be easily adjusted when required, as the knot carries <30% of the load.

Main disadvantage is larger risk of human error. Retracing the load bearing ends can go wrong, you need to tie a knot, and visual inspection is more demanding compared to the other hitches.

Breaking Strength of hitch is 150% of cord MBS.

Single cord, retrace version with auxiliary cord

When you want to use the retrace version frequently, adding the auxiliary turns improves locking performance significantly. It is a bit more work, but it makes the hitch less sensitive to tightness of tying.

As mentioned already, there is a higher risk of human error with this hitch.

Breaking Strength of hitch is 150% of cord MBS.

Double cord version

Use when you have a loop with correct length with minimum 5 mm thickness accessory cord. 4 top turns are not reliable, think of 5 to 6 top turns. You need to practice on the ground well to be familiar with the two-step tying (first as a normal Distel hitch, then adding the additional turn).

Due to the double cord and minimum 5 turns, it is a rather long hitch.

Risk of human error is less compared to the single cord, retrace version. Risk is mainly in correctly counting the turns. This risk is somewhat reduced as one turn less gives longer eyes. This would be a sign that something is wrong.

Breaking Strength of hitch is 200% of cord MBS.

Double cord version with auxiliary cord

Use when you have a loop with correct length with minimum 5 mm thickness, and have the auxiliary cord with you. 4 top turns are not reliable, so make your loop length for at least 5 top turns.

Due to the double cord and minimum 5 turns, it is a rather long hitch.

It looks troublesome to add the auxiliary cord, but this version ties easier then the double cord only version.

Disadvantage is that you need a second piece of accessory cord for the auxiliary turns. When not applying the auxiliary cord, you just have a double cord Distel hitch that locks unreliably as the loop is a few cm too long, and you don't have offset.

Risk of human error is similar to that of the Double cord version.

Breaking Strength of hitch is 200% of cord MBS.

"Breaking Strength of hitch" is just based on the force distribution in the cord, including the loss due to a 50% efficient knot. When the hitch and rope holds, the cord will break at the values mentioned. If the knots would be 100% efficient, the hitch will still break at a lower value then based on the cord MBS (Nylon or Polyester). So you will never reach 400% of MBS for a double cord hitch.

When using aramid cord, the breaking strength of the hitch will be significantly less compared to cord MBS.

The weak point in the Distel hitch is the small bend radius of the rope section that makes the half hitch around the rope (the bottom turn). This affects "Tech" cords more than PA or PES cords. The hitch may likely fail at much lower force due to slippage or damage of the climbing rope.

When using the hitches on a rope that is loaded and unloaded below the hitch (diameter change), without continuous tending (using shock cord), you very likely need the "shock cord friction loop" (chapter 8).

Short summary:

- When you have just as single cord (minimum 7 mm), use the “single cord, retrace version”. It is stronger than the single cord version, even with sewn eyes. To improve locking, you may add the auxiliary turns, but that requires an additional piece of cord. There is a relative high risk of human error compared to the other versions.
- When having a cord loop (minimum 5 mm), use the “double cord with auxiliary cord” version. It is preferred over the “double cord” version.
- When you need to descend over small distance, go for a double cord version, as it puts less wear on the cord and rope.
- The “single cord retrace version” is most versatile. It can be tied with just a piece of cord, it is rather strong, and you can decide at the latest moment to use (or not to use) an auxiliary cord to improve locking. It is not suited for descending when full body weight is on the hitch.
- Double cord versions are the strongest, but need more turns to avoid slipping under load, they are long, and have more no-load friction.

10. Recommended cord

The extra turn (or auxiliary cord) to create offset, gives you larger choice of accessory cords that provide good results. The DO-hitch versions with double cord have preference as you can have thinner cord while maintaining good Safety Factor. In addition, you don't need eye knots.

Twice comes the single cord, retrace version, as it is about 50% stronger than a standard Distel hitch, but has higher risk of human error.

Aside from strength, flexibility of the cord is important for good hitch operation. A simple test is to form a bight between your fingers, and observe how it bends, see figure 10.1. When you need force to form the cord into a narrow bend, it is not a good cord for a smooth working hitch.

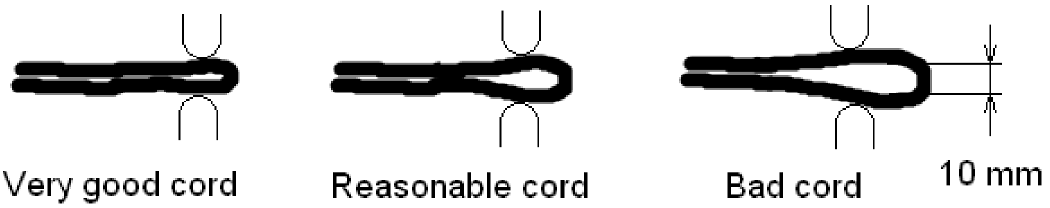


Figure 10.1; testing accessory cord

The width of the bend (inside measure) must be well below the diameter of the rope. 10 mm as shown in the right figure will give a bad locking friction hitch when using say 9.8 mm climbing rope. It may work on a 11 mm (or thicker) semi-static rope.

10.1. Life support application

Use accessory cord that meets std. EN 564. These static (low stretch) cords are designed for use as PPE (Personal Protection Equipment).

When considering performance/price ratio, polyester (PES/PET) accessory cord is a good choice: low elongation, stable performance wet or dry, good abrasion resistance, MBS specification, and good UV resistance. Nylon (PA) accessory cord comes twice, due to larger elongation and moisture absorption.

Strength of PES or PA accessory cord is similar. You should think of MBS of 7 to 9 kN for 6 mm cord, and 10 to 12 kN for 7 mm cord. Read the manual, besides MBS strength of loops made with common climbing knots is also specified.

When price is not an issue or in case of frequent use, you may use a specialist "hitch cord" with aramid sheath (see further down the text).

> Do not use nylon or polyester cord for descending using a DO-friction hitch as a replacement for a figure 8 or other mechanical descender. Only use it in a real emergency.
>
> When there is a need to descent, use a second hitch with a foot loop, when possible. This enables you to transfer your weight to the non-moving hitch.

10.1.1. Occasional work

For occasional work, you can stay with the regular PES or PA accessory cords. When the load is on two cord sections, use minimum 7 mm cord. When the load is on 4 cord sections, use minimum 5 mm cord. When you are heavy, or take lots of gear with you, or expect some shock load, use thicker cord. I use 6 mm cord for the double cord DO-hitch, as that provide MBS > 30 kN (without knots).

Edelrid 6 mm PES (Polyester) cord has strength of 6.5 kN when using an overhand bend (follow through overhand knot). The 7 mm PES cord has strength of 7 kN when using an overhand bend. Source: user manual.

10.1.2. Professional use

There are so-called "hitch cords" containing blends of aramids (Kevlar, Technora, etc) with other fibers. They may meet Std. EN 564. These cords are specially designed for frequent, heavy professional activity, including descending on double rope and single rope systems. They can be very flexible so that even hitches using thick cord lock well.

When the sheath is out of an Aramnid (Kevler, Technora, etc) these cords do not show glazing. Aramids don't have a melting point. Use them because of their abrasion resistance, not because of their strength.

Read the instruction manual very well, as they behave differently compared to PES or PA cord. All recently manufactured cords that meet Std. EN 564 must be provided with strength loss for common climbing knots. The strength is given for a loop (so not for a single cord).

10.1.3. Not recommended cord / rope types for life support

Do not use

- Polypropylene (PP) utility rope. It has bad abrasion resistance, low melting point, and has significantly less strength. The low melting point in combinations with the low abrasion resistance makes it dangerous. A single slide of a loaded hitch out of PP can result in complete destruction of the cord.
- Paracord, the word "paracord" is used for everything, so you don't know what you get. Though the original paracord is made out of Nylon (PA), cord out of PP is also sold as paracord.
- 100% Dyneema, though a very strong fiber, it is very slippery, and most knots in Dyneema cord slip at a load well below the breaking strength of PA or PES cord. In addition, its melting point is even below that of PP. It is useless for friction hitches.

10.2. Non-critical applications

You can use Polyester, Nylon or Polypropylene cord from DIY stores. Note that Polyester has best UV-resistance. Polypropylene (PP) has bad UV resistance and wears out fast. If possible avoid PP for friction hitches that may (shortly) slide under (partial) load. This is because of the heat that is generated during sliding.

It is recommended to maintain a Safety Factor of >7 for vertical non-critical lifting. As knots have efficiency in the range of 50…60%, the lifting rope should have MBS of about 12…14 times the load to be lifted (or better of course).

For the “prusik cord” you can use rope with diameter of about 60…80% of the rope where the hitch is tied on. When you wrap the cord onto the rope and you need some force to keep the turns onto the rope, use a step thinner cord. This mostly results in SF > 7 for the “prusik cord”, including the bend.

The DO-hitch with double cord and auxiliary cord has preference as it is easier to have sufficient SF and wear is less due to the double cord. Start with a double cord Distel hitch with at least 5 turns. Does it work well, you don’t need the auxiliary cord turns.

10.3. Storing your prusik cords

Store your cords, especially cords that you use for climbing, out of sunlight in a cool, dry, ventilated place, away from chemicals (think of paint thinner alcohol, oils, fuels, etc.). Note that some specialist hitch cords have moderate to bad UV resistance, so store them away from direct or indirect sunlight. In general UV damage is not visible, unless the damage is such that the MBS has reduced so much that the rope or cord is well beyond safe to use.

Keep track of the manufacturing date and use history. Rope/Cord shelf life is 10 years. Check your cords before use. In case of any doubt, don’t use them for climbing or rigging anymore. You can use them for other applications, as long as they can’t be mixed with cords you use for climbing or rigging.

11. Test your hitches!

11.1. Testing in general

Testing your hitches should give answers to:

1. Is its construction strong enough?
2. Can it be released?
3. Is its holding power sufficient?
4. Does it lock/grab when it needs to lock?

The first “rule” is to test your hitches under the circumstances that may occur and using the materials that you are going to use in your application. When using new rope, also test on old rope, as new rope becomes old during use.

The first question is easiest to test as it is just an administrative one. Use the right cord (type and thickness) in combination with the right knot and safety factor. Read the instruction manual on knot strength.

The second question is also relatively easy to test by applying some shock load and/or let it slide a few cm under load. When it can be released (easily) it is fine. You need to check this under real circumstances. That may be wet, dry, polluted, etc.

Question 3 and 4 are more elaborate, especially question 4. The last two questions are discussed below.

11.2. Holding power

This is just the load force where the hitch starts to slip (or fails). A friction hitch may lock very well, but may have low holding power, and vice versa. Holding power and locking are two different things. Jerking onto the hitch to check that it grabs, does not mean that it holds well.

The force it should withstand (without sliding), depends on the actual load (including peak load due to dynamics). In a DRT / MRS climbing system, the hitch only carries half your weight. This is similar to a work positioning line that goes around your back or connects to the left and right waist ring on your harness.

In an SRT system, or positioning line that goes directly from your harness to an anchor point, the friction hitch must carry your full body weight, and that is more demanding for the hitch.

The holding power (load were above slipping occurs) is mostly determined by the number of top turns and Dcord/Drope ratio. A double cord hitch (such as discussed here and the Autoblock) needs generally more turns to hold well.

So check the holding power using the short descent and jump/bounce tests (paragraph 11.5 and 11.6) with a well tied hitch. Do it again with a somewhat loose hitch. Then you know whether or not you have sufficient margin.

11.3. Locking behavior

Locking is also very important, as when it doesn't the outcome can be fatal.

When you tend the DO-Distel hitch with an elastic cord (no other tending device, see figure 7.2C), it does lock, even when the hitch is very loose. This way of tending is typically used during ascend or as let go protection when hoisting things. It can also be used as rope grab function when climbing into a construction where the rope is already in the top of the mast (so you don't need a Y-lanyard) Tending with elastic cord creates (near) zero slack, so you can't make a hard fall.

A very loose hitch you recognize via the large distance between the top turns and the bottom turn when loaded. Note that when using more top turns, the distance between the top and bottom of hitch under load increases.

In the event that the hitch doesn't lock during ascend, you can lock it manually and correct the issue.

Grabbing/locking

- Goes well when the no-load friction is relatively high
- Goes better when the offset is large
- Goes better when the cord is very flexible
- Instantly reduces when you load a rope below the hitch, as the diameter reduces.
- Instantly reduces when the hitch enters a region where the rope diameter is less (for example due to that a section is more heavily loaded).
- Goes better with a lightweight hitch, as the hinge works better.

When having a hitch with 5 top turns, and the rope diameter reduces 1 mm (from zero load to full body weight), you have 19 mm slack inside the hitch. A hitch that wasn't already tight, may slide down when it is not loaded. When the load is removed from the rope, the rope becomes somewhat thicker and the hitch no longer slides down.

When you use a second friction hitch as a backup device (for example above your main hitch) it must lock. First sliding and then locking will introduce shock load, and it shows you that the safety margin is insufficient.

Tips to improve locking

- Keep the hitch lightweight, so do not leave longer cord tails then necessary.
- Do not use thicker cord then required for sufficient safety (thin cord is more flexible and weighs less)
- Use flexible cord
- Use more offset then you would normally use for a progress capture hitch (check for holding power). Both single cord and double cord hitches work well with 3 auxiliary turns with good holding power, but somewhat increased backlash.
- Use a tight hitch, yes this may increase no-load friction at thicker parts of the rope, for example rope sections that were not loaded for long time.
- With same no-load friction, single cord DO-hitches lock better then double cord hitches (on average). They weigh less, and the offset works better because of the hitch is shorter.

11.4. Testing for good locking

When using all measures from the previous paragraph optimally, it is likely that on a rope that is loaded and unloaded below the Hitch under Test, an unloaded hitch will slide down. This is just because of the dynamic variation in rope diameter. So be prepared for negative results and that the “shock cord friction loop” is required.

Testing for good locking requires an anchor point at say 2.5 meters above you, a piece of rope that you are going to use during work, and a friction hitch with foot loop (or your harness). The friction hitch with foot loop is to load and unload the rope so that the diameter changes. Instead of the foot loop, you may tie a loop in the rope just above the ground that you use as foot loop. When you have a sit harness, it works great as you have both your hands free.

> When you are not familiar using foot loops, you need to practice first. Be prepared that you may fall during practicing. Start with a short foot loop so that the hitch is well below chest level. This avoids that you accidently press onto the hitch and fall onto the ground.
>
> When you step onto the foot loop, you need to pull the rope to your chest (use both hands). The foot that is in the loop you move somewhat backwards and you straighten your back. You may move your other leg forward, horizontally, as this eases standing in the foot loop. Keep your hips horizontally to reduce stress on your lower back, as you stand on a single leg.
>
> Your torso should contact the rope and your whole body is near vertically. Practice with both your left and right foot and try to stand stable using one hand only (that takes more effort).

Testing for unintended sliding

It is assumed that you already did the descent tests before these tests, as they affect sliding and locking also.

The Hitch under Test should be above the foot loop hitch, but not where you put your hands to transfer your weight onto the foot loop. Do not load the rope yet. Move the hitch up and down and let it lock to feel that it is tied correctly.

Wiggle with rope above the foot loop hitch or eye termination to remove the stress in the core and sheath. Move the Hitch under Test down (without letting it lock) so that it is at the wiggled rope section. Wiggle with the hitch and the rope, to get the stress from previous loading out of the Hitch under Test.

Now move the hitch above you, without loading it. During moving upwards, avoid that the carabiner hangs onto the eyes of the Hitch under Test. It should not slide down. Now put your weight onto the foot loop, this reduces the diameter. The Hitch under test should not slide down. You may repeat this test with a hitch that is somewhat loose. When the accessory cord is relatively stiff, the hitch will slide down when standing onto the foot loop. If so, this is a failure. Yes, when you pull the hitch it will lock, but it may slide down before locking, and that shows insufficient margin.

When you have a failure, repeat the test with the shock cord friction loop. The hitch should not slide down. Load the rope and push slowly on top of the top turns to feel how much margin you have. When only minor force is required to push down the Hitch under Test, you need to tighten the shock cord friction loop.

Note

> Do not tighten the auxiliary turns to increase the no load friction. It is unreliable when the diameter of the rope changes, and tight auxiliary turns impede good function of the hinge, negatively affecting locking.

When the hitch does not slide down with repetitive loading and unloading of the rope in combination with wiggling, and you have some margin, you can go to the lock test.

Testing for good locking

Move the hitch to a position where the rope is free of stress (wiggling). Wiggle the hitch to remove stress. Move the hitch above you without loading it.

Step onto the foot loop (to reduce the rope diameter). The Hitch under Test should not slide. While standing on the foot loop (or hanging in your harness), slowly pull the load bearing eyes (mostly just pull the carabiner). The hitch must lock. The lower turn may move a few cm down, but the top turns should virtually not slide. Maximum 5 cm of sliding of the top turns is acceptable. Move it a bit upwards, and pull slowly again. After the first locking test, it locks better next time.

Locking of a loaded hitch that has been released

Load the hitch heavily (with a foot loop, jump on it, etc). Remove the foot loop from the Hitch under Test. Release the Hitch under Test with only minor load onto the rope, move it a bit up and down. Stand on the foot loop (or sit in your harness) to tension the rope, and slowly pull the hitch, it must lock without sliding except for the lower turn. Sliding of the top turns of maximum 5 cm is acceptable. Move it a bit upwards and pull slowly again. It must lock.

You may repeat this test a few times, and with a hitch that is somewhat loose, so you know your margin.

When it doesn’t lock reliably, you may tighten the shock cord friction loop somewhat to increase the no load friction. This will mostly result in a reliable locking hitch.

11.5. Testing the holding power

A double cord Distel hitch is not well known, so you need to test it well. Don't rely on Distel hitch data based on a single cord or an YT video. It is of no value when using double cord. Even when using a single cord version, test it! The tests described below are highly recommended.

When testing with Autoblock hitches it happened that when you break the hitch under load and let it slide, it would not lock reliably again when maintaining the load. As double cord DO-hitches have similar turns pattern, this effect also occurs, but to a lesser extent. There are 3 reasons for this behavior:

1. Deformation of the turns due to flattening of the cord cross section and stretch, increasing slack inside the hitch (figure 1.1).
2. Reducing of friction due to flattening of the cord surface that is in contact with the rope (figure 1.1C).
3. Glazing of the accessory/prusik cord area that is in contact with the rope, reducing the friction coefficient.

The DO-hitch is not a good hitch for descending, but the double cord version can be easier broken under load compared to the single cord versions. This may be useful during an emergency maneuver. Due to the double cord, the friction force is divided over two sets of turns halving the contact pressure. This eases breaking of the hitch, and puts less (but still high) stress onto the rope and the cord.

When the single cord hitches have say 6 turns or more, breaking the hitch for descending goes better.

Breaking the hitch under load is a good test to test its holding power due to reasons 1 and 2.

The Hitch under Test can be loaded via a foot loop, or using a sit harness. When you are not familiar using foot loops, and want to use them, you need to practice first. Be prepared that you may fall during practicing. Start with a short foot loop so that the hitch is well below chest level. This avoids that you accidently press onto the hitch and fall onto the ground.

When you step onto the foot loop, you need to pull the rope to your chest (use both hands). The foot that is in the loop you move somewhat backwards and you straighten your back. You may move your other leg forward, horizontally, as this eases standing in the foot loop. Keep your hips horizontally to reduce stress on your lower back.

Your torso should contact the rope and your whole body is near vertically. Practice with both your left and right foot and try to stand stable using one hand only (that takes more effort).

Required Setup
The setup is virtually the same as for testing locking behavior. You need a short vertical climbing rope section anchored at about 2…3 m above ground. Tie the friction Hitch under Test and add a rope loop of about 0.9..1.2 m of loop length through the carabiner that is connected to the friction hitch. You can use this loop as a foot loop. This enables easy transfer of your weight onto the hitch. Do not use your harness to apply shock load. If so, use a harness that is no longer in service.

Putting body weight onto the hitch and descending
Position the hitch so that the foot loop is about 0.6m above solid ground. Grab the climbing rope and step into the foot loop while pulling the rope to your chest, but without pressing onto the top of the hitch. This transfers all your weight onto the hitch. The top of the hitch should be at about chest level. When not, readjust the foot loop. Jump into the loop to see whether the hitch slips/slides. When it slides, you don’t have to continue. You need an additional top turn.

When standing in the foot loop, push onto the top of the hitch with your hands, so that part of your weight transfers from the foot loop to the top of the hitch. Slowly increase the force on top of the hitch, until it breaks and slides slowly down.

When it slides down you need to suppress your normal grab reflex, as that will send you to the ground. When it starts sliding, you reduce the force onto the hitch to control the descent rate. Descent about 10..20 cm. When you stop pressing/hanging onto the top of the hitch, it should stop sliding immediately.

Press onto the top of the hitch for the second time so that it slides about 10..20 cm. It should stop again when reducing the force onto the top of the hitch.

Carry out another (third) short descent. You should not step out of the foot loop during these three short descents. Make sure that your feet don’t touch the ground. jump into the foot loop (creating shock load) to check that it doesn’t slip.

Three short descents of about 10 to 20 cm per descent, while remaining on the rope, are important. The descents are required as hitch behavior may change after the first descent due to rearrangement of the turns, cord stretch and flattening of the cross section. When it descent too easy after the third descent, add another turn and/or check for a loose hitch. Yes, this requires changing the loop length in case of double rope versions.

Especially when checking the single cord versions with relative thin cord, you may need thick cloves to protect your skin, as you need to apply a significant part of your body weight onto the friction hitch to break it. It is a bad sign when you need lots of force to break the hitch, and then it slides down easy. When it slips a bit further after removing the pressure from the top, you need an additional turn. It must stop sliding immediately after removing the pressure.

11.6. Checking for glazing effects

Three short descent tests are good for checking turns deformation. When doing more short descents, you can check for glazing and further flattening of cross section of the cord. You need to descent over larger distance, think of 5 m in total. Of course you can do this in many sessions so that you stay close to the ground. Just descent say 50 cm, step out of the foot loop, move the hitch up and descent again.. Leave the DO-hitch on the rope during all the tests. This assures that cord orientation doesn't change.

When you experience

- breaking of the hitch becomes very easy compared to the beginning of the test.
- sliding doesn't stop immediately,
- short slipping during jumping into the foot loop (shock load),

there is something wrong. You don't have sufficient margin.

First check whether the hitch is less tight compared to the situation before the descent tests. This can be due to cord stretch, further flattening of the cross section, or due to the bend giving out rope. It is therefore advised to start with a hitch that is tight, as it becomes less tight during use. You may mark the cord sections that leave the bend to check for giving out rope.

Important note

> When the hitch is still tight enough after the test, but breaking goes easy, or it slips when jumping in the foot loop, there is likely glazing. You must use an additional top turn to increase the friction, and avoid slipping/descending during use.

An additional top turn adds no-load friction, but you can better be safe then sorry.

There is another reason for short descent testing, even when you will never on purpose descent using the DO- (or other) hitch. You may arrive in a situation that shock load occurs. When holding power is relatively low, peak forces are limited because of slippage. That is a nice feature. However when the slippage causes glazing and flattening of the cord, and the hitch hasn't sufficient margin, it keeps slipping/sliding. This may end fatally. Therefore you need to be sure that a hitch has sufficient margin for its application.

When you plan to descent using the hitch, use cord with an aramid sheath (Kevlar, Technora, etc), and use a VT or XT hitch as that puts less stress onto the rope. Better is to use also a device that takes over a significant part of your weight, or use a mechanical descender. Descending using a friction hitch with your full weight causes wear of your climbing rope. Nylon accessory cord is not suited for descending over large distance. You should only do it when in an emergency with no other options.

11.7. Let’s resume

When the hitch passes all tests, you have a hitch that

- is strong enough, based on the cord, knots, expected load and type of hitch (just administration)
- releases well, also after receiving some shock load or a short descent (intended or unintended)
- locks well, also on rope that is loaded and unloaded below the hitch (diameter change issue).
- can hold the load with sufficient margin, including negative effects because of short descent, minor glazing of the cord and slight loosening of the hitch

You may think, everything is fine now, so I don’t need a backup hitch. When putting your life onto a hitch, a backup is highly recommend (yes, I know many people don’t). A backup hitch is on another rope, or above your primary hitch.

It is recommended to have a short lanyard between your hand ascender or your foot loop friction hitch. It is not suited for fall protection, but you may be able to put your weight on it in a slow manner when your main friction hitch behaves unexpectedly. This gives you time and free hands to solve the problem.

Check your gear continuously during and outside your activities, and be your own devil’s advocate.

Make sure you have sufficient spare material with you, so that you can resolve problems.

Don’t forget, climbing is dangerous. This document is not a substitute for good training on how to tie friction hitches and how to test and use them.

12. Annexes

12.1. Annex 1, adjustable loop hitch

This hitch is intended for creating adjustable loops where the load is inside the loop (ring load, parallel load). It is not suited for eye terminations (such as a figure 8 loop termination).

When tightened, it doesn't come loose when wiggling.
Little effort is required to release the hitch when you need to adjust is.

Tying the hitch
Figure A.1.1 shows how to tie it.

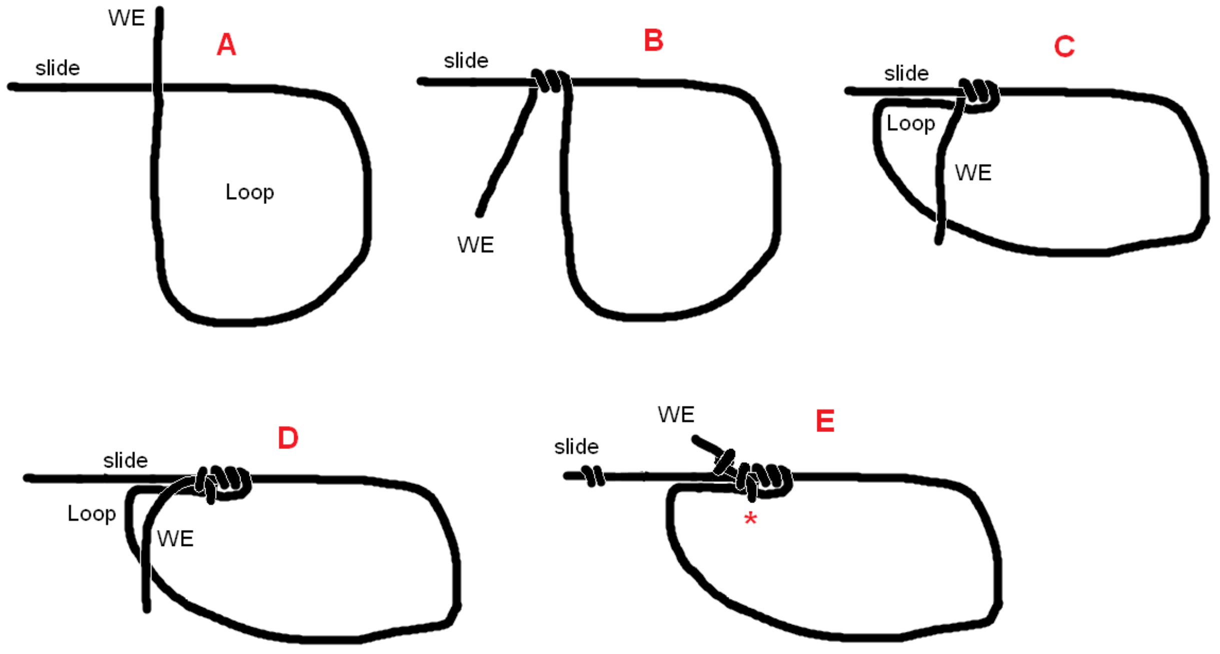


Figure A.1.1; adjustable loop hitch

Figure A, B

Start with a loop and apply 3 turns. 3 turns are mostly sufficient to create a friction hitch that has holding power >35% of MBS when using polyester or nylon cord.

Figure C

Fold a short section of the loop parallel to the slide rope section.

Figure D

Tie an overhand knot around the slide and loop rope section. The winding direction is the same as for the 3 turns.

Figure E

Put an overhand stopper knot in the working end and dress the hitch so that the overhand stopper knot touches the hitch. The E-figure shows some distance between the stopper and the hitch, this is for clarity only. There should be no clearance.

Tie a double overhand stopper knot in the slide rope section so that you can’t pull through the sliding end by accident.

Making the loop larger

When the hitch wasn’t heavy loaded (see figure A.1.1E)

Grab the hitch with your left hand at the most right turn and pull through the cord with your right hand.

When the hitch was heavy loaded

You first need to release the hitch. Grab the three turns with you right hand, and push the overhand knot with the thumb of your left hand to the left side. You put your thumb at the position of the red star in the E-figure.

This action creates sufficient cord inside the hitch to pull rope through the hitch when you grab the hitch at the most right turn.

Making the loop smaller

When the hitch wasn’t heavy loaded

Grab the most left part of hitch with your right hand, and pull through the rope with your left hand.

When the hitch was heavy loaded

You first need to release the hitch. Grab the three turns with you right hand, and push the overhand knot with the thumb of your left hand to the left side. You put your thumb at the position of the red star in the E-figure.

This action creates sufficient cord inside the hitch to pull rope through the hitch when you grab the left side of the hitch with you right hand.

For making loops for tending a hitch without a ring, use 3 to 4 mm of Polyester or Nylon cord. When having very flexible single braid cord, you may use 5 mm as this reduces friction. PP (Polypropylene) is not recommended because of higher friction and low abrasion resistance.