

TECHNICAL NOTE

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Mirror Images in Knots

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ABSTRACT: Most knots are asymmetric and thus can be tied in two forms which are mirror images. An individual tends to tie one of the mirror images habitually which increases the significance of an analysis of the knot. Of 103 college students, 68 surveyed tied a knot based on an overhand knot. Of these, approximately 75% of the right-handed persons tied the overhand knot in one orientation while the other 25% tied the mirror image of it. Some background information relating to analyzing common knots is discussed.

KEYWORDS: forensic science, knots, surveys

Background Information

The analysis of knots is one of those specialties within forensic science that has a high cost : benefit ratio. A lot of work produces few results. Considerable study is required to master the background knowledge; practice is needed to become proficient in distinguishing knots; and experiments or surveys or both must be conducted in order to judge the significance of what is observed in an instant case. Developing any forensic science specialty demands this expensive procedure of study, practice, and experiment. However, most specialties have a higher case-load demand than does the analysis of knots. Also, most specialties produce more information than does the analysis of knots.

Developing the expertise itself presents several problems. The sheer volume of the subject overwhelms the novice. Encyclopedias of knots [1, 2] name up to 3900 different knots. A simple problem is finding the knot you want out of nearly 4000. It is merely time-consuming. A complex problem is determining the significance of a particular knot. Usage of knots is based on an interaction of training and habits. Virtually everyone uses simple knots to tie their shoes, packages, and clothing articles such as neckties and scarfs; but some 49 trades and recreations together use about 120 specific knots a significant amount [3].

The literature on the knots for these trades and recreations is specialized, scattered, and limited in scope. Most sources, such as general encyclopedias, scout and seamen's manuals, macrame manuals, and "how-to-do-it" books, illustrate from 10 to 50 knots and give only limited background information. For example, Svensson and Wendel [4] present over 40 different

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knots that can be used as nooses. However, their book presents little information which can be used in analyzing these nooses.

Understandably, the nomenclature for knots is far from standardized. Knots have been used in every culture and many different trades sometimes for centuries. Figure 1 illustrates how the same basic motion can be used to tie four knots with different names. The convention, which is not always followed, is that if the rope is tied on itself it is called a knot; if two ropes are tied together, it is called a bend; if a rope is tied onto something, it is called a hitch; and if it forms a loop, it is called a loop.

The confusion also extends to individual knots. The same knot can be called by several different names according to how it is used while the same name can be used for different knots. A particular knot when used to tie up a horse is called a Picket Line Hitch, but when the same knot is used to tie up a bag, it is called a Miller's Knot, yet when used by deep sea fishermen, it has a third name, the Ground Line Hitch. On the other hand, different books list the Miller's Knot, Sack Knot, and Bag Knot interchangeably (see Fig. 2).

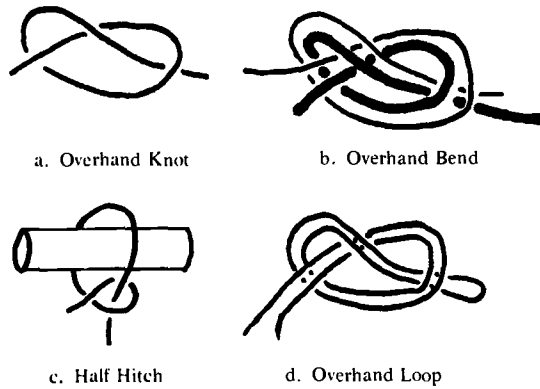


FIG. 1—Overhand variations.

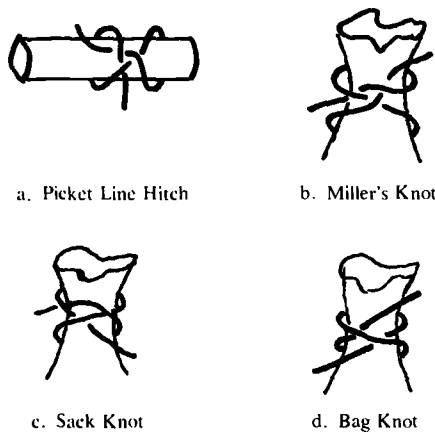


FIG. 2—Confusion in naming knots.

Recent publications by Budworth [3,5] have made the most significant contribution to date towards bringing order to the chaos of knots for the forensic scientist. Budworth has developed a system of classifying knots based on their line crossings. He also has compiled the rudimentary terminology and background information on 120 of the basic knots commonly used today.

Mirror Images

This paper adds the detail of mirror images to his work. A knot with an asymmetric structure can be tied in two different ways which are mirror images of each other. Svensson and Wendell [4] noted two different ways of tying two of the simple nooses but did not elaborate that they were mirror images or that most other knots also have mirror images. One third of the knots classified by Budworth have an uneven number of line crossings and are therefore asymmetric by definition. But most all of the knots with an even number of line crossings also have an asymmetric structure and thus have mirror images.

The most common basic knot is the overhand knot. It has three line crossings and is therefore asymmetric and thus can be tied in two different ways. These two ways are illustrated in Fig. 3 and are labeled dextra (D) and sinistra (S) forms. At first glance one would think that the dextra form in Fig. 3a could be flipped and then look like the sinistra form in 3b. But they are different just as the "S" and "Z" twists in yarn are different.

By contrast, the knots in Fig. 4, the Lark's Head with two crossings and the Figure Eight Knot with four crossings, are symmetric and have no mirror images. They may be tied with a different sequence of motions but the end result is indistinguishable.

The two most commonly tied knots, the Square (Reef) Knot and the Granny Knot, are formed by tying an Overhand Knot on top of an Overhand Knot. Although both knots have an even number of crossings, each results in two forms illustrated in Figs. 5 and 6. The knot in Fig. 5 is called the Reef Knot by most of the world, but is called the Square Knot in the United States.

Some knots can change form to what is called an equivalent knot. The most familiar change is the collapse or breaking of the Square (Reef) Knot when you pull on one end so that the knot can be slipped off. The same thing can happen to the Granny Knot. When the Granny Knot breaks, it changes into Two Half Hitches. When the Square (Reef) Knot breaks, it changes into Reversed Half Hitches. Not only do the two knots, Granny and Square (Reef), break into different type knots, but each D and S version breaks into a D and S version of the Half Hitches as illustrated in Figs. 7 and 8.

One interesting variation of this style knot is the Thief Knot, so called because it looks like a Reef Knot at first glance (see Fig. 9). A sailor suspecting that someone was getting into his duffel bag would tie it with a Thief Knot. If someone did untie and then retie the knot, he would most likely retie it with a Reef Knot. Supposedly no one would tie a Thief Knot by mistake. However, if someone tied a Lobster Bouy Hitch (Fig. 10), it could be changed into a Thief Knot. The unusual part is that the Lobster Bouy Hitch has two forms while the Thief Knot is symmetric and has no mirror images.

Many people extend the Overhand Knot into a Double or Triple Overhand Knot. Each of the three knots has a D and S version. Figure 11 illustrates the mirror images of the Double Overhand. A Triple Overhand Knot merely adds another turn to the Double Overhand Knot. Just as any knot based on the Overhand Knot has a D and a S form, likewise, any knot based on the Double or Triple Overhand Knot has a D and S form. An example is the Surgeon's Knot which is a Square Knot tied on a Double Overhand Knot. Figure 12 illustrates the D and S forms of the Surgeon's Knot.

Most crime scene texts caution against untying or cutting the knots themselves. Svensson and Wendell [4] describe a technique of cutting each cord and immediately tying the cut ends with a smaller string. They also recommend mounting a noose on an object of a similar diameter to avoid disruption of the knot. Even more extensive precautions may be advisable on certain types of knots. One can tie a string or put a piece of tape around the knot itself to keep it

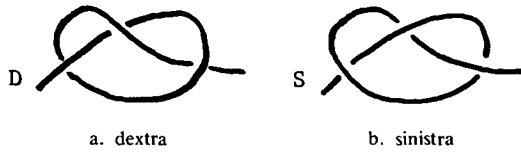


FIG. 3—Overhand Knot—mirror images.

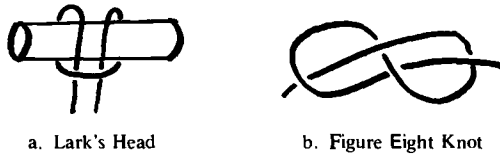


FIG. 4—Symmetric knots.

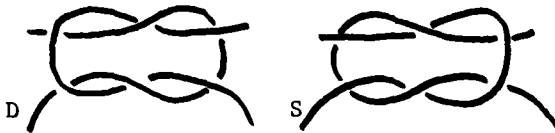


FIG. 5—Reef or Square Knot—mirror images.

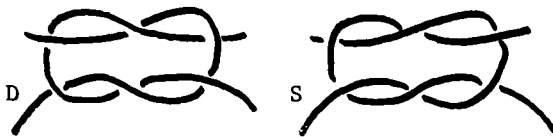


FIG. 6—Granny or Lubber's Knot—mirror images.

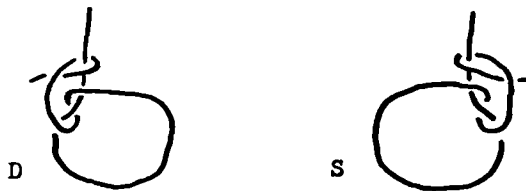


FIG. 7—Two Half Hitches—mirror images.



FIG. 8—*Reversed Half Hitches—mirror images.*

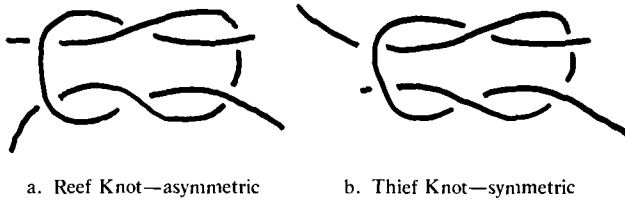


FIG. 9—*Look-alike knots.*

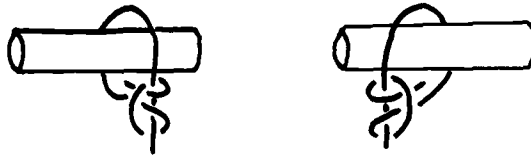


FIG. 10—*Lobster Buoy Hitch—mirror images.*

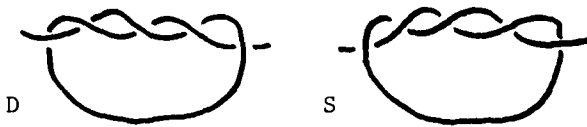


FIG. 11—*Double Overhand Knot—mirror images.*

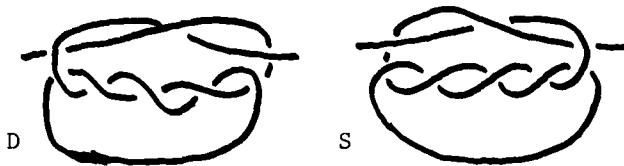
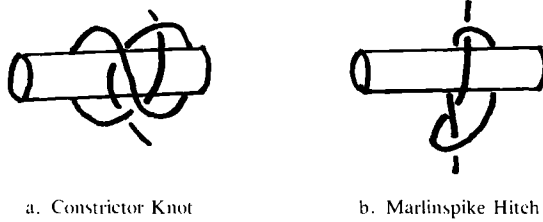
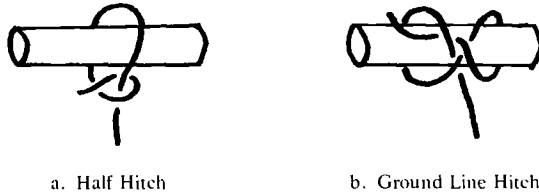


FIG. 12—*Surgeon's Knot—mirror images.*

FIG. 13—*Transitory knots.*FIG. 14—*Knots easily changed into Overhand Knot.*

from changing to an equivalent knot in transport. This technique is particularly important with knots that fall apart if removed from the object. Figure 13 illustrates two such knots, the Constrictor Knot and the Marlinspike Hitch. Care is even important when the knot does not completely fall apart. Both the Half Hitch and the Ground Line Hitch (Fig. 14) may change to look like a plain Overhand Knot if removed without some precaution.

Experimental Procedure

To ascertain the significance to casework of mirror images in knots, five types of information were considered necessary. First, which knots are most commonly tied? Second, do persons consistently tie the same version of an Overhand Knot, or do they switch between the two? Third, does tying the knot in an awkward position change how one ties it? Fourth, is either the D or S version of the Overhand Knot more frequently tied than the other? Fifth, is there a relationship between the D and S versions of the Overhand Knot and right-handed and left-handed tendencies?

Four surveys were conducted to obtain this information. The first was an informal survey in which a number of people would tie Overhand Knots with time intervals between each tying session. A second, preliminary survey of 30 persons indicated that most right-handed persons tied one form of the Overhand Knot and that most left-handed persons tied the other. A third survey of 103 college students was then conducted to verify this and to determine what knots are tied most commonly. Each student received a length of rope with instructions to:

- (1) tie a knot as if they were going to tie someone up,
- (2) indicate whether they were right- or left-handed, and
- (3) indicate if they had any previous training in knots.

A fourth survey of 27 laboratory persons was conducted in which each one first tied a knot (Square or Granny) in front of them and then tied a second knot over their head.

Results

The survey of 103 students is tabulated in Table 1. The most commonly tied knot is the Granny Knot with the Square Knot and multiple Granny Knots the next most commonly tied. All three knots are based on combinations of the Overhand Knot.

All of the persons who tied the Overhand Knots at intervals were consistent in the form that they tied. In fact, most persons had considerable difficulty deliberately trying to tie the opposite form.

Changing position when tying a Granny/Square Knot does make a difference. Of 27 persons, 20 changed the D/S form of the knot when they tied the knot over their heads. Of the 27, 10 changed the knot itself from a Granny Knot to a Square Knot or vice versa when they tied the knot over their heads.

The overall results strongly indicate a relationship between how a person ties an Overhand Knot and his tendency towards being right- or left-handed. The preliminary survey of 30 persons selected by chance encounter suggested that about three fourths of the right-handed persons tie the form of Overhand Knot labeled in this paper as dextra (D). Similarly most of the left-handed persons in the group tied the sinistra (S) form. However, the survey of the 27 laboratory personnel split the 23 right-handed persons with 12 tying the dextra and 11 tying the sinistra. The college class provided a larger and more random sampling. The results, tabulated in Table 2, verified the first study. None of the surveys had enough left-handed persons to place any confidence in percentages, but in all three surveys ²/₃ to ³/₄ of the left-handed persons tied the sinistra form. Two ambidextrous persons, one in the laboratory survey and one in the college class, both tied the sinistra form.

The effect of training was not clear-cut, possibly because no one had had extremely rigorous training. Of 53 persons who tied Granny Knots, 10 had had some training in knots. Out of the 20 persons who tied either a Square Knot or a sophisticated knot, 8 had had some training.

Conclusions

Caution must be exercised in interpretation because of limited study in this area, but the tying of knots appears to be a habitual act. However, a person tying a knot in an awkward position may override the force of habit. One must also be careful in evaluating the significance of a

TABLE 1—Knots tied by 103 college students.

Granny Knot	41	Bowline Knot	3
Multiple Granny	12	Stevedore Knot	2
Square (Reef) Knot	14	Hangman's Knot	1
Overhand Knot	1	Fisherman's Knot	1
	<u>68</u>		<u>7</u>
Overhand Loop	4	Miscellaneous	
Slip Knot/Noose	8	combinations	12
Other Noose	4		
	<u>16</u>		

TABLE 2—Mirror image forms tied on overhand-based knots by 67 students.

Form	Right-Handed	Left-Handed	Ambidextrous	Totals
D	46	2	0	48
S	13	5	1	19
Totals	59	7	1	67

particular knot as the struggling of a victim may inadvertently break a knot into its equivalent form.

The habits of an individual in tying a knot can be of significance in associating that individual with a crime. The degree of significance varies with the frequency with which a particular knot is tied. A Bowline, which few know how to tie, could be quite important; but since approximately 40% of the population can be expected to tie the common Granny Knot, it is of much less value. However, the analyst can obtain additional significance by ascertaining whether or not the mirror image is the dextra or sinistra form. This is because the starting movement in tying the Granny Knot is the Overhand Knot, and individuals habitually tie either the dextra or sinistra form when tying the Overhand Knot. Likewise, determining the dextra/sinistra form improves the significance of other knots based on the Overhand Knot.

The exact form of non-Overhand-based knots should also be noted if encountered in casework. A particular starting movement for any asymmetric knot will result in a particular mirror image of the knot. A more extensive study would reveal the significance of that particular knot as to the frequency of occurrence of the type of knot itself and to the particular forms encountered.

Acknowledgments

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