**Creating a Leak-Proof Ligature with Confidence**

**Part 1: Overview of Ligation & Surgical Binding Knots**

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Certain binding, or friction, knots are highly useful in achieving consistently secure ligations, and ideal qualities of a first-throw friction knot include the ability to:

- Cinch down tightly and completely without premature binding
- Resist loosening once placed, allowing time for additional throws to be performed for a permanent secure knot.

Very little information is available in the human and veterinary literature describing indications and contraindications for use of friction knots for ligation, and we could find no published, well-illustrated instructions on how to tie these knots. There is also considerable confusion regarding the descriptions on tying, and correct names for, these knots.1

The goal of this article series is to review principles surgeons use to achieve hemostasis on blood vessels (or pedicles) and factors related to ligation security, and provide step-by-step instructions on how to create friction knots.

**SUTURE SELECTION & SECURITY**

**Ideal Suture Selection**

Generally speaking, it is good practice to choose the smallest suture material size that provides sufficient strength for the intended ligation.

For surgery, ligatures are used to tightly occlude blood vessels.23 Ligation of solitary vessels, or multiple vessels within a pedicle (mass ligation), is used virtually daily in practice for ovariohysterectomy, castration, amputation, splenectomy, and lobectomy.

Despite the introduction of newer electrosealing devices4-6 for use in open and minimally invasive surgery involving large vessels, ligatures are still considered the gold standard method to achieve hemostasis. Therefore, creating secure ligations is one of the most critical steps in most soft tissue surgeries.

**IMPORTANCE OF LIGATION**

Ligation is the act of placing a ligature, and a ligature has 2 components:

- Material that encircles tissue
- Knot that secures the material in place.

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**TABLE 1. Recommended Absorbable Monofilament Suture Materials**

<table>
<thead>
<tr>
<th>SUTURE MATERIAL</th>
<th>BRAND NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polydioxanone</td>
<td>PDS II (ecatalog.ethicon.com)</td>
</tr>
<tr>
<td>Polyglyconate</td>
<td>Maxon (surgical.covidien.com)</td>
</tr>
<tr>
<td>Glycomer 631</td>
<td>Biosyn (surgical.covidien.com)</td>
</tr>
<tr>
<td>Poliglecaprone 25</td>
<td>Monocryl (ecatalog.ethicon.com)</td>
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</tbody>
</table>
monofilament material of 0 to 3-0 size for most small animal applications, such as the suture material listed in Table 1.2

Within the recommended suture size range listed, larger size suture materials are generally chosen for more substantial vessels or bulky pedicles. For larger arteries, some surgeons still recommend monofilament nonabsorbable suture material, such as polypropylene.

Other Suture Materials

Multifilament sutures, such as silk—a suture noted for its excellent handling and ligation qualities—can be used successfully for ligation, but:

- Have been shown to increase risk of suture-related wound infections

- Tend to bind prematurely during tying: the first throw of the knot may not tighten fully around the vessel or pedicle because the suture develops friction among its strands.

Chronic catgut sutures have fallen out of favor for ligation because:

- The suture is much weaker than the aforementioned materials, even after careful knotting

- Within standard square knots, the suture often shows signs of fraying, which weakens the ligation.8

Therefore, if friction knots are used as part of ligation, chronic catgut is contraindicated due to the risk of excessive abrasion and fraying of the multifilament strands during tightening.
Testing Ligation Security
One of the most common, but dangerous ways, surgeons attempt to determine whether a ligation is leak-proof is to carefully and slowly release the clamps and any tension on the ligated pedicle; then watch to see whether bleeding occurs.

However, this method can be unsuccessful because:
1. Simply crushing the vessel or pedicle with hemostatic forceps may only temporarily stop bleeding, particularly in hypothermic and/or somewhat hypotensive patients.
2. Any tension on the pedicle may temporarily occlude flow through the vessel, giving the false impression that “all is well” at the site.
3. Any fragile clot at the ligated site or crushed area can dislodge with extra blood flow as the patient is warmed, hypotensive effects of the anesthetic drugs wear off, and blood pressure rises.
4. The ligature may appear to be tight, but only a millimeter or 2 of loosening of the knot can create a potentially life-threatening situation.

Unfortunately, especially when the ligature knot crushes deep within the pedicle during tightening, it is quite difficult to know for sure that safe and permanent hemostasis has been achieved. Most seasoned surgeons have experienced a latent bleed after a splenectomy or lobectomy, even though there was absolutely no evidence of bleeding from any pedicle at the time of approach closure.

Seasoned, meticulous surgeons safely practice the principles of secure ligation (Table 2, page 47) rather than relying solely on whether the pedicle bleeds soon after the ligation is completed.

BINDING (FRICITION) KNOTS
Binding knots, also called friction knots, are knots on a strand that either constrict a single object or hold multiple objects snugly together; the ends of the strands are either joined together or tucked under the turns of the knot. These knots are held in place by either:
- Friction between the windings of line
- Two ends of the line being knotted together.

During surgery, once the first friction knot/throw is applied and tightened firmly, it should be considered only temporarily stable; additional square throws are applied on top of it to make it permanently secure. In most cases, 3 to 4 snug additional square throws will secure the ligature knot.

Whippings, seizings, and lashings serve a similar purpose to binding knots, but contain too many wraps to be properly called a knot.

History of Binding Knots
Originally, these knots were designed for use by solo field workers to firmly close the end of burlap sacks. Binding knots were chosen because they would temporarily hold the neck of the sack tight without assistance until the knot was permanently secured with additional square throws.

Some of the more common friction knots used at that time were the miller’s, constrictor, strangle, double reverse half hitch, and surgeon’s knots.1

Why Not This Knot?
The surgeon’s throw can be used for ligation in practice, but it is generally NOT recommended for this use because:
- This knot can bind prematurely, allowing the surgeon to falsely believe the knot has been tightly applied when it has not.
- When the strands are tensioned and, as the encircled tissue is tapered, the double twisted throw tends to bind and resists further tightening.3
- Compared with other friction knots, it has been shown to be the least able to resist loosening when placed under expansile force.10

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![Figure 1. Surgeon’s knot.](image1)

![Figure 2. Double reverse half hitch knot.](image2)
1-Pass or 2-Pass Friction Knots

Friction knots commonly employed in veterinary surgery can be classified by how many passes are placed around the pedicle.

Some surgeons choose a 1-pass friction knot as it is easier to apply, requiring only 1 pass of the suture around the pedicle or vessel. One-pass friction knots include the surgeon’s knot (Figure 1), which is not recommended for ligation, and the double reverse half hitch knot (Figure 2).

Two-pass friction knots take a bit more effort to pass twice around the pedicle; however, the first throw effectively resists loosening. The highly dependable 2-pass friction knots commonly chosen in practice include the traditional miller’s knot (Figure 3) and the newly introduced strangle knot (Figure 4).9,10

IN SUMMARY

Ideally, a tightly placed friction knot will remain tight around a pedicle until subsequent square throws are completed, and this permanently locks the tight ligature knot in place, safely maintaining hemostasis.

In Part 2 of this article series, step-by-step instructions and images will provide guidance on how to tie surgical ligature friction knots.

References


Photos courtesy of Charlie Kerlee, Medical Photographer, Colorado State University.

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