Roeder’s Knot: Solution to Intra-Corporeal Knot Tying

*Department of Surgery, Holy Family Hospital and Rawalpindi Medical College;**Islamabad Medical and Dental College

Abstract
Background: To evaluate the security and diversity of application of Roeder's knot.
Methods: In this prospective study patients (n=771) undergoing laparoscopic surgery, along with application of Roeder's knot, were included. The formula for making the Roeder’s knot was (1:3:1) ‘one hitch, three winds and one locking hitch’. Loop was made around a post and then a simple knot was made. With the shorter end, three winds were made around both posts and were secured with the last half hitch. Excess length of the string was trimmed. Knot was held in the grasper and was slid down the trocar into the abdominal cavity. Once inside the abdominal cavity, the structure to be ligated, was placed through the loop. Free end of the string was passed thorough the eye of a knot pusher and knot pusher was slid through the trocar and knot was tightened. End of the knot was trimmed with scissors. For a structure that is not blind ended (eg. an artery or cystic duct), the thread was passed under the structure. Both ends were taken out, loop was tied in a similar manner and was then tightened with knot pusher. To tie the knot, over a suture, needle was brought outside and procedure was repeated.
Results: Roeder’s knot was placed in a total of seven hundred and seventy one cases out of total 1883 procedures performed during the study period. The time to assemble the knot was 33 seconds. The time to place a pre-tied knot was two minutes three seconds. The time to assemble and place Roeder’s knot in laparoscopic appendectomies averaged about 2 minutes 36 seconds. It took an average of 3 minutes 40 seconds to assemble and place it in laparoscopic cholecystectomies. While time to place a traditional square knot intra-abdominally averaged about 4 minutes and 39 seconds. In all 771 cases where the Roeder’s knot was placed, an incidence of knot slippage or hematoma formation was not observed. Roeder’s knot was applied in all appendectomies, laparoscopic cholecystectomies in which cystic duct diameter was greater than clips and hernial sac not reduced completely.
Conclusion: Roeder's knot is easy to assemble and place, secure and is a cost effective alternate to intra-corporeal suturing and staples during laparoscopic surgeries.
Key Words: Roeder's knot, laparoscopic knots, sliding knot

Introduction
Laparoscopic surgeries have made present day surgery safer with less chances of infection, less postoperative recovery period along with minimal scarring. At the same time, the approach through tiny incisions poses many challenges to the technique. Such as the tying of knots intra-abdominally with the help of laparoscope is challenging and difficult due to limited space for movement, 2 dimensional vision, second hand camera view of the operative site, lack of twist movement at the wrist joint, the fulcrum for movement due to long instruments, is far from the desired site and it also requires great manual dexterity.1,2
Intra-abdominal knot tying is an increasing area of concern for the laparoscopic surgeons as the knot is the weakest link in the surgical suture. When a knotted suture fails to perform its functions, the consequences may be disastrous. Massive bleeding may occur when the suture loop surrounding a vessel becomes untied or breaks. Wound dehiscence or incisional hernia may follow knot disruption. Knot construction for surgeons is mostly a matter of guesswork, habit or tradition. Only a few surgeons practice optimal knot tying technique, others agreed they employed the usual square knots which later became untied.3
Due to numerous difficulties and challenges to intra-corporeal knot tying, the surgeons try to avoid intra-corporeal suturing and make use of GIA staplers, clipping pre-tied knots and extracorporeal sliding knots. Stapling devices and clippers however fail to ligate large structures such as inflamed cystic duct and thus traditional knots must be used. To make use of extra-corporeal knots, the idea is to make the knot outside the body and then slide it in to do the job. The
knot applied must be as secure as the traditional ones, quick and easy to apply and reproducible. The ultimate goal of this linkage is the perfection of the surgical discipline with the least possible scar and without infection.  

There are various types of extracorporeal knots, non-sliding (static knots such as Revo knot, square knot and half hitch) and sliding knots (such as Duncan or Hangman’s knot, Roeder knot, Lieurance Modified Roeder knot, Tennessee Slider, Meltzer’s knot, Tayside’s knot, Weston slip knot). Roeder’s knot amongst these was the first knot described in laparoscopic surgery. It is inspired from the hangman’s knot and was first used by Albert Hans Roeder who used it in 1931 during a tonsillectomy.  

**Patients and Methods**

This prospective study was conducted in Holy Family Hospital September 2009 to September 2012. Patients (771) undergoing laparoscopic surgery, along with application of Roeder’s knot, were included.

**Figure 1: Diagramatic representation of the Roeder’s knot**

The formula for making the Roeder’s knot was (1:3:1) ‘one hitch, three winds and one locking hitch’ (fig 1) Firstly, a loop was made around a post and then a simple knot was made. With the shorter end, three winds were made around both posts and were secured with the last half hitch. Knot was tightened and checked for sliding. Excess length of the string was trimmed (Figure 2). Knot was held in the grasper and, with grasper, it was slide down the trocar into the abdominal cavity. Once inside the abdominal cavity, the structure to be ligated, was placed through the loop. Free end of the string was passed thorough the eye of a knot pusher and knot pusher was slide through the trocar and knot was tightened. End of the knot was trimmed with scissors (Figure 3). For a structure that is not blind ended (eg. an artery or cystic duct), the thread was passed under the structure.Both ends were taken out, loop was tied in a similar manner and was then tightened with knot pusher. To tie the knot, over a suture, needle was brought outside and procedure was repeated.

**Figure 2: Making of the knot.**

**Figure 3: How to place the knot intra-abdominally**

**Results**

The time to assemble the knot was 33 seconds. The time to place a pre-tied knot was 2 minutes 3 seconds. The time to assemble and place Roeder’s knot in laparoscopic appendectomies averaged about 2 minutes 36 seconds. It took an average of 3 minutes 40 seconds to assemble and place it in laparoscopic cholecystectomies. While time to place a traditional square knot intra-abdominally averaged about 4 minutes and 39 seconds. Roeder’s knot was placed in a total of seven hundred and seventy one cases out of total 1883 procedures over the past 3 years. Out of these 771 cases 676 were used to ligate the base of appendix in all laparoscopic appendectomies, 42 to ligate inflamed cystic duct out...
of 936 laparoscopic cholecystectomies, to ligate 12 out of 43 ectopic pregnancies and in 41 out of 178 hernia repairs. In all 771 cases where the Roeder’s knot was placed there was never an incidence of knot slippage or hematoma formation. This included all appendectomies, laparoscopic cholecystectomies in which cystic duct diameter was greater than clips, hernial sac not reduced completely and ectopic pregnancies (Table 1; Figure 4).

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Total procedures performed</th>
<th>Cases where Roeder’s Knot was used</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laparoscopic Appendicectomy</td>
<td>676</td>
<td>676</td>
<td>100%</td>
</tr>
<tr>
<td>Laparoscopic Cholecystectomy</td>
<td>936</td>
<td>42</td>
<td>4.46%</td>
</tr>
<tr>
<td>Ectopic Pregnancies</td>
<td>43</td>
<td>12</td>
<td>27.9%</td>
</tr>
<tr>
<td>Hernia Repair</td>
<td>178</td>
<td>41</td>
<td>23%</td>
</tr>
</tbody>
</table>

TABLE 1 Cases in which Roeder’s knot was placed

Figure 4 Various Applications of Roeder’s Knot

Discussion

The genius of this solution to endoscopic knot tying, lies in its simplicity. Roeder’s knot (being a modification of hangman’s knot) performs the same purpose inside the body, as execution by hanging the cause of male violence in the society. Roeder’s knot ensures cost saving. By using traditional suture materials (not specially created for laparoscopy) the cost can further be reduced than the more sophisticated ones. GIA stapler and clip applicator costs around $90-150 and $120-200 respectively. The average price of ligating the base of appendix with preformed endoloop was $100 while that for handmade extracorporeal knot was around $5 (500rs/-). Overall postoperative complications, operative time, need for analgesia were compared and showed no statistical difference. Hence the handmade technique was equally reliable in addition to being affordable, quick and easy.7

The safety of the knot not only depends on the knot configuration but also on the suturing material. It is shown that material that swells in contact with water or after being introduced in the body theoretically increases the capacity of knot tying and tightening. Therefore, knots made from catgut, dacron, polyglactin and lactomer can be considered safe, whereas ones made from PDS, silk or polyamide are less reliable.8 Roeder knot with 3 RHAPs (Reversed half hitches on alternating posts) shows the best balance of loop security and knot security when tied with No. 2 Ethibond or No. 2 Fiberwire. Sliding knots tied without RHAPs showed low force to failure and loose suture loops whether tied with Ethibond or Fiberwire.5 Roeder loop security depends predominantly on the number of initial turns around the standing part. Its knot security depends on the additional half hitches used to back up the knot after it has been tightened.14 Knot security has been questioned in various researches. In present study no incidence of knot slippage occurred, proclaiming it clinically secure.3,15

Schaller G et al in their “knot before loop” technique tested on cholecystectomies and hernia repairs also showed independent formation of the knot by the assisting personnel allows quick application, equivalent to the use of clips and staples.9 Time required to assemble and place was significantly less than compared to traditional square knot intra-abdominally, or intra-abdominal suturing. Roeder’s knot can be employed in a vast variety of laparoscopic surgeries, e.g., appendectomy (ligating base of appendix), laparoscopic cholecystectomy (ligating inflamed cystic duct which cannot be ligated otherwise using staplers or clips), hernia repair, ligating arteries (eg. ligating the splenic artery ligation during live donor liver transplant), hysterectomy, tubal ligation, arthroscopic sutures (eg repairs of the rotator cuff, Bankart lesions, capsular shifts, and meniscal repairs where it is shown to work great for tissues under tension), ligation of a myoma, tissue approximation (uterus anterior wall repair) and still counting.10

Several modifications have been made to increase knot security or ease of tying. Many modifications
have been given eponymous names. 4S modification (tied by adding a fourth wrap around the suture loop and securing the loop in place with a square knot rather than a single half-hitch) This modification results in a knot comparable in strength to the strongest laparoscopic multiple-throw square knots. The Meltzer slip knot (double hitch, three winds, two half hitches and a slide) was described in 1991 by Meltzer for use with PDS. Savoi Modified Roeder’s knot is a locking knot instead of a sliding knot. When compared to a field knot it has an additional turn and the first loop is thrown in opposite direction. These modifications improved the security of knot.11,14

As compared to other alternatives Roeder’s knot is equally efficient clinically in addition to having a much more diversity of application. GIA Stapler, Clipping is an alternate to knot tying after ligation and an escape from suturing. Yet an enlarged cystic duct is a common encounter in laparoscopic cholecystectomy which cannot be stapled or clipped and must be ligated. The options to secure its ligation include internal or extracorporeal knots and Roeder knot. A preformed knot can be used e.g. Ethibinder(Endoloop). The Endo GIA is a useful stapling device but is more expensive. Other simpler techniques which do not need special skill or instruments ensure complete ligation of the wide cystic duct using overlapping of the clips.2

**Conclusion**

Roeder’s knot is a low cost solution during laparoscopic suturing. Not only does it save money but it also saves time being quick to assemble and place. It is easy to learn and master. It has been proven to be safe and reliable and has diverse application.

**References**