FUNDAMENTALS OF ARTHROSCOPIC SURGERY TRAINING

Module 6: Arthroscopic Knot Tying

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Problem Identification and Needs Assessment

Identification of targeted learners

All levels of orthopaedic residents, fellows and attending surgeons who wish to improve their knot tying skills.

Identification of need or problem for targeted learners

Periodic observation of skills in operating rooms and arthroscopy courses show very irregular performance in knot tying along with limited knowledge of suture material and knot tying instruments. Poor skills affect the outcomes of surgical procedures.

Current educational approach to address need or problem

Most learners acquire the motor skills of knot tying and associated cognitive information by observation and discussion. There is very little time to practice and the availability of teaching labs is limited. Every surgeon teacher ties knot differently. This leads to a confusing type of learning. "Hands-on" practice outside the operating room is essential and should be tested before entering live surgery. Courses that include 1 to 1 ½ hours of knot tying instruction are a good start but may not be sufficient to achieve proficiency with this skill. The current method of "see one, do one, teach one" is not sufficient in the present day and age of learning.

Ideal educational approach to address need or problem

Ideally, every orthopaedic training program and/or hospital would establish a surgical motor skills lab. Specific time would be scheduled for students to work in the lab with "one-on-one" training. The lab would accommodate repeat visits for "hands-on" motor skills training. Practice at home would also be encouraged. Passing a knot tying course would be required before participating in human arthroscopic cases that require implementation of these surgical skills. The "passing grade" for proficiency would be defined in advance. Discussion and establishment of the "passing grade" should be determined locally and nationally, based upon assessments of expert performance.

Goals and Objectives

Specific educational goals

The broad purpose of this training module is to develop the basic motor skills that are required to tie sutures arthroscopically. Specific goals include:

- Acquisition of basic knowledge concerning various suture materials (including national standards for suture material), options for arthroscopic knots, and alternatives for knot pushers and their use
- Concentration on proficiency tying a few specific arthroscopic knots (rather than practice on a wide variety of knot alternatives)
- Development of skills in the selected knots in progressive stages:
  (1) Tie with rope onto a hook
  (2) Use suture or 17lb fishing line to tie to a hook and then through a cannula, under direct visual control
  (3) Then utilize a video camera system to tie knots while looking at knot delivery on the two dimensional video display

- Tie while using surgical gloves
- Test knots for adequate holding power under a predefined tensile load

Specific cognitive, affective, psychomotor task objectives

The following suture tying objectives were defined by task deconstruction:

- The learner will complete a pre-test and post-test of cognitive materials based on suggested readings. The passing score will be set relative to expert performance.
- The learner will acquire successful knot tying skills (on each knot) with rope and then with suture or fishing line, eventually performing the skill while watching a video image.
- The learner will successfully tie knots with no loose loops, no premature locking, no breakage and no useless twists.

Syllabus Development

Assumptions

The learner has basic medical and surgical knowledge and is generally familiar with the purpose of arthroscopic knot delivery. It would be best if the learner had achieved proficiency for the basic arthroscopic skills covered in *FAST* Modules 1-3. However a learner could engage the current module without specific arthroscopic triangulation skills.

Proficiency benchmarks should be created using appropriate cohorts of experienced arthroscopic surgeons. Learners should progress sequentially to the next exercise only after demonstration of sufficient proficiency for each sub-module. Learners should be encouraged to practice the skills elements in order to enhance their integrated psychomotor performance.

Suggested readings

- Powerpoint presentations on knot tying that have been prepared for courses delivered at the Orthopaedic Learning Center.
- Video demonstrations of specific knot tying skills, accompanied by relevant surgical case examples
- AANA-OLC Knot Tying Manual
- ISAKOS Congress Knot Tying Booklet – April 2005
- AANA-Fall Course-Dr. Lo – Knot Tying Laboratory Manual
- Baumgarten, Wright Arthroscopic Knot Tying Manual 2005 Lippincott, Williams & Wilkins
- AANA Advanced Arthroscopy- The Shoulder: Arthroscopic Knot Tying – Eric McMillan 2010. Saunders & Elsevier

Description of laboratory module

Videos will be provided with step-by-step instruction for tying each knot. This information will be available for viewing on a computer or mobile device. The learner must confirm that he/she has watched all of the requisite video material before proceeding with the motor skills exercises.

All knot tying exercises can be done on the *FAST* workstation (or a suitable substitute, for example a hook attached to a platform, stabilized to a table top using a C-clamp). For the third sub-module, a USB connected video camera, connected to a laptop computer, will be directed at the knot being tied, so the learner can practice knot tying skills under video image control.

Description of techniques and procedures

Several "basic" knots will be demonstrated and then practiced, including the Duncan loop, simple slider, Tennessee slider, Weston, Harryman ½ hitches (with the process of "flipping posts"), and the Revo-SCOI knot. The SMC knot will also be demonstrated as an additional learning option. The objective is that the learner will become proficient in at least one sliding / non-locking knot, one sliding / locking knot, and one non-sliding / non-locking knot.

The *FAST* Workstation (or a suitable alternative) will be fastened to table in front of student. The first sub-module involves knot tying practice with a 1/8" rope (braided synthetic) onto a hook fixed to workstation.

After successful acquisition of knot-tying skills using rope, learners will tie knots using #2 suture or 17 lb monofilament fishing line under direct visual control. The learner will then practice knot tying under video image control through an arthroscopic cannula. Finally, the learner will tie

knots under video control while wearing surgical gloves.

Common errors and prevention strategies

There are many pitfalls that are associated with arthroscopic knot tying in practice. These errors are common:

- Failure to understand nomenclature. To prevent nomenclature errors, begin by identifying the post-limb and loop-limb. The post-limb is typically away from the center of the joint (for example, the limb that penetrates the labrum, peripheral to the articular surface of the glenoid). This is the limb you slide loops down. The loop-limb is used to place loops around the post-limb.
- Failure to determine that suture slides freely. To prevent this error, slide the suture back and forth through an anchor (or tissue). Confirm ability of suture to slide. This dictates the type of knot you use (sliding or non-sliding). If the suture does not slide, use a non-sliding knot.
- Failure to establish and maintain the identity of the initial post-limb. To avoid this, place a single-hole knot pusher on the post-limb, and then attach a hemostat to the end of the post-limb. The knot pusher and hemostat are then controlled with the left hand.
- Unexpected twists and tangles in posts cause knot failure. To prevent this, slide the knot pusher down the initial post limb into the joint to confirm that it passes without tangles, before creation / delivery of hitches.
- Creation of a loop-limb that is too short, which will stop effective knot tying because insufficient suture material is available outside of the cannula after sliding of the knot into the joint. To avoid this common problem, the initial post-limb should be about ½ as long as the initial loop-limb.
- Poor organization of posts causing poor knot creation with hitches. Holding both limbs between the thumb and middle finger of the left hand to start the knot will establish good organization. The index finger is also used to organize loops on the post-limb. This will assist in organizing posts.
- Failure of sliding knots due to insufficient back-up with ½ hitches. All knots should be backed up with at least three Harryman ½ hitches on reversed posts.
- Sutures can become tangled or tissue can become snared within knot, which can lead to clinical failure. To avoid this: (1) use transparent cannulas to observe sutures, (2) always tie through a cannula and never through a soft tissue portal, (3) remove all other sutures from the working cannula (only the post-limb and loop-limb in the cannula during knot tying).
- Suture may be abraded and eventually rupture. To avoid this, push all knot loops straight down the cannula to reduce friction.
- Failure to switch posts results in slip knots that fail (due to stacked ½ hitches that are passed in the same direction on a single post). Learn to flip posts, and PRACTICE, PRACTICE, PRACTICE.

Demonstrate expert performance

Every knot and every error will be demonstrated on the videos to show proper knot tying technique. These videos will also demonstrate the common errors and ways to avoid them.

Recommendations for motor skills practice

Practice knot tying skills repeatedly, over and over again. Many of these skills can be practiced at home. Daily practice for several weeks would be ideal. Follow directions exactly. Carefully avoid old habits in knot tying. Carefully examine your one-handed knot tying technique. You may be constructing only a slip knot. Establish a quiet environment to allow careful focused attention to the work you are doing.

Supplies and station setup

- *FAST* workstation, or a suitable substitute that includes a screw-in hook
- 1/8th inch rope, #2 suture or 17 lb fishing line monofilament, a working cannula (8–10 mm), surgical gloves, knot pusher (single hole), hemostat, scissors
- A USB video camera connected to a laptop computer. Another alternative is to use an arthroscope, light source, and camera connected to a video display (this option is more expensive and less convenient).

Suggested duration for completion of module

Background reading and video review should be accomplished in one to two hours.

Knot tying should be practiced in intervals of 30-60 minutes. This concentrated work is very tiring and requires rest between sessions to maximize the learning experience. The total time for the entire module is unknown.

More important than "time" is the eventual outcome, defined as proficiency in tying solid knots. The learner should strive for perfection. A poor knot, tied quickly, is an incorrect objective. Most surgeons must practice knot tying for many hours before these skills are mastered and become automated.

Estimated budget

- The budget should include expenses associated with the *FAST* workstation (or another suitable alternative that meets the educational requirements).
- Costs associated with rope, suture or fishing line, surgical tools, cannulas, and surgical gloves.
- The USB video camera. Most learners already own laptop computers.

Learner Evaluation and Feedback

Methods of performance assessment

Proficiency with this task is ultimately reflected by surgical knots that hold for a sufficient length of time under in-vivo clinical loading conditions. Failure can occur within the knot itself (knot security) or within the loop (loop security). Both elements are captured by measurement of loop elongation, which is the variable that determines tissue apposition in-vivo. For the current module, learners will measure loop elongation for the knots that they create using a simple tensile loading paradigm.

Sutures will be tied around a mandrel. After completion of knot tying, the learner will gently slip the knot off of the mandrel, taking care to avoid deformation of the knot. The mandrel must be of appropriate size to create a suture loop that is just large enough to accommodate a stationary hook and a second hook that is attached to a "fish scale". (These dimensions are pre-accommodated by the *FAST* workstation.) The learner will gently measure the initial loop size (which should basically be the same as the circumference of the mandrel, using the calibrated knot sizer (provided with the *FAST* workstation). The learner will mount the knot using the stationary islet on the workstation, and will then load the knot for 15 seconds at 15 pounds of steady tensile force. Final loop size will be measured using the calibrated knot sizer. Loop elongation will be defined as the difference between initial and final loop size.

Subjective assessment and feedback should be provided by the mentor during the learning phase. This can be accomplished by direct visualization of the learner, with completion of a task-oriented check list. Another alternative is submission of unedited video data (acquired by the computer using the USB-connected camera), which can then be evaluated secondarily by the mentor.

Suggested proficiency benchmarks

Maximum acceptable loop elongation will be defined relative to a cohort of experts performing these same tasks, using #2 permanent suture and 17lb fishing line, followed by the same loading paradigm. Loop elongation beyond that threshold would be defined as knot failure. Successful completion of this module would be defined as the absence of knot failures on ten sequential knots tied and tested by the learner.

Methods for learner debriefing and feedback

Subjective assessment and feedback will be provided by the mentor to the learner during the first and second sub-modules (knot tying with the rope and knot tying under direct visual control).

Proximate feedback will be provided to the learner by the learner's immediate measurement of loop elongation under tensile load. If the learner has an unacceptable rate of knot failure, the mentor should observe the learner performing the skill, and then provide suggestions for improvement. After subsequent practice, the learner should create ten fresh knots and measure them using the tensile loading paradigm. Coaching should be repeated until the learner is able to achieve an acceptably low rate of knot failure.

Learners will provide curriculum feedback using a web-based, anonymous tool assessing module didactic content, expert video quality and usefulness of skills training.

Periodic Curriculum Review, Evaluation, Validation, and Refinement

Curriculum faculty will annually review learner comments and assess potential improvements in the didactic and manual skills portion of the module. Educational validation will occur when the learner is observed and graded in the clinical setting, noting the specific steps of knot tying under clinical conditions.