Incorporating Evidence-Based Medicine in Arthroscopic Knot Preferences: A Survey of American Orthopaedic Society for Sports Medicine Members

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Abstract

An Internet-based survey was used to determine arthroscopic knot preferences. Inclusion criteria included American Orthopaedic Society for Sports Medicine (AOSSM) membership, and exclusion criteria included physician members without an e-mail address and non-physician members.

Our hypotheses were that the majority of arthroscopic knots used in clinical practice by AOSSM members are described in the orthopedic literature and have undergone biomechanical analysis, that the majority of members reinforced sliding arthroscopic knots with 3 reversed half-hitches on alternating posts (RHAPs), and that the majority of members used a half-hitch configuration that incorporates at least 3 reversed half-hitches and 3 alternating posts.

Of the 1844 members contacted, 937 (50.8%) agreed to participate in the survey. The most common arthroscopic sliding knot used was the Duncan loop. Only 48.1% of respondents used 3 reversed half-hitches and at least 3 alternating posts when using nonsliding knots. Only 31% of respondents used 3 RHAPs to reinforce arthroscopic sliding knots.

Only a minority of respondents used the optimal configuration determined in vitro for sliding knot reinforcement and when using a nonsliding half-hitch knot configuration. An evidence-based approach is recommended for determining arthroscopic knot preference for clinical use.

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An increasing number of surgeons are performing arthroscopic procedures that require arthroscopic knots. With the heightened popularity of these procedures, the number of commonly used arthroscopic knots has increased. To date, no one has examined which arthroscopic knot configurations are actually being used by arthroscopic surgeons in practice.

Multiple studies have shown that there may be a high rate (12% to 95%) of rotator cuff repair failures after arthroscopic surgery.[1-5] The role of surgeon arthroscopic knot preference in failure of arthroscopic rotator cuff repair is unknown.

Although no study has compared all arthroscopic knot configurations head-to-head, several studies have examined the biomechanical properties of arthroscopic knots, and the findings may allow arthroscopic surgeons to choose arthroscopic knots on evidence-based principles.[6-24] In addition, it is well documented that sliding knots reinforced with 3 reversed half-hitches on alternating posts (RHAPs) are biomechanically superior to unreinforced sliding knots and sliding knots reinforced with differing half-hitch configurations when examined in vitro (Figure 1).[6,15,19] Also, multiple studies have shown that, in nonsliding half-hitch knots, half-hitch configurations that incorporate at least 3 reversed

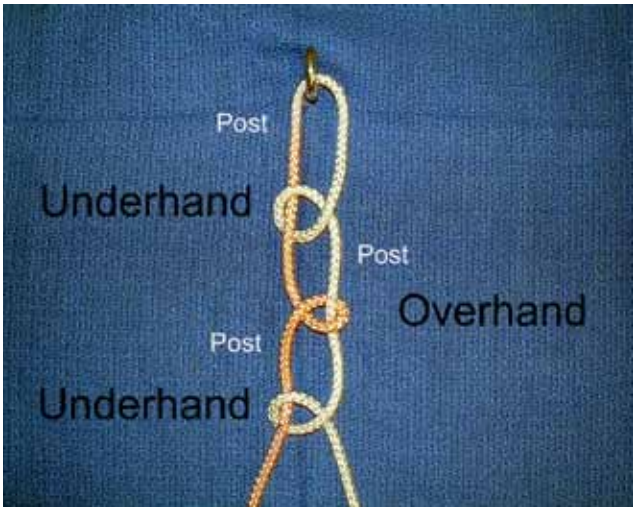

Figure 1. Three reversed half-hitches on alternating posts.

Table. Arthroscopic Knot Configurations Described in Medline-Listed References[a]

Arthroscopic square knot[16]
Dines slider[25]
Double-twist knot[21]
Duncan loop[10]
Field knot[26]
French knot[13]
Giant knot[27]
Hu knot[28]
Inverse knot[30]
Nicky knot[29]
Overhand throw[10]
PC knot[31]
Revo knot[32]
  Original Revo knot[11,33]
  Modified Revo knot[17]
Roeder knot[9,34]
  Lieurance-modified Roeder knot[12]
  Savoie-modified Roeder knot[12]
San Diego knot[20]
SMC knot[35]
Snyder knot[9]
Snyder slider[25]
Taut-line hitch[11]
  Modified taut-line hitch[25]
Tennessee slider[32]
Triad knot[36]
Tuckahoe knot[37]
Weston knot[38]

[a]All these knots have been assessed biomechanically, except for Hu knot, inverse knot, PC knot, modified taut-line hitch, triad knot, and Tuckahoe knot.

half-hitches and alternating posts are biomechanically superior to half-hitch configurations lacking this configuration when examined in vitro.[10,11,23]

A survey of American Orthopaedic Society of Sports Medicine (AOSSM) members was undertaken to determine surgeon preference for arthroscopic knot type. Our hypotheses were that the majority of arthroscopic knots used in clinical practice by AOSSM members are described in the orthopedic literature and have undergone biomechanical analysis, that the majority of members reinforced sliding arthroscopic knots with 3 RHAPs, and that the majority of members used a half-hitch configuration that incorporates at least 3 reversed half-hitches and 3 alternating posts.

Materials and Methods

An Internet-based survey was used to determine the arthroscopic knot type preferences of AOSSM members. Inclusion criteria included AOSSM membership (name appears in October 30, 2006, membership directory), and exclusion criteria included physician members without an e-mail address and nonphysician members. The survey engine used can be accessed at www.surveymonkey.com.

The Medline database was searched for reports that describe arthroscopic knots and examine the knots biomechanically. We found 28 arthroscopic knot configurations, 22 of which had been biomechanically tested (Table). AOSSM members were surveyed about their use of these specific knots. (If the knot they used was not listed, they were to write in its name.) They also were asked if they reinforced their preferred sliding knot with half-hitches and what their preferred half-hitch configuration was; how many half-hitches they used when tying a nonsliding knot, how many times they reversed the half-hitches, and how many times they alternated the posts; and what their source of preferred knot configuration was. Basic demographic data were collected as well.

Categorical variables were analyzed for statistical significance using the χ^2 test. $P \leq .05$ was used to determine statistical significance.

Results

Of the 1844 AOSSM members contacted, 937 (50.8%) agreed to participate in the survey. Of these 937 members, 109 did not use arthroscopic knots, leaving 828 to be surveyed about their arthroscopic knot preference.

Nearly all (97.9%) of the respondents were practicing surgeons; the rest were in fellowship or residency training. Of the practicing surgeons, 16.1% had been in practice less than 2 years; 21%, 2 to 5 years; 18.4%, 6 to 10 years; 27.8%, 11 to 20 years; and 16.8%, more than 20 years. The majority (59.1%) of respondents were in a private practice, 21.5% were in a hybrid practice, and 19.4% were in an academic practice. Nearly all (96.6%) of the respondents were practicing in the United States.

Of the survey participants, 56.8% were members of the Arthroscopy Association of North America (AANA); 15.4% were members of the International Society of Arthroscopy, Knee Surgery, and Sports Medicine (ISAKOS); 6.8% were members of the American Shoulder

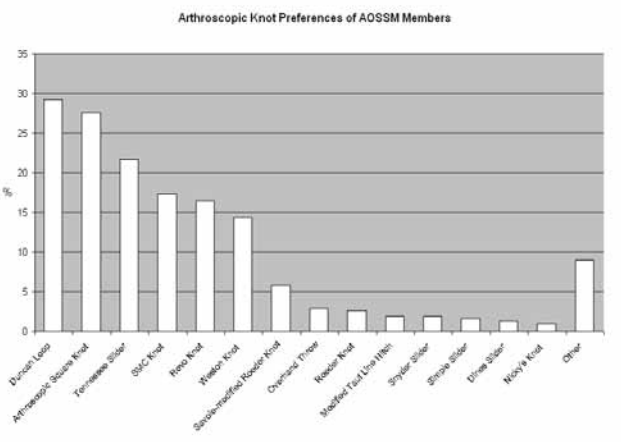

Figure 2. Arthroscopic knot preference of American Orthopaedic Society for Sports Medicine members. Knot types preferred by less than 1% of respondents included Tuckahoe knot, Snyder knot, Lieurance-modified Roeder, field knot, giant knot, triad knot, fisherman's knot, San Diego knot, double-twist knot, PC knot, Abram knot, Wiese knot, taut-line hitch, modified Roeder, Hustler knot, Orvis knot, inverse knot, Hanson knot, Guanche knot, Roeder Melzer knot, Petty knot, Fleega knot, modified Mississippi slider, Texas weasel, sailor's knot, Tommy knot, modified Snyder, modified Tennessee slider, TASMI knot, improved cinch knot, bunt-line half-hitch, modified racking hitch knot.

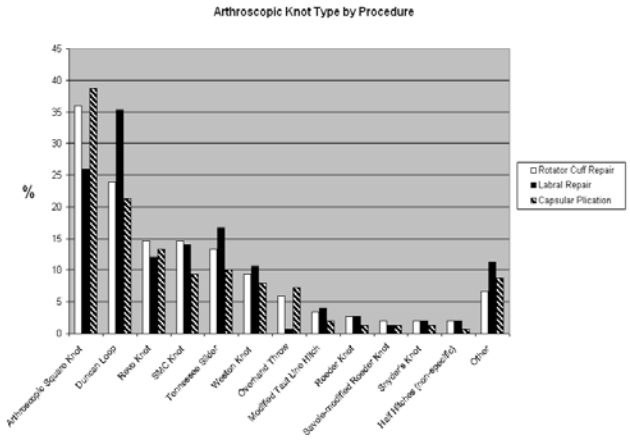

Figure 3. Arthroscopic knot preference by procedure. Knot types preferred by less than 2% of respondents included giant knot, San Diego knot, simple slider, double-twist knot, Dines slider, Nicky knot. Knot types preferred by less than 1% of respondents included field knot, inverse knot, PC knot, triad knot, Wiese knot, simple slider, improved cinch knot, bunt-line half-hitch, Abram knot, modified racking hitch knot.

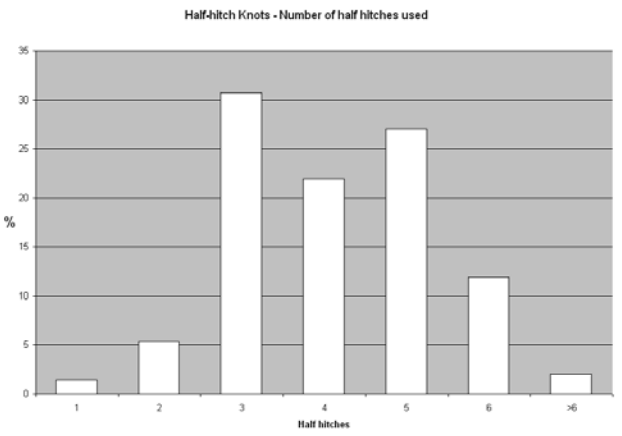

Figure 4. Number of half-hitches used in respondent's preferred nonsliding knot configuration.

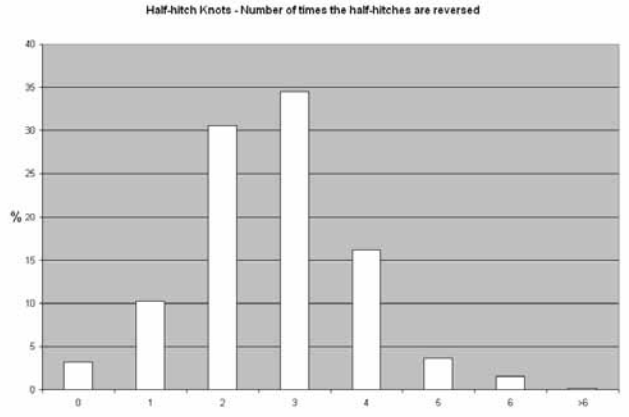

Figure 5. Number of times half-hitches are reversed in respondent's preferred nonsliding knot configuration.

and Elbow Society (ASES); and 2.7% were members of the European Society of Sports Traumatology, Knee Surgery, and Arthroscopy (ESSKA).

Figure 2 shows the arthroscopic knot preferences of AOSSM members who responded to the survey. Most (81.2%) of the respondents used the same knot configuration(s) for all arthroscopic procedures. A minority (18.8%) based their choice of knot configuration on the procedure being performed (eg, rotator cuff repair, labral repair, capsular plication) (Figure 3).

Five hundred ninety surgeons used a half-hitch different from the Revo knot (131 respondents) and Snyder knot (6 respondents). Of these respondents, 1.4% used 1 half-hitch; 5.3%, 2 half-hitches; 30.7%, 3 half-hitches; 21.9%, 4 half-hitches; 27%, 5 half-hitches; 11.9%, 6 half-hitches; and 2%, more than 6 half-hitches (Figure 4). In addition, 3.2% of surgeons did not reverse half-hitches, 10.2% reversed them 1 time, 30.6% reversed 2 times, 34.5% reversed 3 times, 16.2% reversed 4 times, 3.6% reversed 5 times, 1.5% reversed 6 times, and 0.2% reversed more than 6 times (Figure 5). Approximately 18% of surgeons did not alternate posts when using half-hitches, whereas 29.9% alternated posts 1 time, 25.7% alternated 2 times (3 alternating posts), 19.1% alternated 3 times, 6.6% alternated 4 times, and 0.5% alternated 5 times (Figure 6). Only 48.1% of respondents used at least 3 reversed half-hitches and at least 3 alternating posts, as recommended by multiple studies.[10,11,23] These respondents were statistically more likely to reinforce their preferred sliding knot with 3 RHAPs ($P<.0001$) and were more likely to have chosen their preferred knot type through a review of the literature ($P<.001$) compared with surgeons who did not use at least 3 reversed half-hitches and 3 alternating posts in their preferred half-hitch configuration.

The vast majority (94.8%) of arthroscopic surgeons who responded reinforced their sliding knot of choice with half-hitches. The majority (57%) of respondents used 3 half-hitches to reinforce their sliding knots, and the most common half-hitch configuration for sliding knot reinforcement (31%) was 3 RHAPs (Figure 7). Surgeons who had been in practice for 10 years or less were statistically more likely to use the optimal 3-RHAP half-hitch configuration when reinforcing their sliding knot of choice compared with surgeons who had been in practice for more than 10 years ($P = .0004$). Surgeons who performed more than 90% of labral repairs arthroscopically ($P = .02$) and 50% or more of rotator cuff tears arthroscopically ($P = .001$) were statistically more likely to use the 3-RHAP configuration when reinforcing sliding arthroscopic knots. Surgeons who chose their preferred knot type through a review of the literature were statistically more likely to reinforce their sliding knot of choice with the 3-RHAP half-hitch configuration ($P = .04$).

The most common source of preferred knot configuration was mentor during training (47.8%). Other sources were arthroscopic skills course (35.7%), review

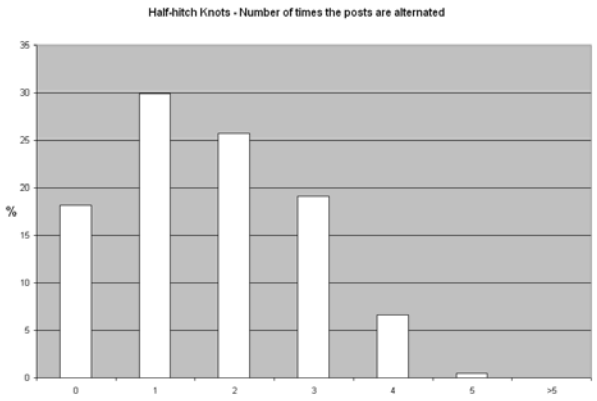

Figure 6. Number of times posts are alternated in respondent's preferred nonsliding knot configuration.

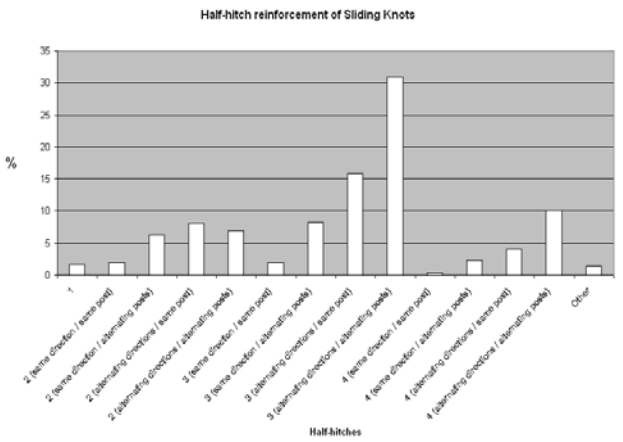

Figure 7. Respondent's preferred half-hitch configuration for sliding knot reinforcement.

of orthopedic literature (17.4%), another surgeon while in practice (17.2%), knot developed/invented independently (7.8%), textbook (7.6%), knot-tying videotapes (1.5%), knot from fly-fishing techniques (0.9%), industry representative (0.9%), open surgery (0.4%), Boy Scouts (0.2%), sailing/naval manual (0.1%), and operating room nurse (0.1%).

Discussion

We found that the vast majority (~96%) of knots used by the arthroscopic surgeons surveyed in this study are described in the orthopedic literature (Figure 2). In addition, approximately 93% of the knots being used have undergone biomechanical testing that has been reported in the orthopedic literature. Of the knots described in the literature, the French knot and the Hu knot were not used by any of the respondents.

Although the majority (57%) of survey respondents reinforced their preferred sliding knot with 3 half-hitches, only 31% of respondents used the 3-RHAP configuration that biomechanical studies have shown to be optimal.[6,15,19] Thus, the second hypothesis of this study was not supported.

A minority (48.1%) of respondents who described their specific half-hitch configuration used at least 3 reversed half-hitches and at least 3 alternating posts, which has been shown to be the optimal configuration for half-hitch knots.[10,11,23] Thus, the third hypothesis also was not supported.

One limitation of this study is that the literature describes several versions of the Revo knot. The original Revo knot incorporates only 4 half-hitches and 2 alternating posts.[11,13,33] According to the Tera and Aberg system, the original Revo knot is coded (SxS//SxS).[39] The modified Revo knot demonstrated in one biomechanical study uses 5 half-hitches with 3 reversals of hitch direction and 3 alternating posts (S=S//xSxS//xS).[17] The Revo knot has 5 half-hitches and incorporates the optimal 3-RHAP configuration (S=SxS//xS//xS).[12,18,32] Thus, for a respondent who reported using the Revo knot, it was difficult to determine the specific configuration of half-hitches. Similarly, the Duncan loop and the Roeder knot each has several versions, and respondents could have become confused as to which one they used.[12,32,34,40]

Another limitation of this study is that it is impossible to verify that respondents tied their preferred knots exactly as described in the literature. In addition, it is not possible to verify that the many respondents who used arthroscopic square knots tied them appropriately. The arthroscopic square knot has a propensity to convert to a biomechanically inferior half-hitch configuration when tied arthroscopically and when tension is applied asymmetrically to the limbs.[32]

Although the respondents may not have used standardized names for their arthroscopic knots, or tied their knots exactly as described in the literature, there was little uncertainty in their responses regarding (1) the half-hitch configuration used when throwing nonsliding knots and (2) the configuration of half-hitches used when reinforcing a sliding knot. Thus, the mentioned limitations do not weaken the conclusions and relevance of this study.

Recently, evidence-based medicine has gained popularity within orthopedic surgery. We suggest that evidence-based medicine should also be applied when choosing arthroscopic knots to use in clinical practice. The majority of our respondents were not using the biomechanically optimal configuration determined in vitro for reinforcing their preferred sliding knot or in the half-hitch configuration of their nonsliding knots. In addition, approximately 4% of respondents used the overhand throw, which has been biomechanically determined to be statistically inferior to other arthroscopic knots—leading one study to recommend against its clinical use.[11]

A significant minority (17.4%) of arthroscopic surgeons chose their preferred knot type through a review of the literature. Review of biomechanical studies reported in the literature should supplement the empirical learning that occurs during training or in a skills

course. Physicians who teach knot-tying courses, teach laboratory courses, and train residents and fellows should examine their knot-tying methods to make sure they are recommending the most biomechanically optimal configurations, as the majority of respondents in this study identified training and skills courses as the source of their preferred knot types.

Multiple studies have shown that the rate of rotator cuff repair failures after arthroscopic surgery varies (12% to 95%) and that not all of these failures become clinically apparent.[1-5] Biomechanical studies have shown that tendon-to-bone gapping after rotator cuff repair occurs before ultimate failure. Incorporating a secure, biomechanically proven knot that is based on the literature would likely decrease gap formation of the tendon repair construct with cyclical loading in vivo. Therefore, we recommend clinical use of the knot configurations with the best biomechanical properties in attempts to reduce the risk for repair failure.

Conclusions

Although the majority of respondents reported using arthroscopic knots that are described and biomechanically examined in the orthopedic literature, only a minority of respondents reported using the optimal knot configurations determined in vitro for sliding knot reinforcement and when using a nonsliding half-hitch knot configuration. We recommend that an evidence-based approach be incorporated into decisions regarding which arthroscopic knots to use in clinical practice.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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