Original Article

Biomechanical Comparison of Banarji Knot with Various Sliding Locking Knots

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Abstract

Background: The most essential part of arthroscopic shoulder surgery is tying a secure knot. A knot should be a low profile, nonbulky, and more stable construct. In the present research, we have compared the biomechanical performance of the new sliding locking knot-the Banarji knot, with two different sliding locking knots: The Samsung Medical Centre (SMC) Knot and the Weston Knot. **Methods:** Two samples of arthroscopic sliding locking knot, Banarji knot with three and five half hitches were taken. They were named Banarji Knots 1 and 2 in the study. The SMC Knot and Weston Knot were taken for comparison with the Banarji Knot. All knots were prepared with high-strength suture material fiber wire (Arthrex, Naples, FL, USA) and were tested in Bose Testing Machine to evaluate the load to failure of knots taken in the research. The statistical significance was determined using a $P = 0.05$. **Results:** The maximum load to failure was higher with the Banarji Knot, and it showed significantly better performance when compared with other knots taken in this study. The maximum load to failure in Banarji Knot 1 was 23% and 17% higher than SMC Knot and Weston groups, respectively, and that for Banarji Knot 2 was 29% and 22% higher than SMC and Weston groups, respectively. **Conclusion:** The Banarji knot is a low-profile, stronger, and stable knot. The biomechanical properties of the Banarji knot were better, and the load to failure was superior to SMC and Weston Knot.

Keywords: Arthroscopic knot, Banarji knot, double locking, secure knot

Introduction

Creating a stable framework for soft-tissue healing to bone is often necessary during arthroscopic shoulder surgeries. The most widely used fixation technique still necessitates the tying of arthroscopic knots, despite the availability of many alternatives.[1] Procedures for arthroscopic repair depend on the adoption of a secure knot-tying method. An initial sliding knot, followed by a string of half hitches to seal the knot, is often the first stage in the arthroscopic knot-tying process.[2] According to their common properties, the various forms of arthroscopy knots that have been reported[3,4] may be simply categorized. There are locking and nonlocking variations of both types of arthroscopic knots, which may be categorized as sliding or nonsliding.[5]

The outcomes of arthroscopic glenohumeral as well as subacromial shoulder operations have improved with the addition of suture anchors. To successfully re-approximate soft tissue to other tissue, it is necessary, among other factors, to choose an acceptable knot for a specified anchor and given suture material. To prevent knot impingement, an arthroscopic knot ought not to bulky, challenging to tie, or time-consuming.[6]

The security of the arthroscopic knot is essential for arthroscopic surgery to provide successful outcomes.[7] Orthopedic surgeons still need to learn how to make arthroscopic knots, despite the recent rise in the use of knotless suture anchors.[8]

The optimal arthroscopic knot must have minimum friction to facilitate sliding and minimal or no slack after the knot. In addition, a low-profile knot might be preferable. Significant features, such as application ease, ability to slide, reproducibility through arthroscopic cannulas, knot profile,

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ease of lock setting, and dependable initial security, are important for the outcome of arthroscopic rotator cuff repairs and capsulolabral procedures.[9]

A knot must have optimum characteristics for both knot security and loop security to be useful.[1] An ideal lockable sliding knot must be easy to use and should offer both excellent loop and knot security.[10] Loop security refers to the tendency of the knot to juxtapose soft tissue to the bone, whereas the surgeon is tying the knot. The ability of a knot to prevent slippage is known as knot security, which relies on friction dependent, internal interference, and the space between throws.[11] The strength of the finished knot after it has been fastened with three consecutive reversing half-hitch throws is referred to as the knot security.[12-14] According to earlier research, sliding knots need to be secured using 3–5 reversing half-hitch knots on opposite posts.[15]

Despite the variety of knots available, all successful knots must satisfy 2 criteria.

- The knot has to be correctly constructed to prevent the suture from slipping and cutting into itself
- It must be simple to tighten to provide optimum strength.[16]

In this study, we have compared the biomechanical performance of the arthroscopic "sliding locking knot," Banarji Knot[17] with existing sliding locking arthroscopic knots: Samsung Medical Centre (SMC) Knot and Weston Knot, by evaluating knot security and load to failure strength.

Methods

Study design

The material we used was ultra-high molecular weight polyethylene suture material (Arthrex, Naples, FL, USA) fiber wire for the description of the knot and comparative study. Poststrands are placed shorter and loop strands longer to form the Banarji knot [Figure 1a-f]. On over of the poststrand, a loop is made, A double loop is seen once the loop strand is pulled through the post. Once both suture strands have been pulled through the second loop, the knot might be placed by pulling off the poststrand. Pulling the poststrand completes advances, and secures the knot while pulling the loop strand tightens it. The knot is finally tightened with a knot pusher. The biomechanical performance of the Banarji knot was compared with SMC Knot and Weston knot. Two types of Banarji knot, with three and five reversing half hitches, were used for the comparative study, and they were mentioned as Banarji Knot-1 and Banarji Knot-2, respectively. Five samples in each of these knots were taken for the study.

The mechanical tests were performed at Biomechanics Laboratory, Indian Institute of Science, Bengaluru, India, by an independent investigator on a Bose Electro force® 3200 [Figure 2].

A single orthopedic surgeon carefully made each knot, taking care to guarantee optimum loop and knot stability by removing twists, minimizing slack between throws, as well as tensioning the 2 suture limbs. Each knot was knotted with as much initial stress as possible. The specimens were tested by soaking the knots in saline for 5 min.[18,19]

Biomechanical performance

Mechanical tests were performed on a Bose Electro force® 3200[14] (Bose Corp., USA) testing system equipped with two L-shaped metal hooks on which suture loops were mounted [Figure 2].

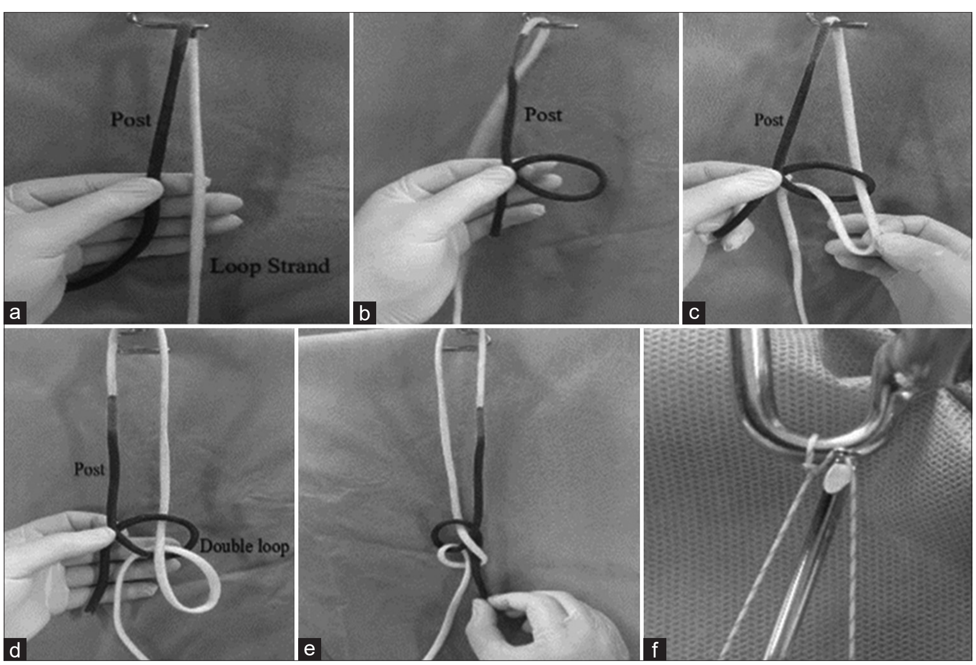

Figure 1: (a-f) Demonstration of Banarji knot

Preload

To eliminate any slack, each suture loop was preloaded to 5N before testing. The top clamp was moved at 0.1 mm/s to stretch the loop until failure.

Load to failure

The construct fails when any one of the following three criteria is satisfied: (1) the knots open up, (2) the suture thread ruptures, and (3) the loop length exceeds 3 mm.[20] The load at failure determines the load at the construct's point of failure. In our experiments, the knots did not open up, nor the suture thread ruptured, and therefore using the third failure criterion, the experiments were terminated when the change in the loop length exceeded 3 mm. The loads were measured using a 220N load cell, and the displacements (changes in the loop length) were recorded at 20 Hz using the machine software.[19,21] The load value when the loop length is increased by 3 mm is referred to as load to failure. A total of 5 samples were tested for each of the four groups. One-way "Analysis of Variance" with the Bonferroni criterion has been performed to test for variations in the results. A $P = 0.05$ was applied to examine statistical significance.[22]

Figure 3 shows the load versus extension results for five samples each in the groups corresponding to SMC Knot, Weston Knot, Banarji Knot 1, and Banarji Knot 2. Each sample is indicated using a different color. The average load to failure was obtained for each of the knots in the different groups in the study and was used to compare the overall strengths of the different groups.

Figure 4 shows the mean ± standard deviation of the experimentally obtained load to failure in each of the different groups in this study. Banarji Knots 1 and 2 showed statistically significant differences in the measured values of maximum load to failure when evaluated to SMC and Weston knots [Table 1].

Results

The results show significantly better performance with Banarji Knots 1 and 2 when compared to conventionally used knots.

Figure 2: Bose electro force 3200 testing machine showing testing of the knot

The maximum load to failure in Banarji Knot 1 was 23% and 17% higher than SMC and Weston groups respectively and that for Banarji Knot 2 was 29% and 22% higher than SMC and Weston groups, respectively. Load to failure and tensile strength were good with the Banarji knot when compared to other knots used.

Discussion

One of the most crucial elements in determining the success of surgery is the arthroscopic knot.[12,20,22] The critical properties of arthroscopic knots to preserve tissue apposition have been determined by many biomechanical investigations.[20,23] These aspects include the inherent qualities of the suture as well as the security of the loop and knot. For the best results of arthroscopic rotator cuff surgery, loop and knot security have been highlighted in several research.[21] We assessed the maximal force at 3 mm of crosshead movement as a measure of knot security, indicating a clinical failure. Numerous studies have shown that the idea of knot security is a crucial fixation characteristic for a range of arthroscopic knots.[1,21] In addition, the knot's capacity to resist loosening over time is crucial because tissue tension has to be maintained until appropriate healing has occurred. Additional crucial factors are the time required to make the knot and how simple it is to operate inside the joint and cannula used.[24]

The maintenance of the structural integrity of the treatment site while healing takes place is a crucial factor in musculoskeletal injuries and surgical repair. Even if the knotted suture never

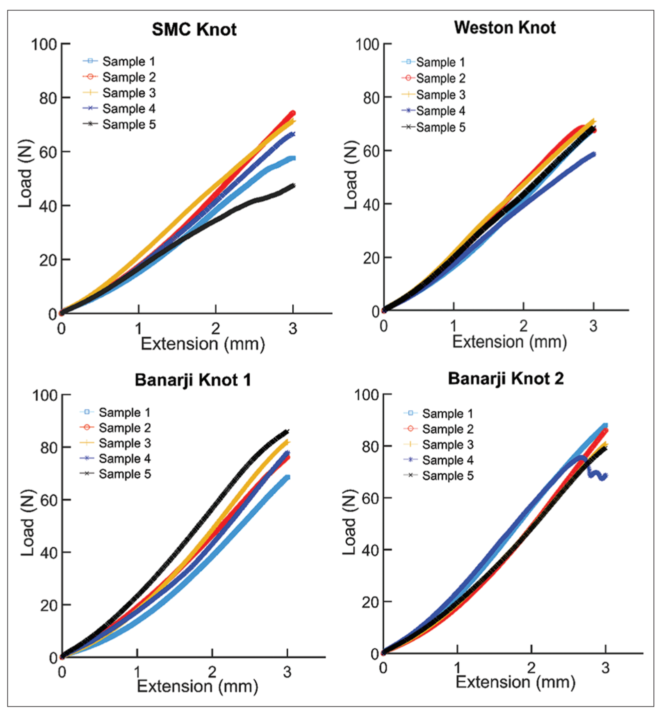

Figure 3: Load versus extension results for five samples of different knots taken. SMC Knot, Weston Knot, Banarji Knot 1 and 2. SMC: Samsung medical centre

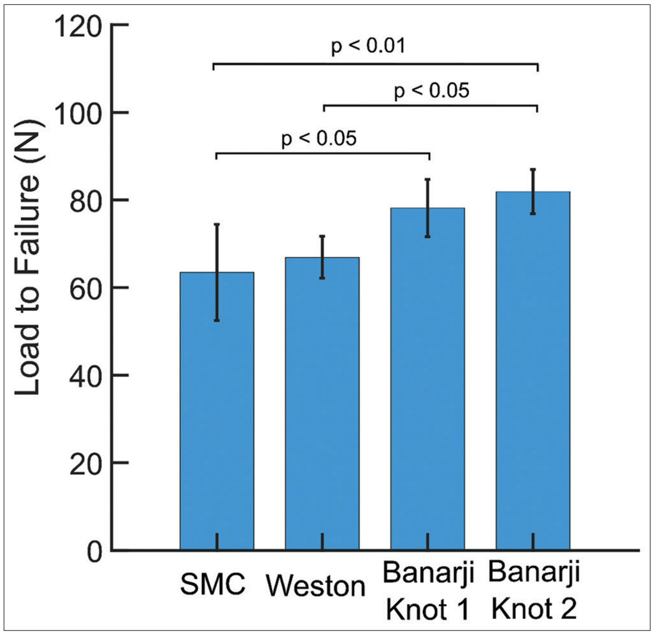

Figure 4: Load to failure of four knots, taken. SMC: Samsung medical centre

Table 1: Result of load-to-failure of each knot configuration

	SMC knot	Weston knot	Banarji knot 1	Banarji knot 2
Load to failure (*n*)	63.47±10.97	66.91±4.79	78.14±6.55	81.91±5.04

SMC: Samsung Medical Centre

breaks, a separation of the tissue of even a few millimeters might be harmful during recovery.[23]

The integrity of a repair construct depends on a surgeon's skill and expertise, regardless of knot or suture creation. Therefore, while creating an arthroscopic knot, it is crucial to take these aspects into account to eliminate such technical variances. Given the large range of alternatives available for arthroscopic knot tying, it is crucial to keep the following factors in mind to achieve the best results. The best arthroscopic sliding knot should fulfill the following five requirements: (1) It should be low profile, (2) It should be easy to throw, (3) It must slide well, (4) It must be easy to set, and (5) It must possess outstanding initial security and holding power.[24]

The Banarji Knot is a kind of sliding locking knot that may be tied during arthroscopic procedures. It may provide biomechanical dependability and is less reliant on the skill or expertise of the surgeon. This surgical knot's dependability was examined biomechanically in comparison to other widely used arthroscopic sliding locking knots. The maximum load to failure in Banarji Knots 1 and 2 were higher than SMC and Weston Knot. Table 1 provides an overview of each knot's load to failure. The Banarji Knot could withstand high tension when compared to SMC Knot and Weston Knot. It has a lesser learning curve and is easily reproducible by the surgeon. Once fastened, it keeps tension effectively and has great knot security. It is extremely good for capsule labral repairs since it is low profile and reasonably easy to tie. In addition, a biomechanical analysis revealed that the Banarji knot was more resistant to failure than the Weston and SMC knots. The Banarji Knot is a fairly simple, double-locking, and readily repeatable knot. Impingement is not a concern since the knot is low-profile and does not generate a bulky knot. It is biomechanically strong has good tensile strength, and high load to failure. The loop strand goes through two loops, making it stronger and raising its tensile strength after it is tightened and secured at different points.

Conclusion

The arthroscopic sliding locking knot-the Banarji knot is simple, easy to tie, relatively less bulky, safe, and stronger, which makes it suitable for most arthroscopic repairs. The biomechanical properties of the Banarji knot are better when compared to SMC and Weston Knot. We are certain that this knot will assist surgeons in reaching improved clinical outcomes.

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Conflicts of interest

There are no conflicts of interest.

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