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学位論文名　A New Technique for Small and Secure Knots Using Slippery Polyethylene Sutures

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論文内容の要旨

INTRODUCTION

Suture knots used in tendon surgery must be strong but small enough so that they do not hinder gliding. Polyethylene sutures have recently been used in clinical practice due to their high tensile strength. However, as these sutures are inherently slippery, they require many throws to tie a secure knot. Such bulky knots on the surface of a repaired tendon hinder gliding of the sutured tendon. Large knots made within repaired sites hinder biological healing and may enhance foreign body reaction. Therefore, knots must not only be strong but also small, even with slippery polyethylene sutures. For this purpose, we devised a unique ‘‘antislip” knot. This study was performed to investigate the size and tensile strength of knots tied using this method.

MATERIALS AND METHODS

Three suture materials were used: polyester (Ethibond), a blend of polyester and polyethylene (Fiberwire), and polyethylene (Nespron). They were tied with either the antislip

knot using a pair of United States Pharmacopeia (USP) 2 sutures or with a conventional reef knot using USP2 single sutures.

Antislip knot : First, a surgeon's knot is made using a pair of sutures. Next, both ends are tied in the manner of a reef knot. Several throws are given to both sides. The throw count is based on the total number of throws of one surgeon's knot and one side knot. Three combinations of three to five throws were made with Ethibond, and four combinations of three to six throws were made with Fiberwire and Nespron.

Reef knot : A conventional suture method was applied (i.e., reef knots were added to a surgeon's knot). Five combinations of three to seven throws were made with Ethibond, and seven combinations of three to nine throws were made with Fiberwire and Nespron.

In total, 30 combinations were examined using different combinations of suture material, knot-tying method, and throw count. Tensile force was applied at 20 mm/min with a tensionmeter (Instron Series 5560). Tensile strength for each suture loop was defined by the maximum load, which was followed by a sudden decrease in load due to rupture or slippage of the knot exceeding 2 mm. 20 knots of the same combination were placed in a graduated cylinder with a 0.1-ml scale, which was filled with 5-ml saline, and the knots were measured to determine the mean volume of each knot.

The uniformity of dispersion was examined by the Bartlett test. Two-factor factorial ANOVA indicated a correlation between the suture material and knot-tying method. Multiple-group comparisons were performed using the Tukey–Kramer post hoc test. A P-value of less than 0.05 was considered to indicate statistical significance.

RESULTS AND DISCUSSION

The incidence of antislip knot rupture was 100% (n = 25) with three throws of Ethibond and five throws of Fiberwire and Nespron. For the reef knot, the number of throws for 100% rupture was seven with Ethibond, nine with Fiberwire, and nine with Nespron. Among the reef

knots, the maximum value was observed with Fiberwire knots with seven throws (mean 293 N, SD 33 N), eight throws (mean 308 N, SD 27 N), and nine throws (mean 309 N, SD 23 N), and a Nespron knot with nine throws (mean 283 N, SD 30 N). So, the maximum tensile strength was observed with Fiberwire antislip knots with five throws (mean 587 N) and six throws (mean 590 N), and Nespron antislip knots with five throws (mean 554 N) and six throws (mean 552 N); no significant differences were found among the four knots.

Tensile strength per volume showed maximum values with Fiberwire antislip knots with four throws (mean 17.4 N/ μ l) and five throws (mean 16.8 N/ μ l), and Nespron antislip knots with four throws (mean 17.6 N/ μ l) and five throws (mean 16.8 N/ μ l), which were not significantly different and were over 1.25-fold greater than the value for a reef knot.

Ethibond had less tensile strength than Fiberwire and Nespron.

This biomechanics study in vitro demonstrated that an antislip knot has greater tensile strength than a reef knot. However, as many factors are involved in vivo, the advantages observed in vitro are not always seen in vivo. Therefore, for application in clinical practice, a good understanding of the advantages and disadvantages of the antislip knot is necessary.

CONCLUSION

The antislip knot is smaller with the same or greater strength than the conventional reef knot, and a 4- or 5-throw antislip knot is the most effective type of knot for slippery polyethylene suture materials such as Fiberwire and Nespron.