学 位 論 文 の 要 旨

氏 名　四本　忠彦

学 位 論 文 名　Optimum Locations of the Locking Loop and Knot in Tendon Sutures Based on the Locking Kessler Method

発 表 雑 誌 名
（巻，初頁～終頁，年）　Journal of Orthopaedic Science
10, 515-520 (2005)

著 者 名　Tadahiko Yotsumoto, Ryuji Mori, Yuji Uchio

論 文 内 容 の 要 旨

INTRODUCTION

Increasing tensile strength of the tendon suture and eliminating the gap at the suture site are important factors when repairing the lacerated tendon and initiating an early mobilization program. Some authors reported that single locking method in the tendon suture provided strong tensile strength and antigap resistivity. However, differences of the locations of the locking loop and knot had not yet been investigated. We hypothesized that subtle differences in the location of the knot result in differences in tensile strength and mode of failure. We investigated the effect of the knot location in the single locking method by observing the tensile strength, mode of failure and resistance to repair site gap formation (stiffness). In addition, we tried to conceive a practical suturing technique, comparing two locations of loop in the single locking method.

MATERIALS AND METHODS

Bovine tendons of the medial heads of the gastrocnemius were removed from male Japanese black cattle (24 months old, weight: 450-500 kg, diameters: 15-16 × 9-10 mm). The tensile strength of all the intact tendons was greater than 3000 N. The tendons were transected into two pieces and then sutures end-to-end using USP 2 polyester multifilament suture. The locking loops were applied at two locations. One was in the upper surface portion of the tendon that facing the operator (upper surface loop) and the other was in the side portion of the tendon (side loop). At the time of suturing, a custom-made, elliptically shaped tendon fixation unit was used to measure the area of the locking loop, encompassing 30% of the entire cross sectional area of the tendon. Knots were applied at two locations: close to or far from the tendon stump. All knots were formed outside of the repair site. Four suture techniques were applied (10 samples in each technique): an upper surface loop with a knot close to the stump; an upper surface loop with a knot far from the stump; a side loop with a knot close to the stump; and a side loop with a knot far from the stump. To measure the tensile strength of the sutured tendons, we used to the Instron 5565 tensiometer. Specimens were loaded until failure occurred with a crosshead speed of 20 mm/min in the Instron apparatus. Values of loading and elongation of all specimens were registered in an x-y recorder. The loading values, movements of the knot, and formation of the gap length were measured. Stiffness (N/mm) was determined by calculating the ultimate failure force divided by the gap length.

RESULTS AND DISCUSSION

While applying the loading cell of the Instron tensiometer, the tensile strength gradually increased and a gap was formed between the sutured tendon stumps. With both upper surface loop methods, a transient tensile decrease (dip) occurred. The tensile dips occurred when the suture thread was drawn into the tendon in all upper loop methods (n = 20). The mode of failure in all groups was rupture of the suture thread close to the knot. There were no samples that failed because of suture slippage at the knot or tendon fiber with the suture thread. Tensile strength of the upper surface loop with a knot close to the stump was 169.0 ± 3.6 N; the upper surface loop with a knot far from the stump was 195.1 ± 4.8 N; the side loop with a knot close to the stump was 171.8 ± 4.6 N; and the side loop with a knot far from the stump was 196.6 ± 2.8 N. Statistical analysis showed that the tensile strength was not influenced by the locking loop location, although it was influenced by the knot location. That is, the tensile strength was greater when the knot was located far from, rather than close to, the stump in both the upper surface loop group and the side loop group (p = 0.0001). Stiffness of the suture was 5.18 ± 0.09 N/mm for the upper surface loop with a knot close to the stump, 5.17 ± 0.10 N/mm for the upper surface loop with a knot far from the stump, 5.68 ± 0.14 N/mm for the side loop with a knot close to the stump, and 5.70 ± 0.09 N/mm for the side loop with a knot far from the stump. The stiffness was not influenced by the location of the knot, but it was influenced by the location of the locking loop (p = 0.0001). In our study, the tensile strength was greater when the knot was located far from the stump. Our finding that the tensile strength differed even when the knot was located in the limited area outside the repair site has not been reported elsewhere. The stiffness depended on the location of the loops, irrespective of the location of the knot. We believe that the side loop with a knot far from the tendon stump is an excellent suture method based on the experimental results of tensile strength and stiffness. In clinical practice, first, we need to make a locking suture. It is relatively easy to confirm the locking with the side loop method because we can observe the intersection of the transverse and vertical components on the tendon during operation. In addition, we need to form the knot as far as possible from the tendon stump. With the side loop method, when placing a knot on the upper surface of the tendon (facing the operator) the knot can be formed at a site far from the tendon stump without too much care. Therefore, we believe that the side loop method with a knot far from the tendon stump is the most effective locking suture method in terms of certainty and simplicity in clinical practice.

CONCLUSION

A greater tensile strength with less of a gap is obtained by forming locking loops in the side portion of the tendon, and forming knots far from the tendon stump.