Surgical time for graft preparation using different suture techniques

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Summary

Background: **The purpose of the present study was to compare the operative time for graft preparation using different techniques for graft suturing.**
Material and methods: **Flexor profundus tendons were harvested from fresh pig hind-leg trotters. Three different suture techniques were investigated: the Krackow stitch (K), the Whipstitch (W), and the Modified Finger-Trap suture (MFT). Tendons were sutured starting at 10 mm from the distal free end of the tendon. The suture configurations of the Krackow stitch and Whipstitch were completed with five suture throws. According to the MFT technique, the suture was wrapped five times around the tendon over a distance of 30 mm. The time required to perform a complete suture on each tendon was measured. Five independent examiners of different levels of training measured the time required for graft preparation during 3 separate occasions to determine intraobserver repeatability and interobserver reproducibility.**
Results: **The mean time required for graft preparation following the Krackow technique was 69.1 seconds ± 18.3 SD (range 31.8-120). The Whipstitch technique took an average of 59.9 seconds ± 21.2 SD (range 27-93). The MFT suture required a mean of 29.3 seconds ± 11.4 SD for completing the suture (range 21.6-33). In all examiners the time required to complete the MFT suture was significantly less than the other suture techniques ($p < 0.05$). Intraobserver intraclass correlation coefficients for each examiner ranged from 0.72 to 0.83.**
Conclusion: **Low graft preparation time is required to complete a MFT suture in a porcine tendon model. Further, time required for graft preparation using the MFT was shorter than other suturing techniques such as the Krackow and Whipstitch techniques.**
Clinical relevance: **The MFT suture could be used for graft set-up with the main advantage of reducing the time required in comparison with other suture techniques.**

KEY WORDS: fiberwire, grasping tendon, krackow suture, modified finger-trap, suture tendon, suturing tendon, whipstitching.

Introduction

In the last two decades, an increase in the use of hamstring grafts for several surgical ligament reconstruction procedures has been observed. In fact, autogenous gracilis and semitendinosus tendons are the first choice of many orthopaedic surgeons when reconstructing the anterior and posterior cruciate ligaments[1-3]. Because of low site morbidity, hamstring has started to be used in other surgical procedures such as coracoacromial ligament reconstruction, ulnar collateral ligament reconstruction of the elbow and rotator cuff repair[4-7]. During ligament reconstruction, the free ends of the tendon are usually sutured to secure and handle the tendon during harvest and to apply tension to the graft during final fixation with an interference screw[8]. Furthermore, a suture passed along the tendon allows an easier graft tunnel transfer and insertion into a bone tunnel, specifically when a retrograde graft tunnel transfer is required. To date, several suturing techniques have been proposed for graft preparation[9-11]. Krackow stitch, the baseball stitch and the whipstitch are the most well known suture techniques used by surgeons during ligament reconstructions[12]. They consist in passing the suture with a different configuration through the tendon using a needle. Although these suture techniques are effective, potential disadvantages have been reported such as possible damage to the integrity of the ten-

don and permanent viscoelastic elongation of the graft due to slippage of the suture within the tendon tissue[13,14]. Furthermore, passing a suture through the tendon is relatively time-consuming and it could increase the duration of the surgery[11]. For these reasons, different Authors advocate the use of grasping suture techniques rather than locking suture techniques[11, 14-17]. The most known grasping suture technique is represented by the modified finger-trap (MFT) suture. Following the MFT technique, a suture is tied over the graft with a criss-cross suture pattern, allowing the surgeon to constrict the graft when tension is applied to the sutures. In order to prevent slippage of the crosshatch suture from the end of the tendon graft during loading, an additional final rolling-hitch suture is applied[11]. Main advantages of this suture technique are represented by an increase in the surface area of the suture-tendon interface and the no violation of the graft itself by needle and sutures. Furthermore, the MFT represents a potentially faster approach for graft preparation. Even MFT-graft construct has been already studied and compared with other suture techniques, to our knowledge no data is present regarding the merit of the MFT to reduce the surgical time of graft preparation[11,18]. The aim of the present study was to compare the operative time for graft preparation during a ligament reconstruction using different techniques for graft suturing. The Authors hypothesized that the MFT technique may provide a shorter operative time for graft preparation when it was compared to other tendon suture techniques.

Materials and methods

For this study, flexor profundus tendons were harvested from fresh pig hind-leg trotters. The choice of porcine tendons was based on their immediate availability, smaller size and lowcost. Tendons were cut to the same length close to the distal osseous insertion in order to obtain a tendon length of 10 cm. No tendons used presented degenerative or pathologic changes. At this point, all tendon grafts were immediately wrapped in a normal saline soaked cloth and stored at -20° C until testing. Then tendons were thawed at room temperature and kept moist to prevent drying, being sprayed with saline solution during testing. Tendons were fixed in a custom-designed workstation that allows optimizing and standardizing the graft positioning before its suture. Three different suture techniques were investigated: the Krackow stitch (K), the Whipstitch (W), and the Modified Finger-Trap suture (MFT). No. 2 braided non-absorbable sutures (Ticron, Tyco, Waltham, MA) were used in all cases. Tendons were sutured following different techniques starting at 10 mm from the distal free end of the tendon. According to the Krackow and Whipstitch techniques, a suture was passed through the tendon using a round-bodied needle over a distance of 30 mm, with 5 suture throws performed on each sample and leaving a pitch between the suture throws of 5 mm. According to the MFT technique, the suture was wrapped five times around the tendon over a distance of 30 mm. The suture was then tightened and reinforced with a final rolling stitch, leaving a 1 cm distance from the end of the tendon (Fig. 1).

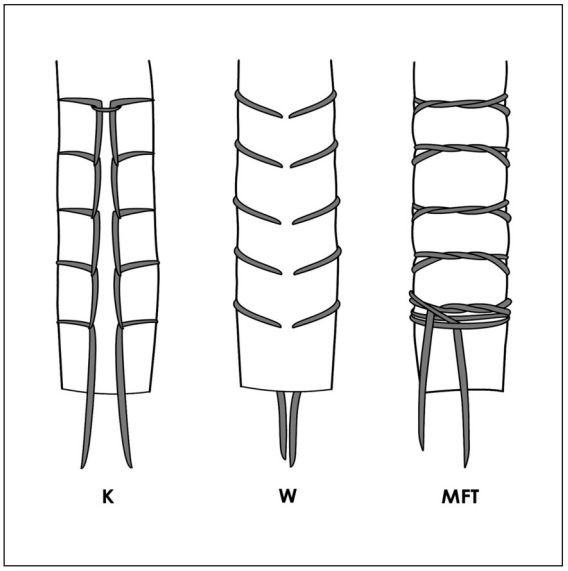

Figure 1. Three different suture techniques were investigated: the Krackow stitch (K), the Whipstitch (W), and the Modified Finger-Trap suture (MFT).

The time required to perform a complete suture on each tendon was measured using a chronometer. In order to standardize the method, a countdown was used to signal the surgeon the beginning of the recorded time. Further, the time was stopped at the end of each test when the surgeon completed the tightening of the suture following the last throw or rolling stitch. Measurements of time required for graft preparation were taken by 5 independent examiners with different levels of training. Specifically, three were defined as expert surgeons (two orthopaedic surgery chief residents, and a high trained Orthopaedic Surgeon) and two were defined as inexpert surgeons (2 orthopaedic surgeons during their 1st year of residency). Intraobserved repeatability was evaluated by having each examiner measure the time used for graft suturing on 3 separate occasions being a minimum of 2 weeks apart to prevent recall bias.

All research was conducted ethically according to international standards[19].

Statistical analysis

The first 6 measurements of each examiner and of each group of sutures were excluded from statistical analysis to avoid arousal responses associated with startle of the study. Data was analysed with SPSS statistical software, version 11.0 (SPSS, Inc., Chicago, IL). Descriptive statistics, including means and

standard deviations, were performed for each suture group and for each examiner. Differences of time required for graft preparation between examiners were analysed using a paired Student's test. A significance level of $p < 0.05$ was used for the study. Further, the interobserver and intraobserver reliability was calculated using intra-class correlation coefficients (ICC) with two-way random effects. A measurement was considered reliable and excellent if the ICC was higher than 0.75[20].

Results

A total amount of 450 measurements was collected. The mean time required for graft preparation following the Krackow technique was 69.1 seconds ± 18.3 SD (range 31.8-120). The Whipstitch technique took an average of 59.9 seconds ± 21.2 SD (range 27-93). The MFT suture required a mean of 29.3 seconds ± 11.4 SD for completing the suture (range 21.6-33) (Tab. I). Statistical differences between means were noted among three suture techniques (MFT *vs* K $p < 0.05$; MFT *vs* W $p < 0.05$; W *vs* K $p < 0.05$). In all examiners the time required to complete the MFT suture was significantly less than the other suture techniques ($p < 0.05$). This was independent from the level of experience of the surgeon. Further, the Krackow suture required a longer surgical time for graft preparation than the Whipstitch and the MFT sutures ($p < 0.05$). Results of measurements of single examiners are described in Table II. The ICC for the experienced examiners ranged from 0.69 to 0.75, indicating fair to excellent reproducibility, whereas the ICC for inexperienced examiners was slightly lower than the average agreement among all examiners and ranged from 0.61 to 0.66. Intraobserver intraclass correlation coefficients for each examiner ranged from 0.72 to 0.83.

Discussion

The main result of the present study is that low operative time is needed to complete a MFT suture in a single limb porcine tendon model. Further, time required for graft preparation using the MFT was shorter than other suturing techniques such as the Krackow and Whipstitch techniques.

During ligament reconstructive surgery, usually the graft is prepared for the final implantation [10,21,22]. In this phase, the graft is sutured proximally and distally in order to obtain correct graft diameter size required for its tunnel transfer. Further, suturing the graft is needed to allow a correct graft handle during its fixation. Generally, an assistant performs this procedure, while the surgeon assesses the joint arthroscopically and prepares bone tunnels. However, the surgeon has to complete the suture of the graft by itself if the tendon is stripped after its bone detachment and in case of unavailability of an assistant surgeon. In these cases, trying to obtain a quicker way to secure the graft could be helpful to reduce the overall surgery time. To our knowledge, any prior study has investigated the operative time requested for graft preparation during a ligament reconstruction. In this study we found that the MFT represents a valid alternative to other suturing techniques reducing the time of graft set-up. Specifically, the time required for graft preparation using the MFT was shorter than the Krackow and Whipstitch techniques in a porcine tendon model. Further, it was found that the Krackow

Table I. Overall time required for graft preparation.

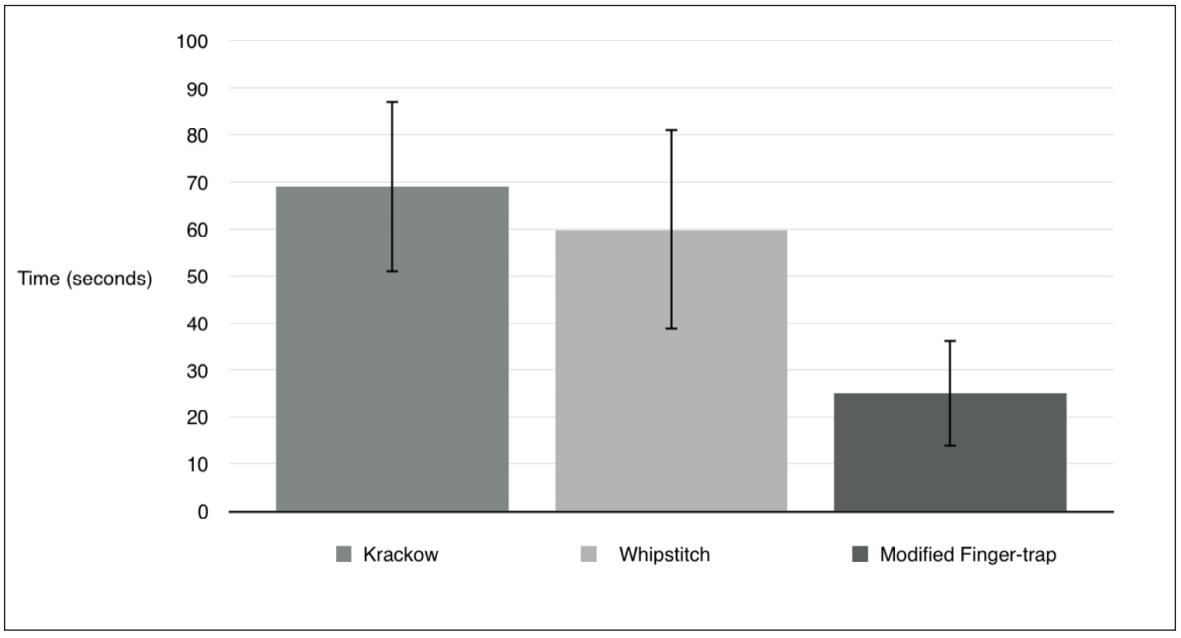

Table II. Data presented as mean ± standard deviation. Values expressed in seconds.

	Examiner 1 Expert	Examiner 2 Expert	Examiner 3 Expert	Examiner 4 Inexpert	Examiner 5 Inexpert
Krackow	69,5 ± 5	45,4 ± 13,7	68,6 ± 24	82,6 ± 4,26	79,3 ± 7,3
Whipstitch	37,6 ± 9,2	40,1 ± 15,5	63,2 ± 15,7	79 ± 3,4	79,7 ± 5
Modified Finger-Trap	23,7 ± 2,9	29,9 ± 4,3	43,3 ± 18,3	24 ± 4,6	25,1 ± 3

technique requires more time when it was compared to the MFT and the Whipstitch techniques. However, in this study just a tendon limb was sutured according different techniques and results obtained not completely reflect the surgical time required for graft preparation. In fact, in the clinical setting both tendon limbs are sutured and during knee ligament reconstruction two tendons (gracilis and semitendinousus) are employed. In this circumstance the time for graft preparation could exponentially increase. On the basis of the results of the current study, it is reasonable to assume that the MFT could be used for graft set-up with the main advantage of reducing the time required in comparison with other suture techniques.

A non-requiring of stitch needle represents another advantage of the MFT. In fact, this decreases the technical demands for tendon handling, decreasing the risk of needle-stick injury to the surgeon or assistant. In addition, it eliminates the risk of breaking the tendon graft or suture strands in the sewing process[11]. Different biomechanical studies analyzed the merits of MFT. Su et al. observed that after 200 loading cycles, tendons sutured following the MFT technique presented less elongation than tendons sutured following the Krackow and the locking Speed Whipstitch techniques[11]. Further, significant differences were note across all suture groups in terms of load to failure values, highlighting the biomechanically superiority of the MFT over other suturing techniques. This could be probably provided by a large contact area between the tendon and the thread surface, limiting the suture slippage over the tendon. Hong et al. evaluated the effect of the number of suture throws on biomechanical characteristics of the suture-tendon construct for 3 currently suture configurations (MFT, Krackow stitch, locking Speed Whip). In this study it has been seen that there were no significant differences in elongation after cyclic loading and load to failure among 3 different suture throws (3 *vs* 5 *vs* 7 throws) for the 3 types of sutures investigated (MFT, Krackow stitch, locking Speed Whip)[18]. In order to homogenize the samples, just n.5 suture throws were evaluated in this study for each suture group. In fact, five crosshatch interlacing sutures in the MFT suture group were used to correspond to the 5-loop stitch in the Krackow and Whipstitch configurations. Further, this is the number of throws described for the original MFT technique[11].

The present study has some limitations. At first, porcine tendons were used in place of human tendons. However, the use of porcine tendon allows a reproducible model for *in vitro* testing. Further, Authors believe that their lower cost and wide availability justified their use in present study. Second, time required for graft preparation does not completely reflect the ability of other surgeons. In fact, the skill to perform a single surgical procedure could vary among surgeons. Third, just one tendon limb was sutured on each test. Indeed, time requested for graft set-up could be different if 2 tendons are sutured together or if the tendon is triple or quadruple. In these cases the time for graft preparation could increase independently from the suture technique used.

Conclusion

Low operative time is required to complete a MFT suture in a porcine tendon model. The MFT suture could be used for graft set-up with the main advantage of reducing the time required in comparison with other suture techniques.

Conflict of interests

The manuscript has been reviewed and approved by all co-Authors. The Authors certify that the paper has not been published (in part or in full) or submitted for publication elsewhere. We certify that each of the Authors has given a substantial contribution so as to qualify to the authorship. All Authors have disclosed all financial support for this work and other potential conflict of interests.

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