BIOMECHANICAL PROPERTIES OF LOCKING VERSUS GRASPING SUTURE

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INTRODUCTION

The ideal flexor tendon repair would have high tensile strength and gap resistance but would minimize suture material on the tendon surface so as to not interfere with tendon gliding or healing. Efforts to develop such repairs have resulted in innovations in suture materials, core suture techniques, and peripheral suture techniques. The result has been better outcome of zone II flexor tendon repairs, but the risk of repair rupture or gap formation remains.

Although increasing the number of suture strands across the repair site increases the tensile strength, there is debate as to whether the suture loop configuration, grasping or locking, increases the pullout strength of the suture. The locking configuration is one in which the transverse component is passed superficial to the longitudinal component, so that the suture passes around a bundle of tendon fibers [1]. Conversely, in a grasping configuration the transverse component passes deep to the longitudinal component, so that the suture does not pass around or lock a bundle of tendon fibers. The purpose of this study was to compare mechanical properties of various locking suture methods to grasping suture methods in a human in vitro model of flexor tendon repair.

METHODS

45 cadaveric human flexor digitorum profundus (FDP) tendons were transected and repaired using one of the following randomly assigned core suture techniques:

(1) **MK:** modified grasping Kessler (grasping, modified with 4 strands, one knot inside repair site, n=9)
(2) **P:** Pennington (locking, modified with 4 strands, one knot inside repair site, n=9)
(3) **MP:** Modified Pennington (locking, modified with 4 strands, locking loops, one knot inside repair site, n=9)
(4) **ML:** Modified Lee (grasping, modified with 4 strands, two knots inside repair site, n=9)
(5) **LL:** Locking Lee (locking, modified with 4 strands, two knots inside repair site, n=9)

All repairs used a 4-0 Supramid looped core suture (S. Jackson, Inc. Alexandria, VA, USA) and an epitenon running suture of 6-0 nylon (Ethicon, Inc. Somerville, NJ, USA). All core sutures looped 1 cm from the cut tendon ends and were tied in the laceration site.

Gliding resistance of the tendon-pulley interface [2] was measured for each repaired tendon. Load transducers were attached to the proximal and distal ends of the FDP tendon. The distal transducer was connected to a 4.9N weight to simulate passive mobilization of the finger and the proximal load transducer was connected to the mechanical actuator. The tendon was pulled proximally by the actuator against the weight at a rate of 2 mm/second. The forces at the proximal and distal tendon ends and the tendon excursion were recorded. The force differential between the proximal and distal ends of the tendon represents the gliding resistance. Mean and peak gliding resistance over the excursion range were reported.

After the gliding resistance test, the tensile properties of the same FDP tendons were measured using a servohydraulic testing machine (MTS, Minneapolis, MN). The grip-to-grip distance was 30 mm, which was the tendon excursion length. A displacement transducer (DVRT, MicroStrain, Burlington, VT) was attached to the tendon to measure gap formation at the laceration site. Tendons were distracted at a rate of 20 mm/min until complete rupture of the repair. The maximum failure load and force required for gap formations of 0.5, 1.0, 1.5, and 2.0 mm were recorded and failure modes were noted.

RESULTS

The mean gliding resistance of the locking Lee repair was significantly higher than the modified Kessler, Pennington and modified Pennington repairs ($p<0.05$) (Fig 1). There were no significant differences among the modified Kessler, Pennington, modified Pennington, and modified Lee repairs. The peak gliding resistance followed the same trends ($p<0.05$) (Fig 1).

During tensile testing, failure of the repair occurred, either by suture breakage or suture pullout from the tendon stump. Suture breakage occurred in 67% of the Pennington repairs, 89% of the modified Pennington repairs, and 100% of the locking Lee repairs.

Meanwhile, suture pullout occurred in 56% of the modified Lee repairs and 100% of the modified Kessler repairs.

The modified Pennington repair was stronger than the Pennington repair ($p<0.05$), and both Pennington repairs were stronger than the modified Kessler repair (Fig. 2). There was no significant difference in strength between the modified Lee and locking Lee repairs.

Gap formation within the first 1 mm was similar for all repairs (Fig 3). The modified Kessler, Pennington, and modified Pennington repairs showed a significantly higher force at 1 mm gap compared to the modified Lee and locking Lee repairs ($p<0.05$). Between 1 and 2 mm gaps, the force sustained by the modified Pennington repair was significantly higher than the force needed to produce a gap with the modified Kessler, Pennington, or modified Lee repairs ($p<0.05$).

DISCUSSION

Pennington [1] described that locking loops provide better grasp of tendon fibers and prevent suture pullout. Since grasping loops do not tighten around tendon fibers it would be expected that grasping repairs would fail by suture pullout with repetitive load. In our study all modified Kessler repairs (a grasping loop technique) failed by pullout while most of modified Pennington repairs (a locking loop technique) failed by breakage. Our results suggest that given a constant number of strands, the core suture design is an important factor influencing the breaking mode. In addition, the results demonstrate that the locking loop technique provides greater tensile strength than the grasping technique, although there was no differentiation in resistance to gapping.

The lack of significant difference in gliding resistance among the similarly designed modified Kessler, Pennington, and modified Pennington repairs suggests that the locking loop configuration itself does not adversely affect tendon gliding resistance. The locking Lee repairs showed a significantly higher gliding resistance than the other repairs, but in the locking Lee technique, there are more locking stitches on the tendon surface, and it is known that the number of exposed loops affects gliding resistance.

ACKNOWLEDGEMENT
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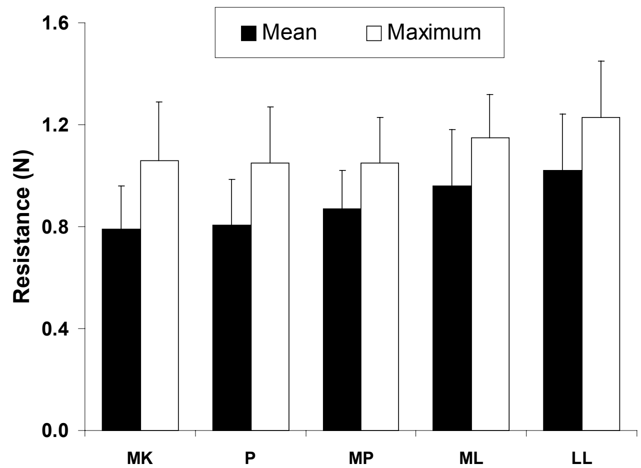

Fig 1: Mean and peak gliding resistance.

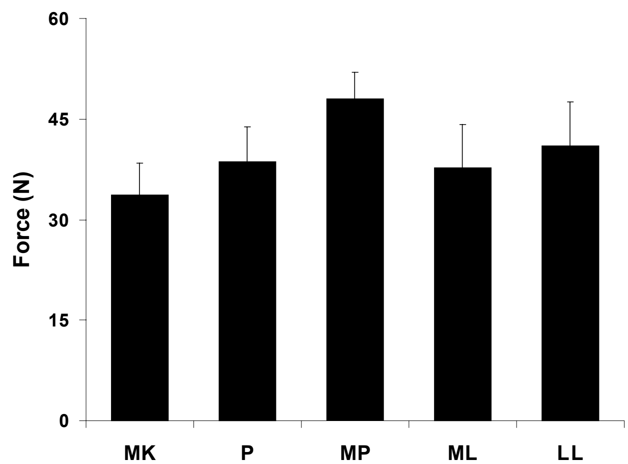

Fig 2: Maximum force.

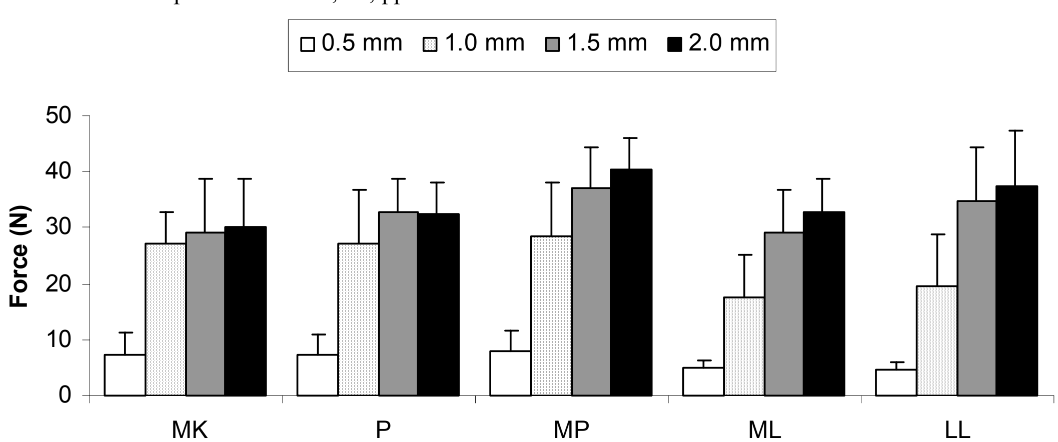

Fig 3: Force to produce gaps of 0.5, 1.0, 1.5, and 2.0 mm.