SCIENTIFIC ARTICLE

Direct Radiological Visualization of Loading on Four Flexor Tendon Repair Suture Configurations

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Purpose To study the deformation of 4 suture configurations used in flexor tendon repair using fluoroscopy.

Methods All flexor tendon repair techniques have a longitudinal component, a link component, and/or a transverse component. We had previously described 4 types of link components, namely an arc (grasping loop), a simple loop (locking loop), a complex loop, and a knot. The effect of loading on suture configurations using each of these link components was tested in flexor tendon from the first ray of porcine feet. Forty flexor tendons were divided into 4 groups of 10 each, and one-half of a tendon repair was simulated on each group using 0.5 mm stainless steel wire. The tendons were mounted on a materials testing machine, and tensile force was applied until failure. The deformation of the suture within the tendon substance was observed using an image intensifier, and the maximal load to failure was measured.

Results The loading of the suture led to unraveling of the suture in an arc, constriction and unraveling in a simple loop, and initial constriction with no further change of the construct in the complex loop with no change in the knot design. The mean pullout strength of the complex loop was statistically greater than all the other 3 designs.

Conclusions Each of the link component designs demonstrated unique deformation characteristics. The complex loop design had the strongest grasping ability.

Clinical relevance This study identified the differences in the deformation characteristics of the 4 types of link components used in flexor tendon repair. This knowledge may allow for the development of better flexor tendon repair techniques and the adoption of a more precise classification of flexor tendon repair techniques.

Key words Flexor tendon, radiological imaging, tendon repair.

Additional material is available online.

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Sebastin et al[1] identified 3 components of any tendon core suture technique, namely a longitudinal, a transverse, and a link component. The link component represents the junction between a longitudinal and a transverse component, the junction between 2 longitudinal components, or the termination of a longitudinal component. All tendon core suture techniques have longitudinal and link components and may have the transverse component. The longitudinal and transverse components are usually placed within the tendon substance, and the link component typically lies outside the tendon (Fig. 1).

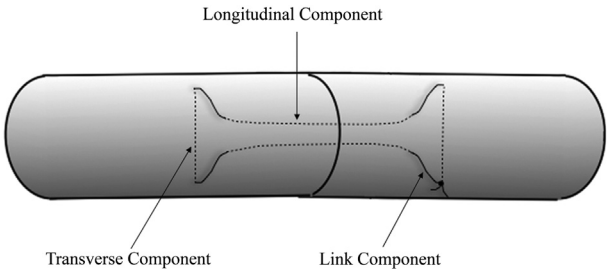

FIGURE 1: Components of a core suture technique.

Variations in the design of the suture configuration result from the orientation of the transverse component in relation to the longitudinal component and/or from differences in construction of the link component. The transverse component may be placed distal or proximal to the far end of the longitudinal component (Fig. 2A). If the transverse component is placed proximal to the far end of the longitudinal component (ie, closer to the cut end of the tendon), 2 additional variations are possible. The transverse component may be passed below or above the longitudinal component (Fig. 2B). If the transverse component is passed below the longitudinal component, it forms an arc (Fig. 3). An arc (also known as a bight in knot terminology) results when the 2 suture components forming it do not cross each other when loaded. This has also been described as a grasping loop.[2–4] An arc link component does not encircle any tendon fibrils when loaded. If the transverse component is passed above the longitudinal component (ie, between the link and the longitudinal components), it forms a loop. A loop link component results when the suture components cross each other on loading and encircle the tendon fibrils within the loop. This has been previously described as a locking loop.[5,6] A loop is simple when there is a single loop and complex when there is more than one loop (Fig. 3). A knot link component results when a loop is secured with a knot (Fig. 3).[1]

Differences in the construction of the link component (arc, simple loop, complex loop, or knot) result in a sliding or an anchored repair on each half of a divided tendon. A sliding repair allows the suture to slide within the tendon substance when tension is applied to one of the longitudinal components, whereas an anchored repair does not allow the suture to move independent of the tendon. An arc and a simple loop link component result in sliding repair, whereas a complex loop and a knot link component result in an anchored repair.[1] In practice, this means that when an arc or a simple loop is used in a multistrand repair, the repair can be tensioned after the placement of multiple arcs/simple loops,

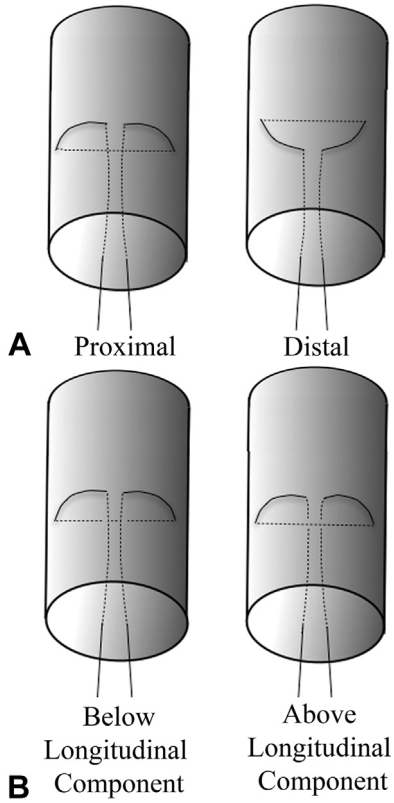

FIGURE 2: Variations in the design of suture resulting from the relative orientation of the transverse and longitudinal components. **A** Variations in the proximodistal placement of the transverse component in relation to the far end of the longitudinal component. **B** Variation in the position of the transverse component in relation to the longitudinal component.

whereas when a complex loop or a knot is used, the tension cannot be changed after the first complex loops/knots are set.

Our hypothesis was that these 4 types of link components (arc, simple loop, complex loop, and knot) would behave differently under tension. Our aim was to observe and record this behavior in real time using stainless steel sutures and fluoroscopic imaging. We also wanted to analyze the maximal load responsible for the failure of these 4 link components designs.

MATERIAL AND METHODS

The first ray flexor tendons of 40 fresh frozen porcine limbs were harvested, and they were divided into 4 groups. Each group was assigned one of the 4 link component suture designs (Fig. 3). Only half of a tendon repair was simulated, and repair was done using 30 cm of 0.5 mm stainless steel wire (Lai Xin Feng & Sons Hardware Pte Ltd, Singapore). The caliber of the suture was chosen according to pilot experiments such that failure would occur by suture pullout rather than