Cyclic Loading of Achilles Tendon Repairs Through Forces Simulating Early Functional Rehabilitation

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Introduction: The management of acute Achilles tendon ruptures remains a subject of debate. Most orthopaedic surgeons advocate operative repair followed by early functional rehabilitation in the young, active patient. However, the optimal repair construct that minimizes tendon elongation during early post-operative mobilization remains unknown. Few studies have examined the response of the repaired Achilles tendon to cyclic loading at forces representative of those placed on tendon in the initial stages of a functional rehabilitation protocol. We sought to compare two different repair techniques, the standard Krakow “locking loop” technique and the modified Krakow “gift-box” technique (in which knots are placed outside the rupture site), when cyclically loaded through forces representative of early functional rehabilitation. We hypothesized that placement of the knots away from the rupture site would result in less overall elongation of the repaired tendon.

Methods: Achilles tendon ruptures were created 4cm proximal to the calcaneal insertion in 12 matched pairs of fresh frozen human cadaver lower extremities. Repairs were performed using a Standard Krakow “locking-loop” technique and a Modified Krakow “gift-box” technique for each pair. All repairs were performed with Arthrex No.2 Fiberwire. Specimens were then subjected to a three-stage loading protocol designed to represent forces across the tendon during early range of motion, followed by early weight-bearing. Stage I involved 1000 cycles from 10N-50N, representing the force across the Achilles as the ankle is ranged from 30 degrees plantarflexion to neutral. Stage II involved 1000 cycles at 10N-100N, representing 30 degrees plantarflexion to 10 degrees dorsiflexion. Finally, stage III involved 1000 cycles at 10-190N, representing weight-bearing in a CAM boot with a one-inch heel lift. Retroreflective markers were placed along the length of the repaired tendons; displacement of these markers was tracked continuously using Qualysys/Optical motion capture (OMC) technology. A paired t-test was performed on displacement data for each loading cycle to assess for statistical significance between the two repair groups.

Results: Average elongation after Stage I loading, which simulated forces during cycling of the ankle from plantarflexion to neutral, was 4.15±2.02mm in the Standard Group versus 2.57±5.6mm in the Modified group. Following Stage II, which simulated plantarflexion to 10 degrees of dorsiflexion, the overall elongation was 12.41±3.41mm in the Standard group versus 11.1±5.35mm in Modified Group. Finally, total elongation after Stage III was 27.35±5.35mm in the Standard Group compared to 24.76±7.73mm in the Modified Group. There were no re-ruptures in either group. A paired t-test
showed no statistically significant difference in elongation between the two constructs when subjected to Stage I, II, or III loading protocols.

**Discussion:** While tendons repaired with both standard and modified Krakow techniques demonstrate minimal lengthening (2cm) when subjected to forces representative of immediate weight-bearing in 1-inch heel lift. Though the Modified repair did demonstrate a trend towards less overall elongation through all stages of loading, this data did not reach statistical significance.

**Significance:** Patients undergoing Achilles tendon repair with either Standard or modified Krakow technique can mobilize the ankle from plantar flexion to neutral without risk of rupture or excessive lengthening. Immediate weight-bearing in a 1-inch heel lift places the tendon at risk for excessive early elongation.

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