SCIENTIFIC ARTICLE

# Biomechanical Comparison of 3 Methods of Scapholunate Ligament Reconstruction

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**Purpose** To compare the biomechanical characteristics of 3 methods of scapholunate (SL) ligament reconstruction, including 1 that provides a biological central axis tether.

**Methods** Twelve fresh-frozen cadaver limbs were mounted on a jig that allowed for wrist and finger motion by tendon loading. The specimens were randomized to receive the SL axis method (SLAM) reconstruction, the Blatt capsulodesis (BC), or the modified Brunelli tenodesis (MBT). Fluoroscopic images were taken to measure the SL interval and SL angle in various positions. The specimens were evaluated in 4 states: intact, with the SL and radioscaphocapitate ligaments cut, after reconstruction, and after reconstruction followed by 100 cycles of simulated motion.

**Results** After cycling, the MBT and the SLAM reconstructions performed significantly better than the BC in recreating the intact SL interval in a clenched fist posture. The SLAM SL interval trended to be closer to the intact state than the MBT SL interval. The SLAM reconstruction also trended toward greater restoration of the native SL angle in the clenched fist posture than either the MBT or the BC.

**Conclusions** The SL ligament reconstruction that uses a 2-tailed tendon autograft placed along the axis of rotation of the SL joint and secured both at the scaphoid and the lunate minimized creep and reconstructed the critical dorsal SL ligament. The SLAM achieved improved the SL interval and SL angle correction compared with conventional techniques of SL ligament reconstruction.

**Clinical relevance** The SLAM method may be a useful alternative for SL ligament reconstruction. 

**Key words** Carpal, instability, ligament, scapholunate, wrist.

SCAPHOLUNATE (SL) INTEROSSEOUS ligament (SLIL) deficiency remains an unsolved problem in hand surgery. The natural history of SLIL ruptures is likely progression to carpal instability with a predictable pattern of degenerative osteoarthrosis known as SL advanced collapse.[1] Scapholunate ligament injuries are the most common intercarpal ligament injury and range in severity from dynamic to static reducible, static irreducible, and arthrotic.[2] Surgical treatment strives to restore the carpal alignment and kinematics, with the ultimate goals of pain relief and avoidance of degenerative osteoarthritis. Surgical options include soft tissue and bony procedures with SLIL repair for acute injuries[3–5] and reconstruction or salvage procedures for chronic injuries.

Current soft tissue reconstruction procedures do not reliably restore normal carpal alignment and kinematics,[6–9] and limited arthrodeses may alter carpal kinematics in the long term.[9,10] No procedure to date reliably fulfills the goals of an SL reconstruction. Loss of the SLIL results in proximal pole scaphoid

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subluxation dorsally with flexion of the scaphoid around the radioscaphocapitate ligament (RSCL) and pronation along the curve of the capitate. Over time, the RSCL, dorsal intercarpal ligament, and other supporting ligaments stretch in response to the new forces. Eventually, the ligamentous and bony changes preclude a closed or even an open reduction, and irreducible SL subluxations are generally not suitable for soft tissue reconstructions.

The best candidates for soft tissue reconstructions are patients with subacute or early chronic SLIL disruptions, ideally where secondary restraints have not been terminally compromised. The Brunelli tenodesis and its modifications attempt to correct the flexion posture and the dissociation of the scaphoid by suspending the scaphoid along a tendon graft connecting the volar trapezium to the dorsal lunate. The tendon graft lies approximately in line with the normal long axis of the scaphoid. As with all tendon-to-ligament reconstructions, early creep and delayed elongation can be expected proportional to the length of the tendon graft between fixation points.

Capsulodeses focus only on preventing scaphoid flexion by tethering its distal pole to either the triquetrum or the distal radius. An additional procedure may be required to address scaphoid pronation, lunate dorsal angulation, and SL diastasis.

The purpose of this study was to compare mechanically an SL reconstruction using tendon autograft against 2 other common methods of reconstruction, the Blatt capsulodesis (BC) and modified Brunelli tenodesis (MBT), in a cadaveric model.

## MATERIALS AND METHODS

Twelve cadaveric upper extremities without evidence of injury were harvested just distal to the elbow. The average age of the cadavers was 75 years. There were 7 male and 5 female specimens. All specimens were prepared in the same manner before randomization. Half of the flexor carpi radialis tendon was transected proximally and split longitudinally, thus allowing one half of the tendon to provide tension with its normal insertion and the other half to be used later for the MBT. The tendons of the forearm were tagged with number 2 FiberWire sutures (Arthrex, Inc, Naples, FL) using an interlocking grasping suture technique. All 8 finger flexors were sutured side to side to function as 1 unit. The forearm was then mounted vertically on a custom jig with a 5-mm longitudinal pin. Metal S-shaped hooks were connected to the suture and prepared to suspend weights to simulate different wrist positions. The degree of motion achieved varied slightly between specimens, depending on the bony architecture and soft tissues.

A clenched fist was simulated with 20-lb (89.2-N) weights applied to the flexor digitorum superficialis and profundus tendons with the wrist positioned in 20° extension, confirmed by a handheld goniometer with 1° incremental markings.

A miniature C-arm and the specimen were positioned to obtain posteroanterior (PA) images of the wrist, as previously described.[11] Radiographic images were obtained after loading the appropriate tendons as described above with the intact wrist in neutral; toward the end ranges of motion for flexion, extension, ulnar deviation, and radial deviation; and in the clenched fist position. The clenched fist view was taken in 20° pronation.[14] This condition was referred to as intact. The jig was rotated 90° to obtain lateral radiographs of the wrist under the same loading conditions.

We then created SL ligament instability through a dorsal capsulotomy. The SLIL was transected using a scalpel followed by division of the volar RSCL to create SL dissociation. After sectioning both ligaments, the SL complex was grossly unstable. The specimens then underwent radiographic imaging in both the PA and lateral radiographic views in all wrist positions using the same loading conditions.

The specimens were then randomly selected using a sealed envelope to undergo 1 of 3 SLIL reconstructions: BC, MBT, and the SL axis method (SLAM). The MBT and BC were performed as described in the literature.[12,13] The SLAM procedure is described subsequently.

Radiographic analysis was repeated under the same conditions as in the intact and cut specimens after reconstruction, and again after manual cycling to the extent of the soft tissue constraints between flexion and extension for 100 cycles at approximately 1 cycle/s. We chose 100 cycles to allow creep of the soft tissues.[11] Cycling was not intended to mimic an anticipated clinical postoperative plan, because in the clinical scenario we would immobilize the wrist for a minimum of 6 weeks to allow for bone to tendon healing.

After we completed testing all 12 specimens, we measured the images for the SL interval with commercially available digital calipers (Model 01407A; Neiko Tools USA, Zhangjiagang, China; accuracy of 0.01 mm) and the SL angle with a goniometer (1° incremental markings). The SL interval was measured on PA radiographs as the distance between the midpoint of the scaphoid and the lunate parallel to the Gilula lines.[14] An oblong metal