Radial Head Replacement for Longitudinal Radioulnar Dissociation Injuries of the Forearm after Ligament Reconstructions with Patellar Tendon and the Herbert Sling Capsulorraphy

[1]Jones, C M; [1]Smark, C; [2]Dy, C; [3]Milne, E; [3]Kaimrajh, D; [1,3]Latta, L; [4]Ouellette, E A
[1]University of Miami, Miami, FL, [2]Hospital for Special Surgery, New York, NY
[3]Max Biedermann Inst., Miami Beach, FL, [4]Miami Intl Hand Surg. Services, N Miami Beach, FL

INTRODUCTION:

Longitudinal Radioulnar Dissociation (LRUD) injuries occur when a compressive load to the wrist results in a triad of injuries: distal radial ulnar joint (DRUJ) disruption, interosseous ligament complex (ILC) tear, and radial head fracture. The forearm is rendered unstable causing progressive proximal migration of the radius with resultant decreased motion, weakness, and chronic pain. Radial head replacement is warranted if it is not repairable. Replacement alone has been shown to be effective at restoring almost 80% of forearm stiffness[1]. However, it may only function as a temporary splint since increased load transmission to the radiocapitellar joint due to an incompetent ILC may cause premature wear. This may eventually necessitate radial head removal. Ligament reconstructions of the ILC or DRUJ in addition to radial head replacement might restore more normal forearm kinematics and decrease radiocapitellar joint force transmission, thereby increasing the longevity of the radial head implant. The goal of this study is to show the effect of the addition of a metallic radial head replacement to the stability and stiffness of the Herbert sling capsulorraphy and bone-patella tendon-bone onlay graft.

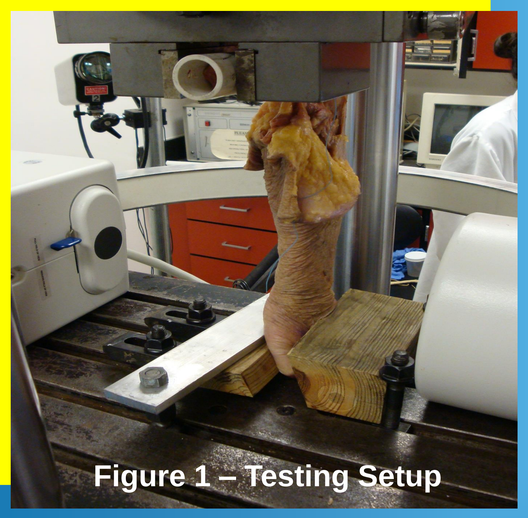
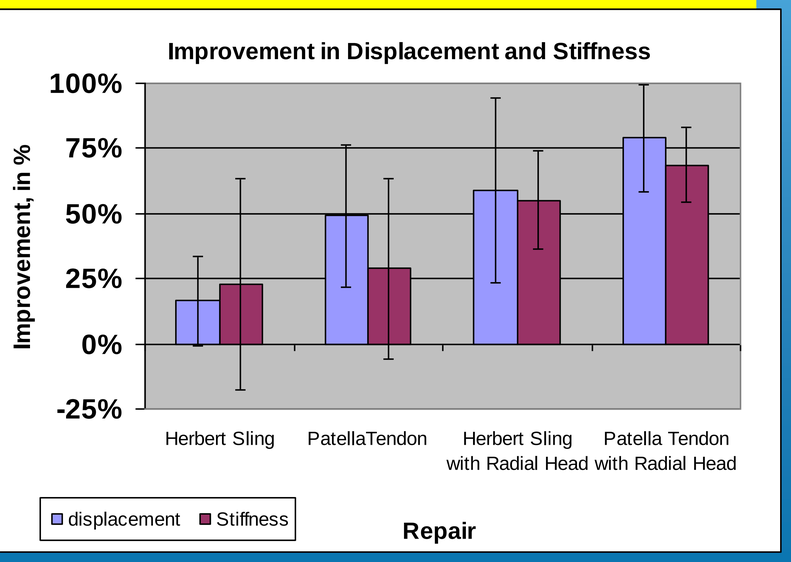


Figure 1 – Testing Setup



METHODS:

Eight pairs of fresh frozen cadaver arms were sectioned at mid-humerus and through the metacarpals for mounting on an MTS machine. Stainless steel beads (1.6 mm diameter) were percutaneously inserted into the distal radius and ulna using a bone biopsy needle. The arms were mounted vertically downward with the elbow at 90^{O}, forearm neutral, and wrist in 20^{O} dorsiflexion, Fig. 1. The arms were loaded cyclically from 13 to 130 N for 10 cycles. Bead motion was recorded fluoroscopically and analysis was performed using Image Pro Express software. Resolution of the fluoroscopic images was 0.26 mm, the measured pixel size. The forearms were first tested in their intact state and then after radial head excision. Next, the ILC was torn using a minimally invasive technique and the TFCC disrupted by a percutaneous incision at the base of the ulnar styloid. The Herbert sling and patellar tendon ILC reconstruction were performed on matched forearm pairs according to previously described techniques[2,3]. Lastly, an appropriate-sized cobalt chromium radial head replacement (Stryker Corp, Mahwah, NJ) was inserted and the arms were re-tested. Radioulnar longitudinal translations at the DRUJ and forearm stiffness were calculated for each testing scenario.

RESULTS:

The average change in ulnar variance at the DRUJ after radial head excision and sectioning of the ILC and TFCC was 4.60 mm when loaded to 130 N. Reconstruction with the Herbert sling reduced this displacement by 16% to 3.86 mm compared to 48% to 2.39 mm for the patellar tendon reconstruction. The addition of a metallic radial head replacement reduced the ulnar variance by 59% to 1.89 mm ($p=0.03$) for the Herbert sling compared to 79% to 0.97 mm ($p=0.05$) for the patellar tendon reconstruction. Under a 13 N pre-load prior to testing, radial head insertion reduced ulnar variance to 1.56 mm and 0.7 mm, respectively. The intact forearms had an average stiffness of 638 N/mm. Reconstruction with the Herbert sling restored 23% of the native stiffness compared to 29% for the patellar tendon reconstruction. Adding a metallic radial head restored 55% ($p=0.60$) and 69% ($p=1.000$) of the native stiffness, respectively. The differences between Herbert sling and patella tendon reconstructions with a radial head were significant for the decrease in ulnar variance ($p=0.05$) but not for stiffness ($p=0.44$).

DISCUSSION:

By measuring relative radioulnar displacement at the DRUJ (ulnar variance), we were able to quantify the ability of two different ligament reconstructions to maintain radial length after a LRUD injury. Neither reconstruction alone or in combination with a radial head replacement was able to restore the forearms to their original stiffness and radial length when loaded to 130N. The ligament reconstructions alone proved to reduce the ulnar variance by only 16% and 48%, with the patellar tendon reconstruction performing better, likely since it is a more robust construct, permitting a greater degree of radioulnar tensioning. However, by adding a radial head replacement, ulnar variance was reduced more to 59% and 79% of the uninjured forearm. Replacing the radial head in an acute LRUD injury, such as our model, should ideally restore full radial length, but we did not measure this at zero load. With the insertion of a radial head, the Herbert sling construct stiffness increased from 23% to 55% of the native stiffness. The patellar tendon construct stiffness increased from 29% to 69%. Although adding a radial head more than doubled the construct stiffness, it did not fully restore the native stiffness. Stiffnesses after radial head insertion likely would have been higher if the radial head were inserted prior to performing the ligament repair. This would have permitted proper radioulnar tensioning after the radius had been brought out to length. In summary, we found that the ligament reconstructions alone were not able to fully restore radial length or native stiffness. However, by adding a radial head replacement, both constructs returned closer to the condition of the uninjured state, with the patellar tendon reconstruction performing better.

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