SCIENTIFIC ARTICLE

The Effect of Capitate Position on Coronal Plane Wrist Motion After Simulated 4-Corner Arthrodesis

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Purpose The objective of this study was to examine the effect of altering the capitolunate relationship on coronal-plane wrist motion after scaphoidectomy and simulated 4-corner arthrodesis. Two positions of different capitolunate alignments were compared: "anatomic" (unchanged from pre-fusion) and "lunate-covered" (capitate translated to cover the lunate). We hypothesized that wrist resting posture would be altered and radial-ulnar motion would diminish after 4-corner arthrodesis in the lunate-covered position when compared with normal wrists.

Methods Six human cadaveric limbs were disarticulated at the elbow and mounted on a custom jig. The resting position of the wrist was recorded with no load applied, followed by a load of 44 N applied to the flexor carpi radialis, extensor carpi radialis longus, and extensor carpi radialis brevis tendons to simulate radial deviation and to the flexor carpi ulnaris and extensor carpi ulnaris tendons to simulate ulnar deviation. Scaphoidectomy was performed and 2 methods of 4-corner arthrodesis with different capitolunate coronal alignments were studied in random order. Range of motion was compared using one-way analysis of variance and Bonferroni correction.

Results The "lunate covered" wrist demonstrated significantly greater radial resting posture than that of the preoperative wrist. Under a 44 N load, the lunate-covered position had significantly greater radial motion than the preoperative radial motion. Wrists fused in the "anatomic" position did not differ significantly from the preoperative wrists in posture or range of motion.

Conclusions In this cadaveric model, complete covering of the capitate head by the lunate placed the wrist in increased radial deviation compared with the anatomic posture. Changes induced in the resting tension of the extrinsic wrist ligaments serve as a reasonable explanation for the increased radial posture and motion. In a clinical setting, these changes may affect postoperative wrist posture and function.

Clinical relevance Maintaining anatomic lunate position leads to preservation of greater wrist motion and anatomic alignment in a patient undergoing 4-corner arthrodesis. *(J Hand Surg Am. 2016;■(■):■−■. Copyright © 2016 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Capitate position, 4-corner arthrodesis, wrist range of motion, scaphoidectomy.

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Scaphoid excision and 4-corner arthrodesis (capitate-hamate-lunate-triquetrum) is a motion-sparing alternative to total wrist arthrodesis, wrist arthroplasty, or proximal row carpectomy in the treatment of advanced stage scaphoid lunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC) arthritis.[1,2] The goals of scaphoid excision and 4-corner arthrodesis are to reduce arthritic pain, provide a stable and functional wrist, and maintain radiocarpal motion. The best technique to maintain motion has been the subject of many studies.[3–7] In particular, the posture of the fused lunate in the sagittal plane has been found to be a determining factor of wrist flexion and extension and is considered by some to be the most important step of the procedure.[3,8,9] Dvinskikh et al[7] performed a biomechanical analysis and suggested that the lunate position in the sagittal plane can affect not only flexion and extension but also radial and ulnar deviation.[7]

Some authors have recommended that the capitate be translated ulnarly to completely cover the distal lunate so as to maximize the surface area of contact between the 2 bones, considering this a "critical step".[2] The theory is that the capitate has migrated proximally in the SLAC/SNAC progression, and thus the reduction of the distal row on top of the proximal row is required to restore alignment.[8] Ferreres et al[10] hypothesized that overreduction of the capitate in longstanding cases might result in a permanent radial deviation posture. We concur with Ferreres et al, after several patients complained about an excessive radial deviation "deformity" and loss of ulnar deviation after 4-corner arthrodesis procedures with complete capitate coverage of the lunate. The objective of this study was to examine the effect of altering the capitolunate relationship on coronal-plane wrist motion and wrist posture after scaphoidectomy and 4-corner arthrodesis. We hypothesized that wrist resting posture would be altered and radial-ulnar motion would diminish after arthrodesis in the "lunate covered" position when compared with those fused in the "anatomic" position of partial lunate coverage.

MATERIALS AND METHODS

Cadaveric dissection and jig setup

Six human cadaver limbs (5 male, 1 female, age 64 ± 12), with no evidence of prior wrist injury or surgery, were disarticulated at the elbow, prepared and positioned as described by Pollock et al.[11] The olecranon was removed using an oscillating saw, ensuring that the proximal radioulnar joint was left intact. Midline volar and dorsal incisions were made in the proximal forearm, and full-thickness skin flaps were elevated. Tendons of the flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris were identified in the proximal forearm, just distal to their musculotendinous junctions. A 2-cm portion of each tendon was freed from the surrounding sheath and a locking suture was placed using #5 Ethibond (Ethicon, Somerville, NJ). The extensor carpi radialis longus and extensor carpi radialis brevis tendons were secured as a single unit. There was no further dissection of the tendons from their fascial attachments, so as to preserve normal anatomic relationships and reproduce physiologic tendon gliding. A nonabsorbable running suture was used to close the skin incisions.

An intramedullary drill hole was made in the proximal radius and ulna, and a longitudinal 4-mm Steinman pin was inserted into each bone. A transversely directed 2-mm Steinman pin was inserted through the radius, approximately 4 cm proximal to the radiocarpal joint, avoiding impingement on the ulna. The forearm was positioned upright on a preassembled jig via the 2 longitudinal and single transverse Steinman pins with the wrist in resting position in both the sagittal and coronal planes (Fig. 1). A second 2-mm Steinman pin was inserted into the carpus via the index-middle intermetacarpal space and supported against a horizontal crossbar to prevent the wrist from falling into flexion. This also ensured that pure coronal motion was measured with application of loads to the radial and ulnar wrist tendons. The suture ends securing the tendons were passed through holes in the base of the jig platform and each secured to a 1 lb base plate. To simulate radial deviation, a 22 N (5 lb) load was applied to the base plates of the flexor carpi radialis tendon and to the extensor carpi radialis longus/extensor carpi radialis brevis tendon complex. The weights used were based on the study of Pollock et al.[11] For ulnar deviation, the same loads were applied to the each of the base plates of the flexor carpi ulnaris and extensor carpi ulnaris tendons. The loads were applied using 5 and 1 lb circular weights, which stacked on the base plates. Fluoroscopic posteroanterior images of the wrist in resting posture (no additional load applied to the base plate), radial deviation (total 44 N load applied), and ulnar deviation (total 44 N load applied) were obtained. Resting posture, radial deviation, and ulnar deviation were measured using the intramedullary axis of the distal radius and third metacarpal. Perfect alignment of the radius and third metacarpal intramedullary axes was considered "neutral." All measurements were made with respect to the neutral position.