

Comparison of the Clinical and Functional Outcomes Following 3- and 4-Corner Fusions

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Purpose To explore the clinical and functional outcomes of 3-corner fusion (3CF) for stage 2 and 3 scapholunate advanced collapse and scaphoid nonunion advanced collapse. We compared the results with 4-corner fusion (4CF) using a recent published report.

Methods Twelve patients (8 men and 4 women) who had a 3CF, mean age 60 years (range, 34–75 y) were reviewed in clinic more than 1 year after surgery. Subjective outcome measures included the Michigan Hand Questionnaire and Patient Evaluation Measure. Objective outcome measures included range of motion with a flexible electrogoniometer and grip strength measured with a digital dynamometer. The results were compared using a recent report of 24 patients (17 men and 7 women) with a 4CF, mean age 55 years (range, 34–68 y) assessed with similar techniques.

Results The patients receiving 3CF had better subjective scores with the Michigan Hand Questionnaire, including the sub-scores for activities of daily living and satisfaction. The radioulnar arc was greater after the 3CF than after the 4CF. Circumduction of the 3CF was more like a normal wrist than the 4CF. This included having faster and smoother motion, with an axis of circumduction closer to the normal wrist. Peak grip strength was similar after either a 3CF or 4CF but grip strength in the 3CF was 82% of the contralateral wrist compared with 59% for the 4CF.

Conclusions The 3CF provided better patient-rated scores and the arc of wrist motion was more extended, with greater ulnar deviation. Motion was smoother and more closely replicated the normal axis and functional motion of the wrist. (*J Hand Surg Am.* 2015;40(6):1117–1123. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic III.

Key words Three-corner fusion, 4-corner fusion, arthrodesis, range of motion, function.

FOUR-CORNER FUSION (4CF) FOR scapholunate advanced collapse (SLAC) or scaphoid nonunion advanced collapse (SNAC) consistently leads to good function with satisfactory grip strength and

pain relief.¹ Despite this, range of motion is markedly reduced compared with other procedures such as proximal row carpectomy.² Recently lunocapitate fusions³ and 3-corner fusion (3CF)⁴ have been advocated to provide improved range of motion, although there are concerns regarding alteration of carpal kinematics and loading.⁵

A 3CF differs from a 4CF by excision of both the scaphoid and the triquetrum and with arthrodesis of lunate, capitate, and hamate. This may allow greater ulnar deviation by reducing impingement between the triquetrum and ulna.⁴ A study⁶ on cadavers reported that the additional excision of the triquetrum (3CF) improved the range of radioulnar deviation by an additional 6°; however, another study reported that excision of the triquetrum increased radiolunate contact pressure.⁷

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Any advantage seen in a cadaveric model may not necessarily be replicated in clinical practice, as a consequence of postoperative edema and contracture. The advantages seen in range of motion may not lead to an increase in patient satisfaction or function of the wrist.

The aims of this study were to present the clinical outcomes of 3CF in patients with stage 2/3 SLAC/SNAC wrists using subjective, objective, and dynamic motion assessment parameters and to compare the results with 4CF from a recent report.⁸ The comparison was between 2 different cohorts from 2 separate institutions performing either 3CF or 4CF for stage 2/3 SLAC and SNAC.

PATIENTS AND METHODS

A cross-sectional clinical outcomes study was performed assessing patients with 3CF performed for stage 2/3 SLAC and SNAC wrists. All 3CFs were performed at a single center. Results were compared with a group with 4CF that was reported previously.⁸ All 4CFs were performed at another single center. Only patients who underwent partial wrist arthrodesis for primary stage 2/3 SNAC or SLAC wrists were included. Patients who had undergone previous partial arthrodesis or had systemic arthritis were excluded. Minimum follow-up was 12 months.

Twelve patients who underwent 3CF (mean follow-up, 6 y) were compared with 24 patients with a 4CF (mean follow-up, 5 y). Two in the 4CF group appeared to have delayed or partial union on initial radiographs; however, they remained clinically asymptomatic and subsequently demonstrated fusion on radiographs at 6 months. All patients in the 3CF group had radiographic evidence of fusion at the time of assessment. The same researcher (H.P.S.) assessed all patients from both groups with their consent and using the same methodology and equipment. We obtained ethical committee approval and patients' consent before inclusion in this study.

The 3CF was consistently performed as per the technique described by van Riet and Bain.⁴ The extensor retinaculum overlying the third compartment is incised, the extensor pollicis longus tendon is retracted, and a longitudinal arthrotomy is performed. The scaphoid and triquetrum are resected using a rongeur and the articular surfaces of the midcarpal joint are removed with a rongeur. Morselized cancellous bone graft from the resected triquetrum is placed between the lunate, capitate, and hamate.

The midcarpal joint is stabilized with 2 memory staples (Depuy, Warsaw, IN). The dorsal intercalated

segment instability deformity was corrected and maintained temporarily with K-wires when a bed was created for the staples. Care is also taken to ensure that the staples do not impinge on the dorsal rim of the distal radius. The fixation and fusion mass are assessed with dynamic fluoroscopy; if satisfactory, the capsule is closed in layers. The patient is placed in a plaster cast for 1 week and then a removable orthosis for 6 weeks. Forceful gripping was permitted at 3 months, at which time a return to all activities was allowed.

The Michigan Hand Questionnaire (MHQ) was used to subjectively evaluate outcome in 6 domains measuring overall hand function, activities of daily living, pain, work performance, aesthetics, and patient satisfaction with hand function. The MHQ consists of 57 question items and the pain domain consists of 5 questions. We also used the Patient Evaluation Measure (PEM) to assess the current state of the hand as reported by the patient, and the overall assessment of the hand and wrist. Both questionnaires are valid and reliable for hand and wrist disorders.^{9,10} A higher PEM score indicates greater disability.

We measured objective outcomes by assessing range of motion and grip strength. Range of motion was measured using an electrogoniometer (Biometrics, XM-65; Biometrics Ltd, Gwent, UK). A standardized validated format was used.¹¹ The goniometer's twin axis sensor and 2 end blocks were applied over the wrist as per the manufacturer's specifications. All measurements were performed with the patient seated and the wrist pronated with the elbow flexed to 90° and the forearm resting on the armrest of the chair. The subject was asked to maintain the pronated position of the wrist and to form a light fist during measurement. Then the patient was asked to perform maximum flexion-extension, radioulnar deviation, and circumduction of the wrist at a comfortable speed. The direction of circumduction was clockwise for the right hand and counterclockwise for the left. We used MATLAB software (version 7.8, The MathWorks Inc., Natick, MA, 2009) to process the electrogoniometer recording and further processed it into summary measures. This software allowed extraction of the flexion-extension arc, radioulnar deviation arc, area, circumference, and velocity of circumduction. Further division of the circumduction curves into 4 quadrants allowed assessment of velocity and smoothness of movement in each quadrant.¹² The center and axis of motion were calculated from the circumduction curve. The obliquity was clockwise or counterclockwise from the vertical flexion and extension plane, depending on whether the left or right hand was assessed.

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