

# Reliability of the 8 Week Time Point for Single Assessment of Midcarpal Fusion by CT Scan

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**Abstract** High rates of nonunion have recently been reported for midcarpal fusions. Due to curvature and overlap of carpal interfaces, two dimensional films are not reliable in determining union of a midcarpal fusion. Computed tomography is the most reliable radiographic method of evaluating osseous union. Initiating motion as soon as fusion has occurred is a priority with the goal of maximizing final range. Cost control in healthcare makes obtaining serial scans unreasonable. The single optimal time point for a computed tomography scan to determine union of a midcarpal fusion remains to be determined. A prospective protocol selected 8 weeks post operative as the point in time to obtain the single determining scan. Forty-six consecutive midcarpal fusions with scaphoidectomy were retrospectively analyzed for the reliability of this time point. All fusions had achieved union by 8 weeks and only this one scan was clinically necessary to advance the patients on to full range of motion without a splint at that time.

**Keywords** Midcarpal · Fusion · Computed · Tomography · Scan · Nonunion

## Introduction

Four-corner fusion with excision of the scaphoid is a standard treatment for scapholunate advanced collapse and scaphoid nonunion advanced collapse patterns of wrist

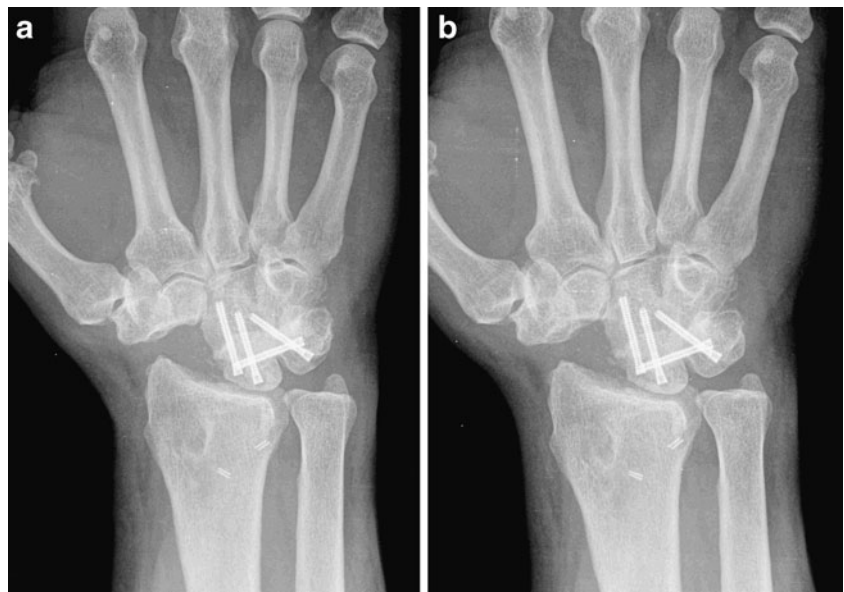
arthritis [1–4]. Much attention has recently been given to the occurrence of nonunion when attempting these ulnar midcarpal fusions [5–7]. Patients may be reticent to sacrifice motion when selecting fusion as a treatment option [8–10]. This places strong emphasis on the need to preserve as much motion as possible. In general, it is expected that a patient will achieve better final range of motion with a shorter period of immobilization following surgery. Thus, the goal in a midcarpal fusion is to first achieve a solid fusion, and then mobilize the wrist in therapy as soon as possible. The dilemma comes in knowing when the fusion has actually achieved union and it is safe to begin full force rehabilitation. It has been accepted that plain films are unreliable in making a definitive assessment of union and that a computed tomography (CT) scan is more reliable [11]. The literature does not contain an agreed upon set of criteria for determining union of a midcarpal fusion either by CT scan or by plain film. This problem is demonstrated by recent work focusing on union rates but lacking sufficient imaging of the fusion site to make a reliable determination [12]. Those authors only placed bone graft in the region behind the titanium dorsal circular plate, an area which is completely obscured by the metal of the plate on a posteroanterior view. Particularly at the capitulate interface, the curved bone surfaces overlap enough on x-ray (including oblique and lateral views) to give the impression of a continuous fusion mass even when fusion has not yet occurred (Fig. 1). If the fusion interface has been packed densely with cancellous bone graft, the erroneous impression of a complete fusion is made even more easily.

Cost constraints in healthcare as well as radiation dosing make it unreasonable to obtain serial CT scans as one approaches the expected time frame for healing of a midcarpal fusion, which has been reported to be anywhere

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**Fig. 1** The immediate postoperative radiograph (a) does not differ substantially in appearance of fusion from the 8 week postoperative radiograph (b)



from 6 to 16 weeks [13–15]. The practical solution is to identify the correct time point for obtaining a single CT scan in the course of treatment to prove that the fusion has united and the patient can be safely mobilized in therapy. That time point should come as soon as possible to optimize motion, but have allowed enough time for a properly performed fusion to have realistically achieved union.

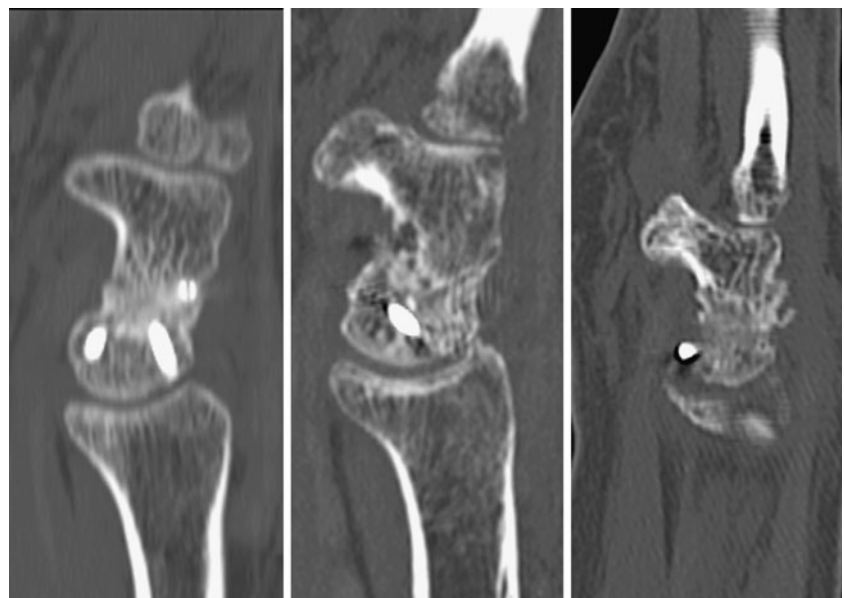
## Methods

A prospective protocol selected 8 weeks as the single time point for obtaining the one CT scan to determine union following midcarpal fusion. This time point was selected

primarily based on clinical experience managing carpal osteosynthesis. Forty-six consecutive midcarpal fusions with scaphoidectomy were then retrospectively analyzed for the reliability of having followed this protocol to demonstrate union and permit mobilization of the wrist. The research protocol was reviewed and approved by the local ethical committee. Criteria for union were the appearance of bridging trabeculae across the midcarpal joint on three sequential cuts at least 3 mm apart and the absence of hardware loosening (Fig. 2). The scans were read by both the community radiologist and the managing surgeon.

There were 40 males and 6 females with a mean age of 49 years (range 30–68). Eighteen patients (39%) were

**Fig. 2** The appearance of midcarpal fusion on CT scan with bridging across the four corner interface is best evaluated in the sagittal plane



smokers. Indications for surgery included 20 SLAC III, 19 SNAC III, five revisions of prior failed fusions, one chronic dislocation, and one Preiser's. Fixation techniques included 11 capitulate fusions with compression screws, 16 four corner fusions with memory staples and K-wires, and 19 four corner fusions with compression screws (Figs. 3 and 4). Bone graft placed between the prepared surfaces to be fused was obtained from the iliac crest in ten cases and the distal radius in 36 cases.

Follow-up examinations were performed in the operating surgeon's clinic at 2,4,8,12, and 16 weeks. Measurements of physical performance were made at the time of discharge from formal therapy by the occupational therapist who had worked with the patient during rehabilitation to improve motion and strength. Long-term follow-up was obtained by contacting the patients at the time of retrospective review, and patients were brought back to the clinic for examination by the surgeon, therapist, and research medical assistant.

## Results

Plain films did not appear different at 8 weeks when compared to the immediate post-operative x-rays where bone graft completely filled the fusion interface (Fig. 1). Thus, plain films were judged to be unreliable in the assessment of definitive union. All 46 cases met the criteria for union by CT scan at 8 weeks post-operatively and were successfully entered into therapy at that time (Fig. 2). Splinting was discontinued and patients initiated full range of motion exercises for the wrist.



**Fig. 3** Four-corner fusion with memory staple; supplementary Kirschner wires are only temporary



**Fig. 4** Capitulate fusion with headless compression screws, triquetrum preserved

There were two complications. One obese smoker developed an iliac crest donor site osteomyelitis. One patient developed a pin tract infection leading to soft tissue infection but not osteomyelitis. Both patients returned to the operating room for wound debridements.

Post-operative measurements included a mean wrist flexion of 34° (57% of contralateral), wrist extension of 37° (62% of contralateral), and grip strength of 32 kg (75% of contralateral).

Specific questions sought by long term follow-up were with regard to possible deterioration of results over time, evidence that the apparent fusion at 8 weeks was incorrect (demonstration of pseudarthrosis upon late follow-up), and additional late complications. We then administered the Disabilities of the Arm, Shoulder and Hand patient outcomes instrument. Plain x-rays were used for long term radiographic assessment; new CT scans were not obtained. The mean long term follow-up was 43 months (range 8–80 months). The mean DASH score was 12.1 (range 0 to 27.5). There was no evidence of progressive deterioration of results over time; to the contrary most patients reported functioning better and with less pain as the years had passed. Long term follow-up did not demonstrate any cases of pseudarthrosis or nonunion that had been erroneously rated as united by the original CT scan performed at 8 weeks post-operatively. One 260 lb patient suffered a new traumatic injury at 3 years post-operative to his prior capitulate fusion in a fall down the stairs and sustained a coronal plane fracture through the lunate such that the fracture plane connected the two entry points of the headless compression screws that had been inserted proximal to distal.

## Discussion

Various techniques have been used to stabilize a four-corner fusion following scaphoidectomy [5, 15–19]. The prime focus of the recent hand surgical literature on this topic has been nonunion, with rates reported between 25% and 33% [6, 7, 10, 14]. When complications do not occur, four-corner fusion appears to produce a relatively consistent result. Total arc of motion reports range from 53° to 95°, and reported grip strength ranges from 65% of contralateral to 79% of contralateral in long term follow-up studies consisting of between 10 and 19 patients [1, 2, 4, 8, 9]. Our physical performance results (71° arc of motion and 75% of contralateral grip strength) are comparable with these other studies. One of the most recent published studies examined the clinical outcomes of a traditional four-corner fusion compared to just a capitulate fusion with excision of the triquetrum [20]. Five of the 16 patients in the capitulate fusion group required repeat surgery for removal of protruding screws due to collapse of the arthrodesis site during the fusion process. In our study, we did not see this complication in any of the ten patients who had capitulate fusion with headless compression screws, but our technique differed in that the triquetrum was not removed (Fig. 4).

However, the current study was not designed to compare clinical outcome results between the various surgical techniques that were employed. The sole question being investigated was the feasibility of selecting a single time point to obtain a CT scan when following the healing of a four-corner fusion. The purpose of doing so is to meet both the goal of entering the patient into rehabilitation as early as possible as well as ensuring that the fusion mass is not mobilized or stressed too early, which could lead to a nonunion. In a study of 18 midcarpal fusions, the six that went on to nonunion had been mobilized on average by 6 weeks, whereas those that united had been immobilized longer [14]. Eight weeks was selected as the time point to obtain the CT scan in this study, and all 46 patients met the criteria for union by that time point. They were then all mobilized fully in rehabilitation with no external protection. The assessment by CT scan proved reliable in that, subsequent to returning to full usage of the wrist, no patient developed symptoms or radiographic findings to contradict the original CT scan determination of union. Likewise, long term follow-up demonstrated no cases of eventual nonunion that might have been misinterpreted in earlier evaluations. It has been suggested that these results may not apply to fusions performed by K-wires alone or circular plates. However, any hardware should be able to achieve the 100% union rate seen in this study as long as the fundamental principles of basic fusion technique are fulfilled: 1) fully prepare each fused surface all the way to

core cancellous bone with no subchondral bone remaining, 2) densely pack the interval with good quality bone graft (not scaphoid), 3) provide motion resistant stable fixation and, if possible, compression while correcting intercalated collapse deformity of the midcarpal joint [5, 16].

Surgeons will often immobilize a midcarpal fusion for as long as 16 weeks post-operatively [13]. The study of Kirschenbaum et al. indicates that 6 weeks is too short a time to begin mobilization and identified nonunions [14]. This study establishes, through long-term follow-up and the definitive imaging of a timed CT scan on each patient, that 8 weeks is a reliable time point to expect union of a midcarpal fusion including a variety of fixation methods.

**Declaration of no conflicting interests** All named authors hereby declare that they have no conflicts of interest to disclose.

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