Radioscapholunate Fusions

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J Wrist Surg 2012;1:135–140.

Abstract

Radiocarpal fusions are performed for a variety of indications, most commonly for debilitating painful arthritis. The goal of a wrist fusion is to fuse the painful, diseased joints and to preserve motion through the healthy joints. Depending on the extent of the disease process, radiocarpal fusions may take the form of radiolunate, radioscapholunate, or total wrist fusions. Surgical techniques and instrumentation have advanced over the last few decades, and consequently the functional outcomes have improved and complications decreased. Techniques for partial carpal fusions have improved and now include distal scaphoid and triquetrum excision, which improves range of motion and fusion rates. In this article we discuss the various surgical techniques and fixation methods available and review the corresponding evidence in the literature. The authors' preferred surgical technique of radioscapholunate fusion with distal scaphoid and triquetrum excision is outlined. New implants and new concepts are also discussed.

Keywords

- ▶ radiocarpal fusion
- ▶ radiolunate fusion
- ▶ radioscapholunate fusion
- ▶ wrist fusion
- ▶ wrist arthrodesis

Radiocarpal arthrodesis is a well-established procedure performed to achieve pain relief and deformity correction in the wrist. This may be performed as a total wrist fusion (TWF) extending from the radius across the carpus and carpometacarpal (CMC) joints; or may be performed as a more limited procedure to maintain range of motion (ROM).

Where the disease process for which the surgery is to be performed is limited to only certain areas of the carpus, it may be more desirable to perform a limited radiocarpal fusion to preserve ROM and improve the functional outcome. Partial carpal fusions have been shown to be effective methods of treating specific carpal disorders.^{1,2} The goal of these reconstructive procedures is to optimize postoperative wrist motion, strength, and stability while reducing pain.

Some readily recognized fusions also occur as a congenital carpal coalition, and certain acquired partial carpal fusions occur as a consequence of disease. For example, in rheumatoid arthritis, spontaneous fusion of the radiolunate joint may

occur, which prevents subluxation of the carpus.^{3,4} These have been used as models in the past for partial carpal fusions.⁵

Pathoanatomy

Inflammatory Arthritis

Rheumatoid arthritis affects the wrist in many ways. It causes synovitis, destruction of articular cartilage, soft tissue attenuation, osteoporosis, and bony deformities. A common deformity is supination, volar and ulnar translocation, and radial deviation of the radiocarpal joint.

Partial and total fusions may be of therapeutic benefit to the rheumatoid patient in many ways:

1. Painful arthritic joints may be fused, resulting in pain relief.
2. Instability may be prevented or corrected.

- Deformities may be corrected, resulting in improved function and cosmesis.

Osteoarthritis

Osteoarthritis of the wrist may be due to primary degenerative osteoarthritis, or it may be posttraumatic in nature. Primary osteoarthritis will usually affect all the joints of the hand and wrist to varying degrees and cause a painful, stiff wrist. Posttraumatic osteoarthritis is most commonly the result of a distal radius fracture. The pattern of involvement of this condition is different from that of primary degenerative osteoarthritis in that the pathology is usually limited to the joints that were involved in the injury. Partial carpal fusions may be more appropriate in these cases. The principles are to fuse the painful arthritic joints and to preserve motion in the nonarthritic joints. In primary degenerative osteoarthritis, all the carpal joints may be involved. In these cases there may be no other option than to perform a total wrist fusion.

Preoperative Assessment

Etiology

The primary diagnosis should be ascertained, as this may affect the management. This may be traumatic, generalized arthritis; crystalline deposition disease; or some other condition. The decision as to the extent of the fusion to be performed may be altered depending on the cause.

Associated Diseases

Other conditions such as nerve entrapment syndromes and neuromuscular conditions should be sought. This is important so as not to miss another potential cause for the patient's pain. Investigations may be required to exclude a generalized form of arthritis.

Anatomical Localization

It is important to identify which joints are involved in the disease process. All involved joints should be included in the fusion. This will aid in deciding which type of fusion should be performed.

Imaging

This should include at least plain radiographs. Computed tomography (CT) scan and magnetic resonance imaging

(MRI) may be of value in assessing if certain joints are involved in the disease process or not. They may assist in cases of deformity and in planning surgery. Arthroscopy may also form part of the decision-making process. Visualization of the articular cartilage of a particular joint may contribute to the final decision as to whether or not the joint should be included in the fusion.

Types of Fusions

Radiolunate (Chamay) Fusion

Indications

The most common indications for a radiolunate (RL) fusion (**Fig. 1a**) are rheumatoid arthritis, posttraumatic osteoarthritis following an intraarticular distal radius fracture, and Kienböck disease.

An RL fusion is commonly performed to treat or prevent the common deformity of volar and ulnar translocation of the carpus in rheumatoid patients.^{4,6} The RL fusion may also be performed in conjunction with a Darrach procedure to prevent this deformity from occurring.

Radiolunate fusions may also be indicated in complex proximal row instabilities with multilevel ligament insufficiencies not amenable to soft tissue reconstruction.⁷

Posttraumatic osteoarthritis of the radiolunate joint may occur after a distal radius fracture with a die-punch lesion, where the lunate has fractured the lunate fossa of the distal radius. In this scenario, if the radioscaphoid joint is uninvolved, then an RL fusion is a good treatment option.⁶

Some authors have advocated RL fusion as a treatment option for advanced Kienböck disease, but results have showed poor pain relief and high nonunion rate with this technique of fusing the distal radius to the necrotic lunate.⁸ However, there have been encouraging reports of using a vascularized radius bone graft for RL fusion in certain cases.⁹

Surgical Technique

Prerequisites for this procedure are that neighboring joints are free of disease (radioscaphoid and midcarpal joint). The integrity of the scapholunate ligament is not important, as the capitate is unable to migrate proximally once the lunate is fused into the lunate fossa of the distal radius.⁷

A midline dorsal approach protecting branches of the superficial radial nerve is used. The extensor retinaculum is

Fig. 1a–d Schematic 3D computer model of the wrist showing the various types of limited radiocarpal fusions. (a) Radiolunate fusion. (b) Radioscapholunate fusion, (c) Radioscapholunate fusion with distal scaphoid excision. (d) Radioscapholunate fusion with distal scaphoid excision and triquetrectomy and the position for screw or wire fixation (authors' preferred technique). (© Gregory Ian Bain. Used with permission.)

incised over the third compartment, and the extensor pollicis longus (EPL) tendon is taken out of its groove and retracted radially. Full-thickness capsular flaps are then developed, and the carpus is exposed. Cartilage is excised from the proximal lunate and the lunate fossa of the distal radius. Cancellous bone graft is inserted into the defect, and the lunate is fixed to the radius. The lunate should be fused in neutral alignment relative to the radius. Methods of fixation include Kirschner wires (K-wires), plates and screws, screws alone, corticocancellous grafts held with screws, and staples.^{10,11} The dorsal capsular retinacular flaps are closed as one, and the EPL tendon is left external to the extensor retinaculum. The wrist should be immobilized in a below elbow plaster cast for six weeks.

Results

Linscheid et al reported results of 14 patients who underwent RL fusions.⁶ Their patients maintained a 55° arc of wrist flexion and extension and a 20° arc of radial and ulnar deviation. Four out of 14 patients (29%) developed radioscaphoid osteoarthritis, and one out of 14 (7%) failed to unite.

Saffar reported 11 cases of RL fusion performed for post-traumatic osteoarthritis.¹⁰ Average postoperative ROM was 33° flexion, 39° extension, 17° radial deviation and 29° ulnar deviation. Grip strength was 57% of the opposite side, and the patients reported good pain relief. Only one case failed to unite (9%).

Gaulke et al reported on 22 cases of rheumatoid wrists that underwent RL fusion using Shapiro staples.¹¹ They reported a high rate of radiologic complications, including nonunion (18%), radiolucency around the staples, intraarticular staple placement, adjacent joint degeneration, subluxation or dislocation of the lunate, staple migration, and subsequent tendon rupture. Clinical results were more encouraging, though, with good or excellent results in 81% of patients.

Radioscapholunate Fusion

Indications

It is rare for patients with rheumatoid arthritis or osteoarthritis to have involvement of the radiolunate joint and not the radioscaphoid joint. If this is the case (→ **Fig. 2**), then a radioscapholunate (RSL) fusion (→ **Fig. 1b**) is indicated rather than an RL fusion. An absolute prerequisite for this procedure is a functional midcarpal joint, where painless motion will occur following fusion of the diseased radiocarpal joint.¹²

Posttraumatic osteoarthritis of the radiocarpal joint, where both the radiolunate and radioscaphoid joints are involved, is a good indication for an RSL fusion, provided the midcarpal joint is normal.

RSL fusion is also an effective treatment for Kienboeck disease, where only the proximal lunate or distal radius joint surfaces are involved (Bain and Begg arthroscopic classification grade 1 and 2a).¹³

Fixation

As with the RL fusions, there are many described methods of fixation for the RSL fusion. These include K-wire fixation, plate and screws, Herbert screws, cannulated screws, and

Fig. 2 Anteroposterior (AP) radiograph of the wrist showing radiocarpal osteoarthritis involving both the radioscaphoid and the radiolunate joints. (© Gregory Ian Bain. Used with permission.)

staples. Fixation devices with more stability may allow earlier mobilization. (→ **Figs. 3a, b**)

A recent paper by Shin and Jupiter reports the use of two angled distal radius plates with locking screws.¹⁴

Results

The nonunion rate for RSL fusion has been documented to vary between 0% and 25%.^{12,14,15} This is possibly due to the increased stresses transmitted to the proximal scaphoid and the fusion mass from the long lever arm of the scaphoid.

This fusion reliably produces pain relief while maintaining some wrist motion. However, ROM is less than in RL fusions, and in young patients the restriction in ROM may be unsatisfactory. In the normal wrist the scaphoid flexes during wrist flexion and radial deviation. When the scaphoid is fused to the radius it is unable to flex, and thus wrist flexion and radial deviation are the movements most affected.

ROM generally is 33–40% of normal.^{7,16} Flexion-extension (F-E) arcs are 40–50° and radial-ulnar (R-U) deviation arcs 21–28°. ^{2,17,18}

There is also a relatively high rate of degenerative midcarpal arthritis, which develops following the RSL fusion. This rate has been reported to be from 35 to 53%.^{2,19}

According to Nagy and Bchler, there is an unacceptably high complication rate when looking at their long-term results of RSL fusion.² They reviewed their series of 15 patients who had undergone an RSL fusion with an average follow up of 8 years. Five patients (33%) needed conversion to a total wrist fusion. Average ROM was as follows: flexion 18°, extension 32°, ulnar deviation 25°, and radial deviation 3°. Eight patients (53%) developed midcarpal arthritis. Four patients (27%) developed a nonunion. Good results were maintained in only seven patients with the remaining eight

Fig. 3a, b AP and lateral radiographs of a wrist showing a radioscapholunate fusion performed with staples. (From Translunate fracture with perilunate injury, JHS Am Ed 2008.) (a) The Medartis radioscapholunate plate provides stable rigid fixation and will allow early mobilization. (b)

requiring further surgery for nonunion, development of midcarpal arthritis, or scaphoid fracture.

In Shin and Jupiter's series, they reviewed five patients who had an RSL fusion using angled 2.4 mm distal radius locking plates, which bridge the radioscaphoid and radio-lunate joints.¹⁴ All five patients achieved union using this technique. Range of motion was not reported.

As a result of some of these poor results, especially with regard to ROM, RSL fusion has been modified to include excision of the distal pole of the scaphoid and/or triquetrum.

RSL Fusion with Distal Scaphoid Excision

The addition of distal scaphoid pole excision to RSL fusion (→Figs. 1c, 4) has been shown to have multiple beneficial effects. These include increasing the ROM, improving the union rate, and decreasing the development of degenerative midcarpal arthritis.

Resection of the distal scaphoid pole unlocks the midcarpal joint and increases flexion and radial deviation.¹⁶ With

the distal scaphoid excised, the scaphotrapeziotrapezoid (STT) joint no longer constrains the scaphoid-lunate-capitate ball-and-socket type of motion, and this improves the radial deviation and flexion of the wrist and also decreases the development of midcarpal arthritis.¹⁵

The importance of the dart thrower's motion in everyday use of the hand and wrist has been previously emphasized.^{20,21} A large proportion of this motion comes from the midcarpal joint. With the scaphoid spanning both the proximal and distal carpal rows, the scaphoid acts as a block to this motion if it cannot flex out of the way during radial deviation. With excision of the distal scaphoid, the dart thrower's motion should be improved.^{20,21}

McCombe et al performed a cadaver study comparing the ROM of a simulated RSL fusion using K-wires, with and without resection of the distal pole of the scaphoid. The mean F-E arc increased from 60° to 122°, and the mean R-U deviation arc increased from 34° to 43° with excision of the distal scaphoid pole.¹⁶

Garcia-Elias et al reported 16 cases of RSL fusion with distal scaphoid excision for degenerative radiocarpal joint disease and found that those patients had less pain and improved flexion and radial deviation compared with previous results published on RSL fusions without distal scaphoid excision.¹⁵ In their series there were no nonunions and a lower incidence of midcarpal arthritis compared with RSL fusion alone (33% versus 12% with distal scaphoid pole excision). The authors postulated that the removal of the distal scaphoid removes a long lever arm and unloads the RSL fusion, leading to higher union rates and lower rates of secondary midcarpal arthritis.

Fig. 4 AP radiograph of a successful union of a radioscapholunate fusion performed in conjunction with excision of the distal pole of the scaphoid. A Darrach procedure has also been performed.

RSL Fusion with Distal Scaphoid Pole and Triquetrum Excision

It has been shown that the addition of distal scaphoid excision to an RSL fusion increases the ROM. With excision of the triquetrum (→Fig. 1d), ROM may be further improved, particularly ulnar deviation.

Cadaver work by Bain et al assessed the effect of triquetrum excision in addition to distal scaphoid excision to improve ROM after RSL fusion.¹² They found that the addition of distal scaphoid excision after RSL fusion resulted in a 25° (35%) increase in the F-E arc and an 11° (34%) increase in the R-U

deviation arc. Subsequent excision of the triquetrum further increased the F-E arc by 13° (13%) and the R-U deviation arc by 9° (21%), predominantly by improving extension and ulnar deviation.

Pervaiz et al performed a comparable cadaver study simulating RSL fusions.²² They found that RSL arthrodesis followed by distal scaphoidectomy and triquetrectomy resulted in a F-E arc of 114° (preoperative 126°) and 77° R-U deviation arc (preoperative 61°). Thus a minor decrease in the F-E arc and an increase in the R-U deviation arc were noted.

Another cadaver study by Berkhout et al assessed the ROM after distal scaphoid and then triquetrum excision.¹⁷ Their study confirmed that RSL arthrodesis diminished the amplitude of movement of the wrist in all directions. Subsequently distal scaphoidectomy and triquetrectomy both improved total wrist ROM in all directions. They concluded that F-E improves most after distal scaphoidectomy, whereas R-U deviation improves most after triquetrectomy.

Surgical Technique

The authors' preferred technique (► **Figs. 5a–c**) is to perform a distal scaphoid and triquetrum excision in conjunction with the RSL fusion.

A dorsal approach to the wrist is performed as previously described. The midcarpal joint is inspected. If the midcarpal joint is functional, then the RSL fusion is performed. The distal pole of the scaphoid and the triquetrum are excised and kept for bone graft later in the procedure. The articular surfaces of the proximal scaphoid and proximal lunate and the distal radius are denuded of cartilage down to bleeding cancellous bone. The scapholunate joint is then reduced and held with two K-wires. It is critical that this joint is reduced, as it will lead to rim loading and degenerative osteoarthritis in the midcarpal joint if it is not. The bone from the excised triquetrum and distal scaphoid is then packed in the RSL interval.

The authors' preferred method of fixation is with memory staples (DePuy International Ltd). The staples are stored in the freezer; once implanted, they warm up and the arms converge, thereby compressing the fusion site.

The lunate and scaphoid are placed in 15° of extension to place the arc of motion more in the functional arc.²³ The wrist is then taken through a full ROM to ensure that there is no impingement. The positions of the fusion and the staples are checked with fluoroscopy. After closure, the wrist is immobilized in a plaster slab for 6 weeks.

Using this technique, a prospective study was performed on 23 patients who underwent RSL fusion for rheumatoid arthritis, osteoarthritis, or Kienböck disease with a mean follow-up of 32 months.¹² There was a minimal decrease in the F-E arc (66° preoperatively to 57° postoperatively) and an increase in the R-U deviation arc (22° to 43°). There were no nonunions, and all patients but one were satisfied with the outcome. There was good pain relief and maintenance of function.

Arthroscopic-Assisted TWF

The wide intraarticular view obtained with arthroscopy provides a valuable tool to assist in the various types of wrist fusion. Combining this with percutaneous fixation techniques, it allows the procedure to be performed through smaller incisions and with less soft tissue dissection.

Depending on which joints are to be included in the fusion, the arthroscope is inserted into the radiocarpal and midcarpal joints. Arthroscopic burrs and curettes are then used to denude the articular surfaces of cartilage. Steinmann pins are inserted percutaneously across the joints to be fused. Autologous cancellous bone graft or bone substitute is inserted through a cannula under arthroscopic vision. The fusion mass can be stabilized with K-wires, or cannulated screws may be inserted.

Ho published a series of 12 limited wrist fusions performed arthroscopically.²⁴ In his series there were three RSL fusions and one RL fusion. All three RSL fusions united. The RL fusion, which was performed with cannulated screws, did not unite. It was revised with an open procedure and went onto union. His total series included 12 cases. Nine cases united, two developed a stable fibrous union, and only the one RL fusion case developed a nonunion. A few other minor complications occurred, which included two pin tract infections and a skin burn caused by an arthroscopic burr.

Fig. 5a–c Simulated radioscapholunate fusion performed on a cadaver wrist with memory staples (DePuy International Ltd). (a) Scaphoid and triquetrum intact. (b) Distal pole of scaphoid excised (increases radial deviation and flexion). (c) Distal pole of scaphoid and triquetrum excised (increases ulnar deviation and extension). (© Gregory Ian Bain. Used with permission.)

Note

No conflict of interest to declare.

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