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Diagnostics and management of acute scaphoid fractures: an update

Andrzej Żyluk

Pomeranian Medical University in Szczecin, Department of General and Hand Surgery, Unii Lubelskiej 1, 71-252 Szczecin, Poland

ORCID: 0000-0002-8299-4525

✉ azyluk@hotmail.com

ABSTRACT
The scaphoid bone is the most frequently fractured bone in the wrist. The diagnosis and management of scaphoid fractures are still troublesome and sometimes controversial. This article presents several aspects of diagnosing and management of scaphoid fractures which are a matter of scientific discussion. They include diagnosis of true fractures among suspected fractures, assessment of the range of displacement, methods and time of conservative treatment in a plaster cast, indications to surgical fixation, assessment of union of the fracture, diagnosis of nonunion, and the consequences of nonunion for the wrist function. The author believes that an updated information about this common injury may help young hand and orthopaedic surgeons in their daily practice.
Keywords: scaphoid fracture; diagnosis; conservative treatment; operative treatment; bone union; nonunion; wrist arthritis.

INTRODUCTION

The scaphoid bone is the most frequently fractured carpal bone, accounting for approx. 60% of all carpal bone fractures. The diagnosis and management of scaphoid fractures are still troublesome and sometimes controversial. Due to the discrete or frequently invisible fracture line on X-ray when performed immediately after injury, the fracture can be easily missed or diagnosed with considerable delay. This fact and peculiar vascularity of the scaphoid (vessels go into the bone mostly in the distal pole) result in an increased risk of healing disturbances (nonunion) that occur in 25–50% of the fracture [1]. Operative treatment of scaphoid fractures reduces the risk of nonunion but does not eliminate it entirely. Scaphoid nonunion is a source of pain and wrist dysfunction but also leads to instability and reduction of wrist motion, and – in a longer perspective – to wrist degeneration (scaphoid nonunion advanced collapse – SNAC) [2].

There are several clinical aspects of diagnosing and management of scaphoid fractures that are a matter of scientific discussion. They include diagnosis of true fractures among suspected fractures, assessment of the range of displacement, methods and time of conservative treatment in a plaster cast, the role of, and indications to surgical fixation, assessment of union of the fracture, diagnosis of nonunion, and the consequences of nonunion for the wrist function.

The objective of this study was the presentation of current opinions on these issues based on the review of newly published literature.

DIAGNOSIS OF SCAPHOID FRACTURES

Scaphoid fractures are difficult to diagnose. It is one problem how to diagnose them and another how not to miss them. It is because frequently (at least in 50% of cases) the fracture line is invisible on an X-ray when performed immediately after injury. Most problems with accurate diagnosis cause fractures localized in the waist of the scaphoid, while those localized in poles (proximal or distal pole) are less troublesome (Fig. 1, 2, 3, 4). Complying with some rules one can avoid missing the scaphoid fracture after wrist trauma [1, 2]. The fracture is suspected from the mechanism of injury and the patient profile, i.e. in a young man who has fallen heavily on his outstretched hand. This injury is typical for males aged 15–40 years. Therefore, when such a patient presents to the emergency department, suffering from pain in the radial side of the wrist, and provides the history of fall on the hand from bicycle or roller, wrist sprain during playing sport, jocks or during fisticuffs – suspicion of the scaphoid fracture should be the first line diagnosis. This is more probable if the following symptoms and signs are present:

— swelling of the wrist,
— tenderness over the scaphoid tuberosity or in the anatomical snuffbox,
— pain in the wrist on palmar/dorsal flexion and ulnar deviation,
— there is no tenderness over the distal radius.

The patient is then sent to radiology with an initial diagnosis of suspected scaphoid fracture. The technician should take X-rays in 4–5 views (so-called the scaphoid series) which can show fracture lines, invisible on standard p–a and lateral views [1]. After taking pictures, they should be viewed by the radiologist. If the radiologist confirms the diagnosis of a scaphoid fracture, the problem is solved and the patient is given treatment. If the radiologist states that an X-ray is clean (no fracture), it does not confidently exclude the fracture, because initial radiographs may not show it. If the patient profile, mechanism of injury, and initial radiographs do not confirm the fracture, then this is a suspected scaphoid fracture [3, 4]. There is a frequently used phrase by radiologists, namely: scaphoid fracture cannot be excluded. In

this scenario, the patient should be informed of the possibility of an underlying fracture and offered an alternative of:

— either resolving the uncertainty with advanced imaging (computed tomography – CT or magnetic resonance imaging – MRI), or

— re-assessment and repeat X-ray after an interval of time, usually within 2 weeks.

Computed tomography is the best option, as it is relatively easily available and its diagnostic accuracy is high, reaching 90% [1, 3, 4]. Moreover, it can show fracture displacement which may be not detected on the radiograph. Magnetic resonance imaging is the same efficient, but much less available. If the re-assessment is chosen, then the patient should be fitted with a plaster cast or splint and seen again in 2 weeks with the next X-ray. In this time interval, one may expect osteolysis of the fracture line which became visible on a standard radiograph.

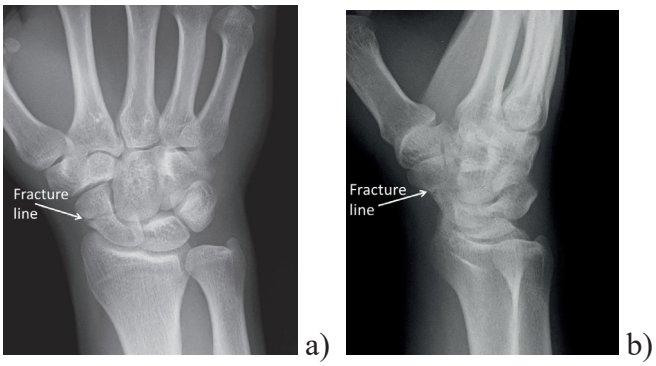


FIGURE 1. Non-displaced fracture of distal 1/3 of the scaphoid: a) p–a view; b) lateral view

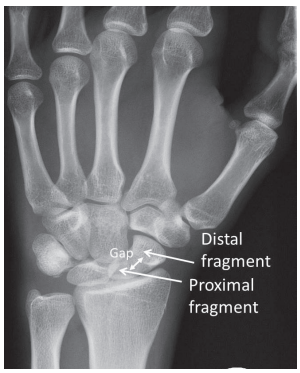


FIGURE 2. Displaced fracture of the waist of the scaphoid (p–a view). Note a gap between bone fragments

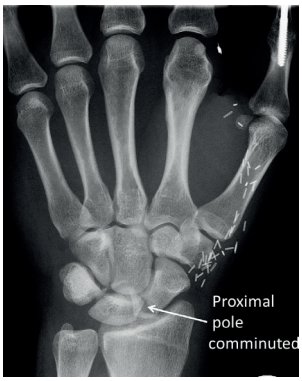


FIGURE 3. Severely displaced and comminuted fracture of the proximal pole

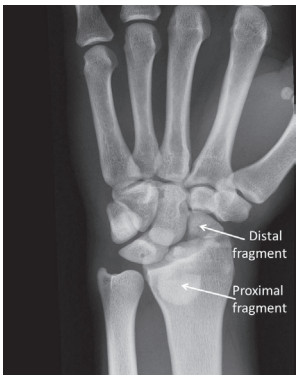


FIGURE 4. Severely dislocated fracture of the waist of the scaphoid (p–a view). Proximal half of the bone dislocated in the forearm

Even a CT or MRI do not have 100% diagnostic accuracy. There is a real risk of false-positive scans as it can be difficult to distinguish between a fracture and a bone bruise, nonspecific signal change on MRI or a vascular channel, and a unicortical fracture on CT. As a result, improved imaging alone cannot resolve the diagnostic dilemma of a suspected scaphoid fracture. Misinterpretation (false positive) can lead to inappropriate operation, restrictions, and unnecessary wrist immobilization [3, 4].

For a person that wants to return to work fast, a CT or MRI is the best option, as it can reduce the probability of a fracture requiring treatment to less than 1%, and it is cost-efficient. The patient can be dismissed home on the day of the presentation with appropriate advice. Patients and doctors can balance the risk of over-diagnosing a scaphoid fracture and the overtreatment of patients following wrist trauma; however, some amount of uncertainty is unavoidable [1].

If the patient who had excluded scaphoid fracture presents again to the doctor, suffering from persisting pain at movements, in the radial side of the wrist, one should think about other posttraumatic pathologies such as triangular fibrocartilage complex injury or dynamic scapholunate instability. In this situation, the best option is an MRI of the wrist which can show both disorders and the patient can be given appropriate treatment.

AN ASSESSMENT OF DISLOCATIONS OF SCAPHOID FRACTURES

Most scaphoid fractures are non- or minimally displaced when diagnosed based on X-ray (Fig. 1 a, b, 2). Results of some studies show that displacement of the fracture increases a 4.4 times relative risk of nonunion, compared with non- or minimally displaced fractures [1, 5]. However, there are no commonly accepted criteria for how to measure it precisely and what is the threshold that indicated a displacement of concern. Three types of displacements are commonly measured: a gap, an angulation, and a step (translation) between fracture fragments [1]. A 1 mm threshold is a displacement of concern in either the step or gap, but only the following values:

— displacement greater than 2 mm,

— angulation greater than 20°,
— fracture associated with dislocation (i.e. perilunate)

are regarded as highly significant and indicate a serious risk of scaphoid nonunion [1, 5]. However, measuring displacement can be confusing, considering the complex, 3-dimensional anatomy of the scaphoid. It is particularly difficult and non-precise on standard X-rays. It is more accurate on CT scans but this imaging also needs careful review and interpretation. Most surgeons and radiologists use saggital and coronal multiplanar reconstructions of the CT scan in the plane of the scaphoid. The presence of substantial step, gap, or angulation on CT scans suggests instability of the fracture; however, it does not imply motion between the fracture fragments [1, 6]. Conversely, fractures which seem to be stable (aligned) on CT, may move when they are viewed with the arthroscope. Angulation between the fragments of the scaphoid is fairly common. Typical angulation deformity is called "humpback", and if present, usually needs correction and operative fixation of the fracture.

Fractures of the proximal 1/3 of the scaphoid (proximal pole) are relatively rare and constitute approx. 5–10% of all scaphoid fractures. In this localization the risk of nonunion increases several times (Fig. 3). Depending on the size of a broken fragment, the healing disturbances are expected in 40–50% of cases which indicates operative treatment of scaphoid fracture at this localization [1, 5, 7]. This phenomenon can be explained by the particular vascularity of the scaphoid. The main blood supply to the scaphoid is from the radial artery. The dorsal scaphoid branches enter the non-articular portion of the scaphoid at the dorsal ridge at the level of the waist and supply the proximal 70–80% of the bone. The palmar scaphoid branches enter at the distal tubercle and supply the distal 20–30% of the bone. Thus, the vascularity of the proximal pole depends entirely on interosseous blood flow. This tenuous blood supply to the proximal pole helps to explain the increased tendency to delayed union, nonunion and avascular necrosis of fractures at this localization [1, 5].

In conclusion of this paragraph, any displacement of the scaphoid fracture should be treated with concern as potentially threatened by nonunion. Although there is no sufficiently convincing evidence on this, most surgeons decide to operate on displaced scaphoid fractures. Likewise, most fractures of the proximal pole are given surgery. Accurate diagnosis of the displacement and its range is difficult on X-rays, but easier and more precise on CT and MRI scans.

MANAGEMENT OF SCAPHOID FRACTURES

Scaphoid fractures can be treated conservatively and operatively. Although there is a trend for early fixation of almost all scaphoid fractures in adults, conservative treatment is still a good option in many cases. The suggested benefits of operative treatment of scaphoid fractures include promoting bone healing, reduced inconvenience of a plaster cast for a long time, and the possibility to return to activities of daily living, sports, and work. However, there is not enough convincing evidence that surgery for scaphoid fractures improves bone union or makes a return to heavy work earlier and safer [1]. Therefore it is suggested to operate on only these fractures which may not unite due to particular localization or configuration [5].

Conservative treatment

Undisplaced or minimally displaced fractures of the waist of the scaphoid can heal when treated conservatively in wrist immobilization in the plaster cast [7, 8, 9]. This treatment is simple, commonly available, and easily applied. It is a basic treatment for most scaphoid fractures. In the past, immobilization included also the thumb, but it is relatively inconvenient for patients as it restricts significantly normal use of the hand. Leaving the thumb free permits the use of the hand and patients are encouraged to return to light work quickly unless their work requires using a strong grip or is associated with the risk of another injury [10]. The wrist is thus immobilized in a below-elbow plaster (or thermoplastic) cast, keeping the wrist in a neutral position, with the thumb free (Fig. 5). The duration of wrist immobilization for non-displaced scaphoid fractures is approx. 6–8 weeks. After this period the cast is removed and fracture healing is then assessed using an X-ray or CT, to confirm the union of the bone.

FIGURE 5. Immobilization of the wrist in the cast for scaphoid fracture treatment

Operative treatment

Operative treatment is recommended for:
— displaced scaphoid fractures,
— fractures of the proximal pole,
— fracture associated with dislocation (i.e. perilunate) – Figure 6.

In these situations, the risk of nonunion after conservative treatment increases several times, therefore operation is a better option. The standard surgery for scaphoid fracture is its internal fixation with a cannulated screw [1, 4, 11]. There are many variants of these screws offered on the market, but their principal idea comes from the particular screw, first designed in 1984 by Australian orthopedic surgeon dr. Timothy Herbert (the Herbert screw). The brilliant idea of this screw consists in its construction. The larger pitch of the leading threads compared to the trailing threads is designed to provide compression across the fracture. The screw is countersunk below the articular surface and generally is not removed. Many further modifications introduced by industry companies did not change the principal idea of the screw which remains a standard implant for fixation of scaphoid fractures.

If the fracture is non-displaced, the fixation is performed percutaneously, without exposition of the fracture site (Fig. 7,

8). Displaced fractures require reduction which can be achieved percutaneously using 2 K-wires inserted in each bone fragment. These wires serve as joysticks for manipulation with the fragments until reduction is obtained. If the percutaneous technique is not suitable or not successful, reduction and fixation require open surgery. There are 2 approaches to scaphoid fractures, depending on the localization of the fracture line: palmar and dorsal. In a palmar approach the screw is introduced from the distal pole of the bone, and this approach is indicated for the fractures of the waist and distal pole of the scaphoid (Fig. 9, 10). In a dorsal approach, the screw is introduced from the proximal pole of the bone and this approach is indicated for fractures of the proximal pole of the scaphoid (Fig. 11, 12). The following rules should be in the fixation of the scaphoid [1, 11]:

— central placement of the guide wire and next the screw,
— undersizing the measured length of the screw,
— ensuring that neither end of the screw penetrates into joints (scaphotrapezial distally or radio-scaphoid proximally).

Correct placement of the screw and avoiding its protrusion into the adjacent joints are the most important prerequisites for the good outcome of surgery for the scaphoid fracture. To ensure the correct position of the screw in the bone, and to visualize possible penetration into the joint, the 4 intraoperative views of the scaphoid on fluoroscopy are required: antero-posterior (a–p) in ulnar deviation, semi-supinated, lateral, and semi-pronated oblique. If in any of these views the screw is prominent in the scaphotrapezial or radioscaphoid joint, its position should be corrected [1, 11]. Other complications such as malunion, infections, complex regional pain syndrome or damage to sensory nerves are uncommon after scaphoid bone surgery.

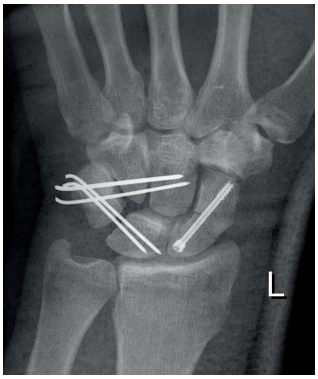


FIGURE 6. Fracture of the scaphoid associated with perilunate dislocation. Note the fixation of the scaphoid with the screw and stabilization of carpal joints with K-wires

FIGURE 7. Percutaneous introduction of the screw into the scaphoid from the palmar approach

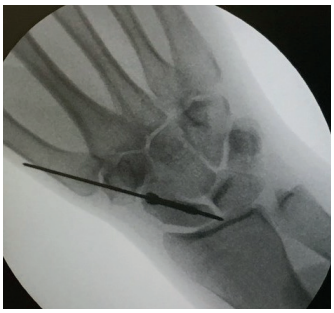


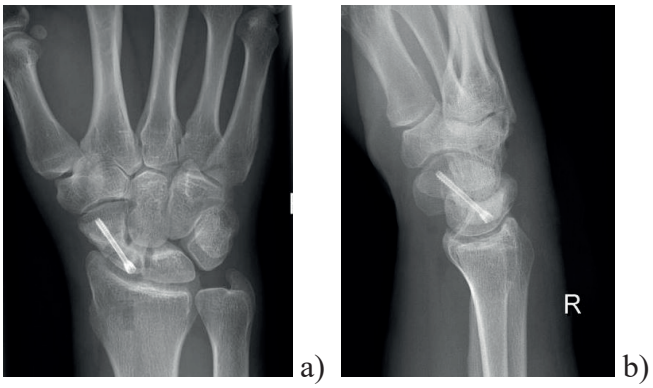
FIGURE 8. Intraoperative X-ray showing the screw inserted in the scaphoid

FIGURE 9. Non-displaced fracture of the waist of the scaphoid (p–a view)

FIGURE 10. Postoperative X-ray showing a fracture fixed with a screw from the distal approach. Note the central position of the implant

FIGURE 11. Non-displaced fracture of proximal 1/3 of the scaphoid

The postoperative regimen includes the immobilization of the wrist in a plaster/thermoplastic splint (but not a cast) for 4–6 weeks until a bone union is achieved. Some surgeons question the need for postoperative immobilization and permit the patients to use their hands with no limits and return to work. This is, however, a risky protocol because the fixation of the scaphoid fracture alone does not warrant its union.



a) b)

FIGURE 12. Postoperative X-ray showing fracture fixed with a screw from proximal approach: a) p–a view; b) lateral view

Nonunion after the operation of scaphoid fracture is a separate problem. Despite the newly developed fixation techniques, including open and percutaneous fixation, the nonunion rate remains as high as 10% after surgical treatment [2, 5].

ASSESSMENT OF HEALING OF THE FRACTURES

X-rays should be performed 6–8 weeks after the cast removal to assess bone union. If an X-ray shows a clearly good union, the treatment is successfully finished. If there is still an identifiable fracture site or the presence of the gap between bone fragments – it implies scaphoid delayed union or nonunion and the need for operative treatment. If there is any uncertainty about union, then a CT scan of the scaphoid should be performed to solve these doubts. This will help classify the degree of bone consolidation early and permit a clinical decision on whether can be finished, corrected, or – when it looks as nonunion – the fracture needs surgical treatment [1, 4, 9]. However, even a CT or MRI may be insufficiently reliable to assess the state of union accurately. An alternative approach in a situation of uncertain union of the scaphoid fracture to discontinue immobilization and take an X-ray in a few weeks to confirm the union. Another test can help in making this decision, namely if pressing firmly on the scaphoid tuberosity elicits no, or only little pain, it is likely that the fracture is united and is difficult to take apart at the surgery for nonunion. The absence of fracture line tenderness implies good clinical healing of the bone.

Sometimes bone union can occur across only a proportion of the fracture line. This is called partial union. If the aforementioned compression test is negative, then a reasonable approach is to assume that bone union is sufficiently firm to allow the patient normal use of the hand [1]. If pressing on the scaphoid tuberosity evokes pain, a better option is the protection of the wrist using removable splint for the next 2 months and the repeat X-ray or CT scan, as in most cases partial union slowly consolidates.

CONSEQUENCES OF SCAPHOID NONUNION

Nonunion of the scaphoid is associated with serious consequences which appear however many years after primary injury. In a nonunited fracture, both parts of the scaphoid move independently: the distal fragment moves against the proximal one and the rest of the proximal carpal row. This is because of the usually intact scapholunate ligament that keeps the proximal scaphoid fragment on site. Non-physiological movements result in high-point loads damage of the articular cartilage and this leads slowly to joint arthritis. In the first stage of this process, there is dorsal dislocation of the lunate bone which is called dorsal intercalated segment instability. Next, degenerative changes appear in the radioscaphoid joint (R–S arthritis) followed by the collapse of the scaphoid [2, 4, 12]. This end-stage of the disease has been termed SNAC. For many years scaphoid nonunion is usually asymptomatic, until arthritic changes became evident. Frequently an additional injury to the wrist is a trigger point which reveals the problem and from this point the SNAC became symptomatic.

It is possible, however, that some nonunions may not cause arthritis. It is not known why the majority of patients with scaphoid pseudoarthrosis develop symptomatic arthritis and some do not. This may be explained by i.e. strong fibrous union of the scaphoid fragments and/or intact, firm ligamentous apparatus, both warranting functional stability of the nonunited scaphoid complex. Therefore, a common opinion that scaphoid pseudoarthrosis inevitably results in SNAC is not a paradigm and some patients may do well with this pathology until reaching old age [12, 13].

SUMMARY AND FINAL REMARKS

The scaphoid bone is the most frequently undergoing fracture bone in the wrist. The diagnosis and management of scaphoid fractures are still troublesome and controversial. These injuries are suspected particularly in young men after high-energy injuries involving the wrist, such as falls from a bicycle, motorcycle, and rollers. Typical clinical presentation is a pain in the wrist at movements and tenderness over scaphoid tuberosity or in the anatomical snuffbox. The scaphoid fracture can escape early detection because in many cases they are subtle and the initial symptoms may be apparently innocent. The fracture line may be not visible on an X-ray when performed immediately after injury, and therefore the fracture can be easily missed or diagnosed with considerable delay. Computed tomography is accurate and reliable imaging for suspected scaphoid fractures when an X-ray is negative. Likewise, CT is more precise in the assessment of the possible displacement of the fracture. Most undisplaced or minimally displaced fractures of the waist of the scaphoid can be treated conservatively in wrist immobilization in the plaster cast. Operative treatment is recommended for: displaced scaphoid fractures, fractures of the proximal pole, and those associated with dislocation (i.e. perilunate). Standard surgery includes internal fixation with a cannulated screw. Bone union is achieved usually after 6–8 weeks of the treatment in the cast or after the operation. If an X-ray suggests some concern about the consolidation of the fracture, then a CT scan can help to confirm nonunion,

delayed union, or partial union. Nonunion of the scaphoid is associated with serious consequences and the most devastating is the SNAC of the wrist.

REFERENCES

1. Dias JJ, Ring D, Grewal R, Clementson M, Buijze GA, Ho PC. Acute scaphoid fractures: making decisions for treating a troublesome bone. J Hand Surg Eur Vol 2022;47(1):73-9.
2. Kozin SH. Incidence, mechanism, and natural history of scaphoid fractures. Hand Clin 2001;17(4):515-24.
3. Bäcker CH, Wu CH, Strauch RJ. Systematic review of diagnosis of clinically suspected scaphoid fractures. J Wrist Surg 2020;9(1):81-9.
4. Ring D, Lozano-Calderón S. Imaging for suspected scaphoid fracture. J Hand Surg Am 2008;33(6):954-7.
5. Kawamura K, Chung KC. Treatment of scaphoid fractures and nonunions. J Hand Surg Am 2008;33(6):988-97.
6. Kawanishi Y, Oka K, Tanaka H, Sugamoto K, Murase T. *In vivo* scaphoid motion during thumb and forearm motion in casts for scaphoid fractures. J Hand Surg Am 2017;42(6):475.e1-475.e7.
7. Johnson NA, Morris H, Dias JJ. Questions regarding the evidence guiding treatment of displaced scaphoid fractures. J Hand Surg Eur Vol 2021;46(2):213-8.
8. Johnson NA, Dias JJ. Scaphoid waist fracture displacement within 2 mm and most proximal pole fractures do not need surgical treatment. J Hand Surg Eur Vol 2021;46(9):1023-6.
9. Eastley N, Singh H, Dias JJ, Taub N. Union rates after proximal scaphoid fractures; meta-analyses and review of available evidence. J Hand Surg Eur Vol 2013;38(8):888-97.
10. Clay NR, Dias JJ, Costigan PS, Gregg PJ, Barton NJ. Need the thumb be immobilized in scaphoid fractures? A randomised prospective trial. J Bone Joint Surg Br 1991;73(5):828-32.
11. Singh HP, Taub N, Dias JJ. Management of displaced fractures of the waist of the scaphoid: meta-analyses of comparative studies. Injury 2012;43(6):933-9.
12. Kerluke L, McCabe SJ. Nonunion of the scaphoid: a critical analysis of recent natural history studies. J Hand Surg Am 1993;18(1):1-3.
13. Walaszek I, Żyluk A. Long-lasting scaphoid pseudoarthrosis with no pain and minimal arthritis: a report of two cases. J Hand Surg Eur Vol 2015;40(5):536-7. doi: 10.1177/1753193413495328.