The late consequences of scaphoid fractures

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The nature and likelihood of later consequences of a fracture of the scaphoid depend upon the outcome of the fracture. For each outcome, one must consider the symptoms of the patient and the natural history of the fracture.1

Fractures which unite

Nearly 90% of scaphoid fractures unite with conservative treatment2,3 and the overall clinical impression is that patients continue to progress well and remain free of symptoms. However, they are rarely followed up after the fracture has united. Dias, Brenkel and Finlay4 followed up patients for between 1.7 and 2.6 years and found that 20% had some pain and 19% tenderness, but grip strength and wrist movement were nearly normal. They suggested that the persistent symptoms could reflect damage to the articular cartilage at the time of the injury.

Secondary osteoarthritis may develop after the fracture has united. Lindström and Nyström5 showed in 1990 that after seven years or more osteoarthritis occurred in 5% of wrists in which a fracture of the scaphoid had healed normally and suggested that it would probably progress. In 2001 Säeden et al6 described a study of acute fractures, some treated in a cast and some by a Herbert screw. The patients were reviewed after 10 to 12 years, when CT scans and plain radiographs were carried out on both wrists. Of the 16 patients treated conservatively, seven had osteoarthritis in the radiocarpal joint and seven in the scaphotrapezial joint. The higher incidence of osteoarthritis reported in this series was probably because it was revealed by the CT scans.

Why should osteoarthritis develop after a fracture has united? It may be because of damage to the articular cartilage sustained at the time of the fracture or, as Lindström and Nyström5 suggest, to some degree of malunion. It would be likely to occur if the fracture had healed with a step in the articular surface. Such displacement is seldom seen on ordinary scaphoid radiographs. It cannot be detected reliably on such films and may only be demonstrable by MRI or CT scans.7

Malunion

As well as a step due to lateral displacement, angular malunion may occur. This is usually seen as a flexion or humpback deformity and again special investigations are needed to detect it. Although the flexion deformity predominates, there may be ulnar deviation and pronation of the distal fragment8 and these are even more difficult to detect and quantify. Such malalignment predisposes to nonunion, but if the fracture heals it will be in a position of deformity.

It has been shown in cadavers that a flexion deformity within the scaphoid causes loss of extension at the radiocarpal and midcarpal joints,9 but the clinical consequences remain uncertain. In 1989 Amadio et al,10 using tri-spiral tomography, reviewed 46 wrists with healed scaphoid fractures. Of these 20 had intrascaphoid angles of <35˚, which was considered normal; 83% had satisfactory clinical outcomes. However, of the 26 wrists with intrascaphoid angles of >35˚, indicating a flexion deformity within the scaphoid, only 27% had satisfactory clinical results as judged by pain, function, movement and strength. The authors concluded that union alone did not guarantee success in treating these fractures.

Jiranek et al11 compared 13 patients with malunion, defined as a lateral intrascaphoid angle of >45˚, and 13 with acceptable union. Both followed Russe procedures for nonunion. There was no significant difference in symptoms or function but the measurements of movement and strength were worse in the presence of malunion. According to the criteria of Amadio et al,10 the 13 patients with malunion would have had a poor prognosis but 12 of them returned to a high level of function despite the deformity.11
Few papers have been published describing the results of corrective osteotomy for malunion of the scaphoid. In 1991 Nakamura, Imaeda and Miura reviewed seven such operations with a mean follow-up of 29 months, all with satisfactory results. All had united within three months. Pain was relieved in six and diminished in one, while both movement and grip strength had improved. Lynch and Linscheid reviewed five corrective osteotomies performed by the latter author between 1.5 and 19 years earlier. All had united, as determined by trispiral tomography, after a mean of 5.5 months. Pain had been completely relieved in three patients and diminished in two. There was a slight improvement in wrist movement, but this was not statistically significant. Grip strength was markedly improved. However four of the five had mild radioscaphoid arthritis.

There is no clear opinion as to whether corrective osteotomy should be undertaken in a scaphoid which has united in a deformed position. In a recent discussion of the subject, Herbert wrote “Fortunately it appears that the wrist is able to adapt to minor degrees of scaphoid deformity, since it is fairly unusual to see patients presenting with significant symptoms as a result of malunion”.

Amadio et al found post-traumatic arthritis in 14 of 26 patients with malunion, compared with four of 20 with union in acceptable alignment, but the findings of Lynch and Linscheid show that corrective osteotomy does not prevent the development of osteoarthritis. At best, it may slow the process. Jiranek et al concluded that corrective osteotomy is probably not justified in an asymptomatic patient. It is best to avoid malunion in the first place.

Nonunion

The expected consequence of nonunion would be pain on use. This is true for most patients, but some may remain free of pain for many years. Amadio identified three types of natural history. Prosser and Isbister in a study of 30 patients treated for nonunion described four different patterns of presentation. Combining their observations we can distinguish the following groups:

1. Patients treated and followed up adequately in whom radiographs reveal nonunion.
2. Patients treated but followed up inadequately. Dias et al showed that radiographs taken at only three months after fracture cannot differentiate reliably between union and nonunion. Union is a process rather than an event and follow-up for a minimum of six months is required. Some patients are discharged prematurely in the belief that the fracture has united. When they return complaining of pain and the radiograph is abnormal they may be told that they have re-fractured the scaphoid. In most cases it had never united. Other patients default from follow-up and remove the cast themselves.
3. Patients who were never treated because they did not consult a doctor. It may be years later, usually when some minor injury aggravates the wrist, that a radiograph reveals long-standing nonunion. Sometimes the original injury had seemed so minor that the patient has no recollection of it.
4. Patients in whom the nonunion is discovered accidentally when radiographs of the wrist are taken for some other reason. This is rare. A review of 2857 consecutive radiographs of the wrist for any indication found only four (0.14%) with ununited fractures of the scaphoid.

A number of papers have been published which claim to describe the natural history of nonunion of a fracture of the scaphoid, but most of the patients who were reviewed had pain. An analysis by Kerluke and McCabe concluded that these were not valid studies of the natural history and suggested that this was not as gloomy as had been reported in the literature. They pointed out the need for a true long-term investigation of the natural history but ironically, such a study had been published a month earlier, though this was six months after their analysis had been accepted for publication. This was a second paper by Lindström and Nyström who described a series with remarkably long follow-up but, inevitably, of small numbers. They reviewed 33 patients whose fractures were not treated. They were seen and radiographs were taken at least 12 years later, when all had radiological evidence of osteoarthritis but five remained free of symptoms. Seventeen years thereafter, an attempt was made to contact those five patients again. Two had died; two had developed pain, weakness and stiffness and one said his wrist was slightly swollen but not painful. These observations are supported by those of Düppe et al who noted that only one of 47 united fractures reviewed between 31 and 40 years later had developed osteoarthritis, compared with five of nine which had not united. Inoue and Sakuma reviewed 104 patients with symptomatic nonunion with a wide range of follow-up and found osteoarthritis in 100% of those whose fracture had occurred ten years or more before. All but one had pain, but it did not correlate with the severity of arthritis or the duration of the nonunion.

It seems that eventually osteoarthritis is inevitable and pain probable, but they may not occur until several decades after injury.

It is not surprising that radioscaphoid osteoarthritis should develop after nonunion. In a fibrous union there is only slight irregularity at the fracture-line, but in a complete pseudarthrosis the two halves of the scaphoid move separately, and the edge of one may scrape the articular surface on the matching facet of the radius. Moreover, the whole shape of the scaphoid may be altered, usually into a flexion deformity so that the distal scaphoid and the corresponding surface of the radius are no longer congruous. The result is a distinctive pattern of osteoarthritis affecting firstly the joint between the radius and the distal fragment of the scaphoid, which is the rationale for radial styloidectomy as a palliative procedure. The earliest stages of this process can be detected by three-dimensional CT. Next affected is the midcarpal joint between the capitale
and the proximal scaphoid and later between the capitate and the lunate. The joints between the radius and the proximal fragment of the scaphoid and between the radius and the lunate are seldom affected.

Inoue and Sakuma\textsuperscript{23} stress the frequent presence of a dorsal osteophyte on the lateral view, which may impinge on the radius in dorsiflexion. This is more likely to develop if there is a flexion deformity at the site of the nonunion.

**Successful bone-grafting**

Few papers have assessed the success of the procedure as judged by relief of pain, although this is the prime purpose of the operation. There is often a striking discrepancy between the clinical and radiological results.\textsuperscript{26} Some patients have their pain relieved despite persistence of the nonunion, presumably because a more stable fibrous union has been achieved or possibly because the operation has resulted in some restriction of movement at the wrist.\textsuperscript{11} Most patients in whom the operation fails continue to have symptoms but decide to put up with them, rather than undergo either a second operation with dubious prospects of success or a palliative procedure.

Some patients in whom union has definitely been achieved still complain of pain. It may be that there is some other abnormality in the wrist. The pain might be due to malunion, but Jiranek et al\textsuperscript{11} found that although this was likely to weaken the grip and reduce the range of movement it did not cause significant symptoms or impair function. They also observed that malunion increased the likelihood of later osteoarthritis.

Lindström and Nyström\textsuperscript{21} concluded that “the best indication for stabilising surgery is the totally asymptomatic patient in whom no sign of arthrosis can be found”. This view rests on the assumption that success in achieving union will prevent osteoarthritis from developing. The likelihood of subsequent osteoarthritis must be somewhere between 5\% and 100\%, but where it lies within this range is not certain, because in many of the published papers the follow-up is short and some do not exclude patients who had already developed early osteoarthritis before bone grafting. It must also be remembered that most series report a failure to achieve union in about 20\% of patients.

**Why should osteoarthritis occur after an operation which leads to healing of a nonunion?**

It may have developed in the absence of a fracture. Bhattacharya et al\textsuperscript{27} studied 73 aged cadavers and found osteoarthrosis of the scaphotrapeziotrapezoid joint in 83\%, almost as many as in the trapeziometacarpal joint (90\%), but the clinical problem usually occurs in relatively young men.

Osteoarthritis may have already developed after the fracture but before the operation. Inoue, Shionoya and Kuwahata\textsuperscript{28} reviewed 215 patients in whom nonunion was treated by a bone graft and Herbert screw. Severe osteoarthritis was regarded as a contra-indication, but 30 patients had mild osteoarthritis before the operation and they had worse results both symptomatically and radiologically. The follow-up was for a minimum of one year but the incidence of osteoarthritis at final review is not clear.

The nature of the operation itself may be a contributory factor. Few surgeons now advocate internal fixation alone for the treatment of established nonunion. The surfaces of the pseudarthrosis must be freshened and some form of bone graft inserted. However, most of the surface of the scaphoid is covered with articular cartilage and such an operation inevitably leads to destruction of some of the cartilage surface and its replacement by bare bone. It is therefore unrealistic to suppose that later osteoarthritis can be eliminated by this type of operation. The longest follow-ups are of the earlier types of operation. Martini and Schiltenwolf\textsuperscript{29} compared 49 patients with nonunion of the scaphoid and 55 in whom a Matti-Russe reconstruction had been carried out successfully. Both groups were observed for between three and 39 years. They found that the clinical and radiological appearance seemed to be better in those who had undergone an operation. However, no patient was free from arthritic change after ten years.\textsuperscript{29} Similarly, Mulder’s patients, also treated by the Matti-Russe procedure, were reviewed 22 to 34 years later by Hooping Van Duyvenbode et al\textsuperscript{30} who found that most had slight osteoarthritic changes. Steiger and Sennwald\textsuperscript{31} examined 25 patients at least 25 years after this type of operation and found signs of osteoarthritis in most of them, especially those with dorsal intercalated segmental instability. Jiranek et al\textsuperscript{11} compared radiographs taken before and after operation in 16 patients and found that the occurrence of union did not always arrest the arthritic process, but suggested that progression was slower than in patients who had an untreated nonunion.

However, these types of operation are not widely used today and Filan and Herbert\textsuperscript{32} suggest that modern methods, using a wedge-type of graft and compression screw, are more likely to restore the length and shape of the scaphoid which should reduce the likelihood of later osteoarthritis. Unfortunately there are no published reports of long-term follow-up after this type of operation for nonunion. Filan and Herbert\textsuperscript{32} themselves had difficulty in following up all their 431 patients. Their mean follow-up for 304 patients was 34.2 months, with a minimum of six months, but only 163 were treated for nonunion. Of these, 40\% had radiocarpal osteoarthritis before the operation and 49\% afterwards, though for severe osteoarthritis the increase was only from 3\% to 7\%. They concluded that the progress of osteoarthritis was reduced by successful internal fixation, but were unable to advise to what extent it was reduced in the long term. Rajagopalan, Squire and Samuels\textsuperscript{33} reviewed a much smaller number of cases but for a slightly longer period, assessing 21 patients treated by wedge-grafting and Herbert screw fixation at a follow-up of between 17 and 55 months (mean 48). Seven patients had radiological evidence of osteoarthritis. In four this had been present before the operation. In the other three it was only evident.
afterwards. They suggested that the degenerative changes were caused by the nonunion and not by the surgery. However, in those patients with pre-existing degenerative changes it is not possible to separate the symptoms induced by the nonunion from those relating to osteoarthrosis.

Osteoarthrosis might result simply from putting a screw into the scaphoid. McLaughlin used compression fixation with a conventional lag screw but no bone graft. The screw did not enter the scaphotrapezial joint, being introduced into the distal fragment from the radial side through a dorsoradial approach. Brostrom, Stark and Svartengren made this procedure easier by removing the radial styloid. They examined 17 patients 13 to 19 years later. Before operation, seven had radiocarpal osteoarthrosis. However, at follow-up this number had doubled to 14, nine being severe and four also having unspecified intercarpal changes. No bone graft had been introduced and the radial styloid had been excised, which should have prevented the head of the screw from impinging on the radius.

The Herbert screw has no head and its rear end is sunk beneath the surface of the articular cartilage on the distal pole of the scaphoid, but the manoeuvres required to insert it must damage the joint surface. In established nonunion it is combined with a bone graft. Several medium-term reviews show surprisingly little evidence of osteoarthrosis in the scaphotrapezial joint as a consequence of opening up and putting a screw into one side of it. However, Saend et al., using CT scans ten to 12 years later, found that 17 of 23 patients had osteoarthrosis in that joint and 11 in the radiocarpal joint.

How should we manage a patient who has a nonunion but little or no pain? The case for a prophylactic operation to prevent osteoarthrosis is not strong. The operation will necessarily involve inconvenience and a period off work. It may result in reduced movement at the wrist. One in five will fail to achieve union and some of the remaining four will still develop osteoarthrosis, but perhaps later than they would have done without operation. There might be a better case for operating to prevent the onset of pain but union does not guarantee the absence of pain. A preventative operation is more appropriate in young patients. It is more likely to be successful with nonunion at the wrist than at the proximal pole, if this is not long-standing. A further factor is the experience and skill of the surgeon in this difficult type of surgery.

The management of fractures of the scaphoid is not simple. In order to avoid troublesome consequences, it is necessary to define precisely the nature of the fracture, to choose the most appropriate method of treatment and to review the patient until the outcome is determined.

References