Kienböck's Disease

Ian A. Trail

Contents

Abstract

Kienböck's disease or avascular necrosis of the lunate bone is an uncommon condition affecting the wrist of young adults. The diagnosis should be considered in such an individual who presents with an insidious onset of continuing pain, stiffness and weakness of the wrist. The diagnosis is usually confirmed by a plain x-ray, although bone scans can be used in the early stages. In addition, a CT or MRI scan will give additional information, particularly with regard to the shape of the lunate, the presence of any fractures, the degree of carpal collapse as well as any other associated findings.

Classification is traditionally by the Lichtman grade. However, surgical treatment if necessary is sub-divided into reconstructional or salvage. Reconstruction should be considered if the lunate has retained a significant amount of its shape and has not become fragmented. Surgical techniques commonly used include some form of wrist joint- levelling procedure, usually radial shortening, together with the insertion of a bone graft. Lunates that are fragmented and deformed are probably best treated by salvage procedures. These include, partial or total wrist fusion or proximal row carpectomy. The former is ideal for someone who requires a strong wrist and the latter for someone who wishes to retain some movement. Finally, for the later stages, when osteoarthritis supervenes, treatment should be targeted towards the arthritic process rather than the lunate.

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Introduction

In 1843 Peste, following an anatomical dissection, first described collapse of the lunate bone. In 1910 Kienböck from Vienna described the x-ray appearances. Since then the condition has been reported world-wide. Whilst not common, the diagnosis should be considered in younger patients presenting with an insidious onset of continuing pain and stiffness in the wrist. It is often said that the average Orthopaedic surgeon would expect to see one or two cases in a year. Clinicians specialising in hand surgery would see more.

The exact aetiology of the condition is still unclear. It is generally felt however, that patients who develop this condition have a pre-existing anatomical abnormality, probably vascular, which is damaged by a traumatic event. Added to this, a negative ulnar variance has been associated with Kienböck's disease since first being described by Hulten in 1928 [7].

Surgical treatment if required falls into two categories. Firstly reconstruction which is an attempt to re-vascularise the lunate whilst maintaining its normal shape. The second is salvage, when the lunate has collapsed and fragmented and cannot be reconstructed. The choices here range from arthrodesis of the wrist, either total or partial, to proximal row carpectomy.

The aim of this chapter is to provide a general overview, concentrating particularly on diagnosis, but also on the indications for the various surgical treatments available.

Aetiology, Applied Anatomy and Biomechanics

As with all tissues that can undergo avascular necrosis, a thorough understanding of the normal vascular anatomy is crucial. The intra-osseous blood supply to the lunate was first studied by Gelberman et al. [6]. Various patterns were described ranging from a 'Y' pattern in 59 % of specimens, an 'I' pattern in 31 % and an 'X' pattern in 10 % (Fig. 1). They also concluded that various areas particularly the section of the lunate adjacent to the radial articular surface were relatively avascular. Based on this and further work it was postulated that lunates that received their blood supply from a single vessel were more at risk of avascular necrosis than those that had dual or more blood supply.

In 1928, Hulten described a negative ulnar variance in association with Kienböck's disease and felt that this was a significant aetiological factor (Fig. 2). This association has been confirmed by others. Its relevance however, rather than leading to the development of management of the condition, is mainly related to the altered biomechanics and the forces that are transmitted through the lunate. Work by Werner and Palmer [27] investigating normal cadaveric wrists showed that in neutral variance the radio-carpal joint supported 81.6 % of the total transmitted load across the wrist, whilst 18.4 % crossed the ulno-carpal. With 2.5 mm of negative ulnar variance however, the load across the radio-carpal joint increased to 96 % with only 4 % crossing the ulno-carpal. Consequently it was postulated that patients with a negative ulnar variance had a markedly uneven load distribution across the lunate. As a result, when the lunate becomes avascular in the presence of a negative ulnar variance, the section on the radial side will collapse sooner and to a greater extent than that on the ulnar side.

Finally, the role of trauma has been considered and much debated over the years. Kienböck himself thought that the condition was associated with a fracture. There is no doubt that in many patients with Kienböck's disease fractures, often osteochondral involving the proximal articular surfaces, are frequently seen. Whether this is the cause of avascular necrosis or as a result remains unclear. In our series published in 1996 only 50 % of patients could recall any significant trauma to the wrist prior to the onset of their condition.

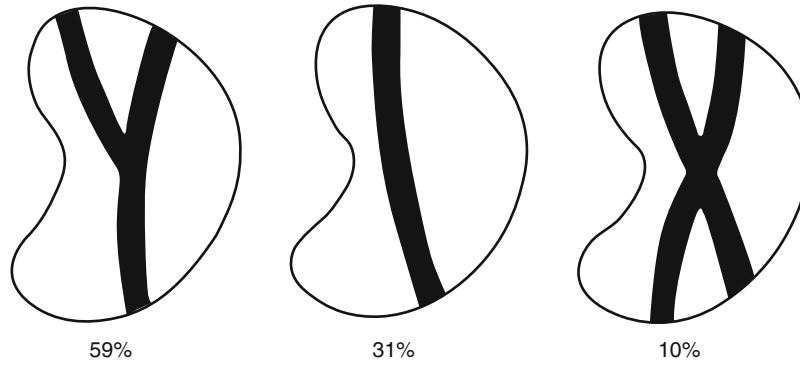

Fig. 1 Diagram-patterns of blood supply to the lunate [6], showing single bifurcation and double arterial supply

Fig. 2 A-P radiograph of the wrist showing negative ulnar variance

Diagnosis

History and Examination

The initial presenting complaint is one of continuing pain in the wrist often localised to the dorsum in the mid-line. A number of patients can recall a particular traumatic event and certainly the pain is made worse by overuse, and eased by rest. Patients are typically of a younger age group ranging primarily from 20 through to 40 years of age. It is reported to be more common in males and females. Associated with the pain can be some discrete swelling over the dorsum of the wrist with associated reduced range of motion and weakness of grip.

The principle differential diagnoses include inflammatory arthropathy, scapho-lunate ligament injury, non-union of the scaphoid, sequelae of previous distal radial fractures(osteoarthritis), damage to the triangular fibro-cartilage, instability of the luno-triquetral joint and finally mid-carpal instability.

Investigation

The diagnosis is usually made by a plain X-rays. Usually in the initial stages, increased bone density is noted, followed subsequently by fracture, fragmentation and collapse of the lunate bone in more advanced cases (Fig. 3). More detailed assessment can be obtained by the use of either CT or MRI scans. The author prefers the former and indeed would recommend such a scan in all cases as it undoubtedly allows a more detailed examination of the lunate bone. Specifically, to detect the presence of a fracture either complete through the lunate or osteochondral as well as giving a more accurate assessment of collapse (Fig. 4).

Finally in early stages, that is prior to definitive X-ray changes, an MRI scan or bone scintigraphy may demonstrate avascular necrosis.

Classification

The commonest used classification is that described by Lichtman in 1997 which is a modification of an original system described by Stahl in 1947. This classification system is based on plain K-rays (Table 1, Fig. 5).

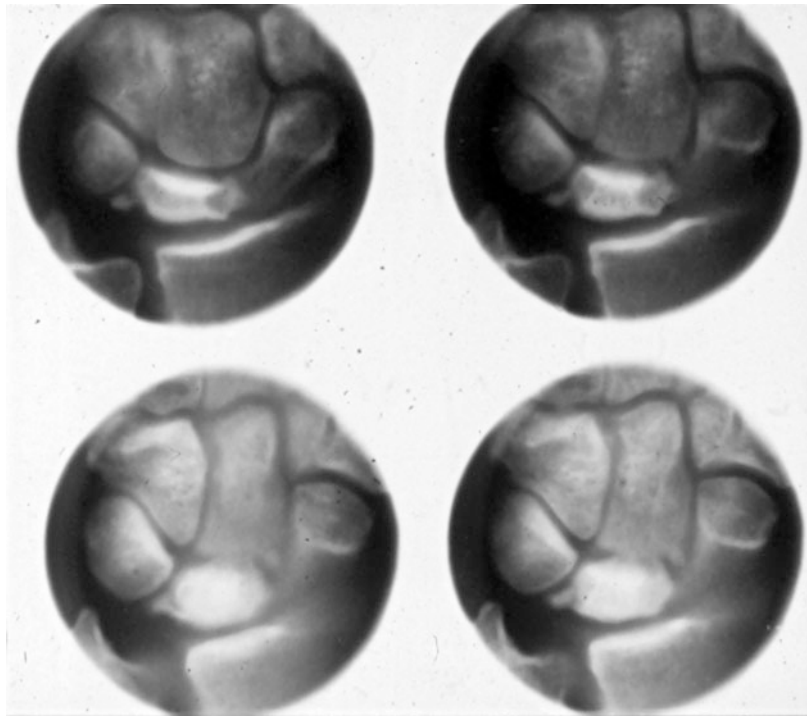

Fig. 3 Wrist tomograms showing collapse of the lunate in an advanced case

Indications for Surgery

Not all of patients who suffer with Kienböck's disease need surgical intervention. As with all conditions the principle indication for surgery is pain; that is pain with a persistent requirement for analgesia, causing sleep disturbance and interfering with day-to-day activities. Added to this are loss of movement and weakness of grip, resulting in a diminution in function. The latter includes an inability to work, play sport and perform heavy day-to-day tasks. Most, if not all, patients should be given a trial of conservative treatment. That is a period of immobilization in either a cast or splint. Whilst this may not halt radiological progression, it is important to remember that in Kienböck's disease as with many other Orthopaedic conditions it is paramount to treat the patient and not their X-ray.

If conservative treatment fails, however, and surgery becomes indicated, then there are various techniques available. All of these procedures generally fall into two categories, that is either *reconstruction* where attempts are made to re-vascularise the lunate and prevent further collapse, or *salvage*. The latter being undertaken when the lunate is so collapsed and fragmented that reconstruction would not be feasible. The procedures used in reconstruction include bone graft, either free or local vascularised, with a joint levelling procedure, usually radial shortening. Examples of salvage procedures include partial or total wrist fusion, or proximal row carpectomy (Table 2).

Operative Techniques: Reconstruction

The techniques for the selection and insertion of local vascularised bone grafts around the distal radius are beyond the scope of this chapter. For this the author is referred to the techniques described by Zaidemberg et al. [28] and further amplified by Moran et al. [11]. At this time the author uses a combination of distal radius cancellous graft and a local vascular graft, either 1,2 inter-compartmental super retinacular artery (1,2 IC SRA) or the

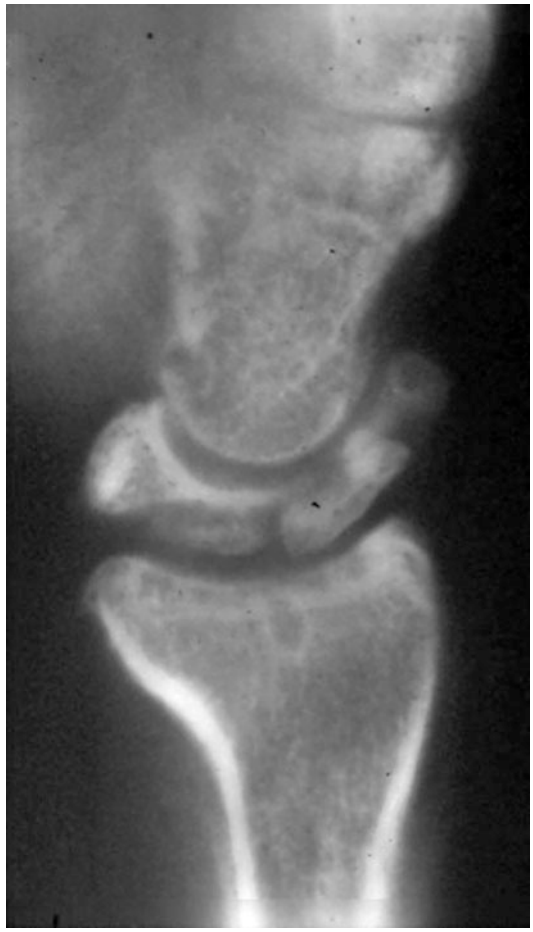

Fig. 4 Lateral radiographs showing an osteochondral fracture of the radial surface of the lunate

Table 1 Lichtman classification

Stage	Description
1	The absence of radiographic changes, diagnosis by either isotope or MRI scan
2	Increased radio density of the lunate on plain x-ray with no lunate or carpal collapse
3a	Increased radio density with associated collapse of the lunate. The collapse generally begins radially on the AP view and the lunate elongates on the lateral projection
3b	Advanced collapse of the lunate with associated carpal instability. Usually the latter involves a flexion deformity of the scaphoid
4	Characterised by the development of generalised degenerative changes within the carpus and fixed rotatory scaphoid subluxation and lunate collapse

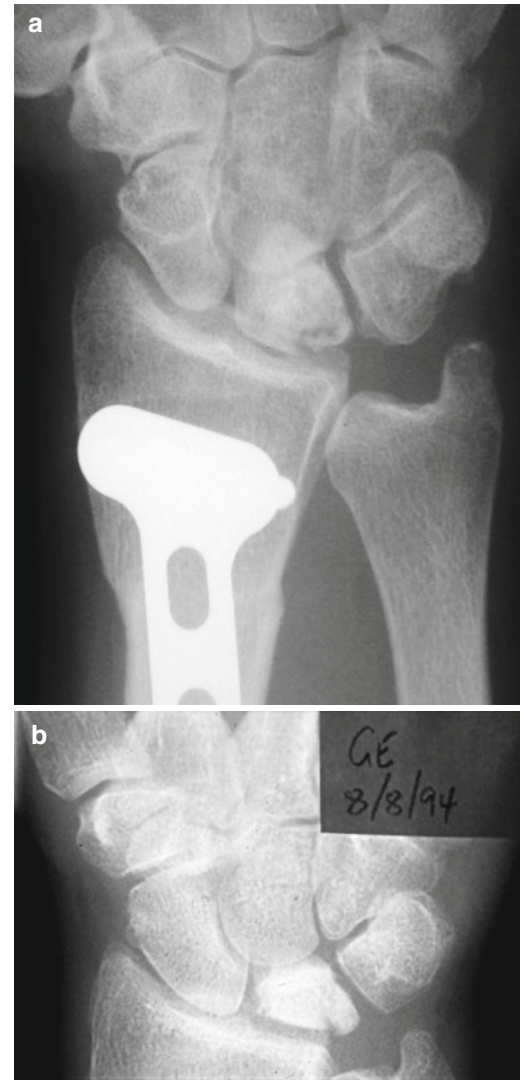

Fig. 5 Radiographic examples of Lichtman stages. (**a**) Stage 2 with no lunate or carpal collapse. (**b**) Stage 3b with both collapse of the lunate and carpus

4,5 extensor compartment artery (4,5 ECA) (Fig. 6). The latter undoubtedly provides a longer pedicle making re-implantation easier and is now preferred. Other techniques include pisiform transfer as described by Erbs and Bohm, or a direct implantation of the second and third metacarpal artery and vein as described by Horii.

Joint levelling procedures are undertaken to reduce the forces transmitted through the lunate

Table 2 Algorithm for surgical treatment in Kienböck's disease

Stage	Description
1	Re-vascularisation with radial shortening if a negative ulnar variance and capitate shortening or STT(scapho-trapezio-trapezoid) fusion if there is neutral ulnar variance
2	Re-vascularisation with radial shortening if a negative ulnar variance and capitate shortening or STT fusion if a neutral ulnar variance
3a	Provided the lunate is not fragmented, has no more than one complete fracture or has not collapsed significantly. revascularisation with radial shortening if a negative ulnar variance and capitate shortening or STT fusion if a neutral ulnar variance
3b	If the lunate has collapsed and fragmented into several pieces, then reconstruction is impossible and salvage should be considered. Options include either a proximal row carpectomy or a partial/total wrist fusion
4	Options include partial/total wrist fusion, or proximal row carpectomy

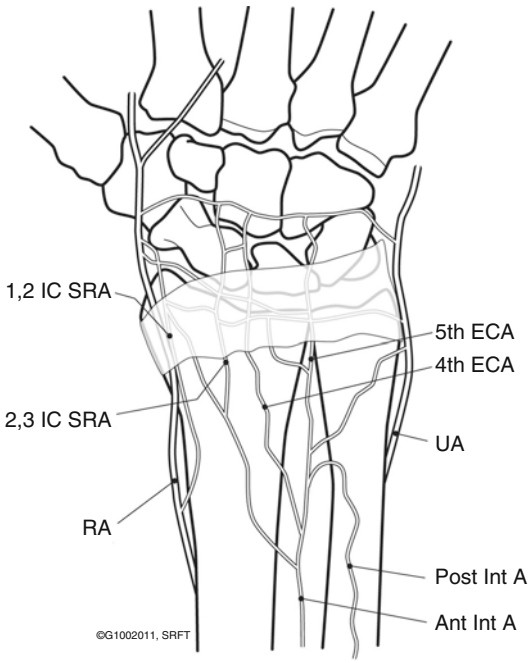

Fig. 6 Diagram of the dorsal aspect of the distal radius and ulna demonstrating extra-osseous vessels

fossa transferring them either to the scaphoid/ scaphoid fossa or triquetrum/ triangular fibrocartilage sections of the wrist. Several biomechanical studies have confirmed that this does occur with both ulnar lengthening, radial shortening as well as capitate shortening and scaphoid-trapezoid-trapezium (STT) fusion. The rationale is that these procedures allow the lunate to revascularise in the presence of a reduced compressive load.

In 1950, Persson described ulnar lengthening and this procedure was used for many years. Unfortunately there is a small but definite incidence of non-union and as a consequence the procedure was replaced by radial shortening. This in now more widely used.

Technique of Radial Shortening

The operation is usually performed under a general anaesthetic with the patient supine and the arm extended on an appropriate table, under strict asepsis and with a tourniquet in situ. A longitudinal incision is made over the flexor carpi radialis tendon (Fig. 7). This begins just distal to the radio-carpal joint and is extended proximally for 6 cm. The flexor carpi radialis tendon is then retracted radially and the base of its sheath again incised longitudinally. Retracting the radial artery laterally and the long flexor tendons and medial nerve medially, the pronator quadratus muscle is visualised. This is released off its radial attachment and reflected ulnarwards exposing the volar surface of the distal radius. The radio-carpal joint is then identified with either the use of a needle or X-ray.

Fixation of the osteotomy is undertaken using one of the numerous distal radial fracture fixation plates now available. Usually a three or four hole plate is required. The chosen plate is then applied to the distal radius and the site of the osteotomy marked (Fig. 8). The distal transverse part of the plate can then be fixed temporarily to the distal radius by two or three screws. It is important at this stage to check the alignment of the plate. The plate and screws are then removed and a section of bone at the osteotomy site removed (Fig. 9).

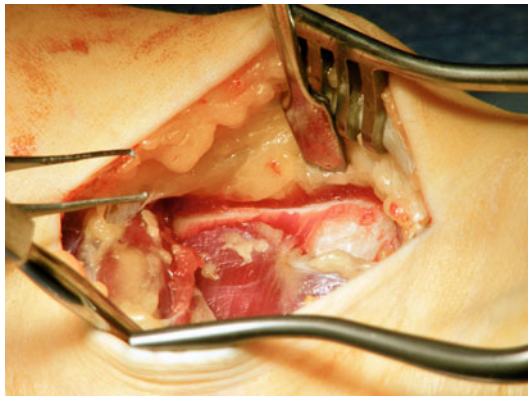

Fig. 7 Dorsal skin incision over the wrist

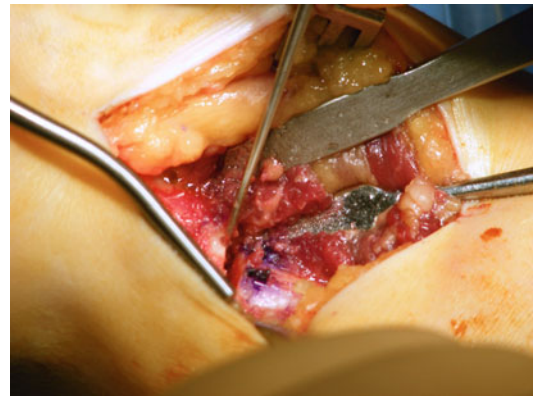

Fig. 9 Removal of section of posterior lunate

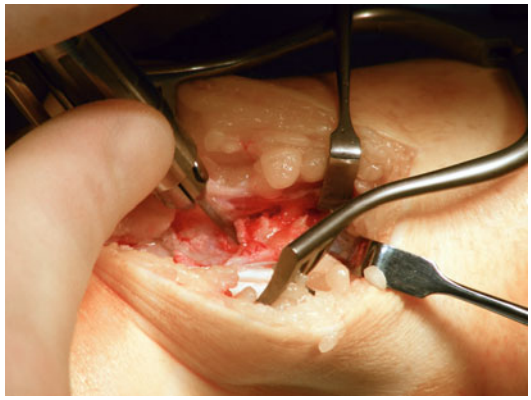

Fig. 8 Site of radial osteotomy

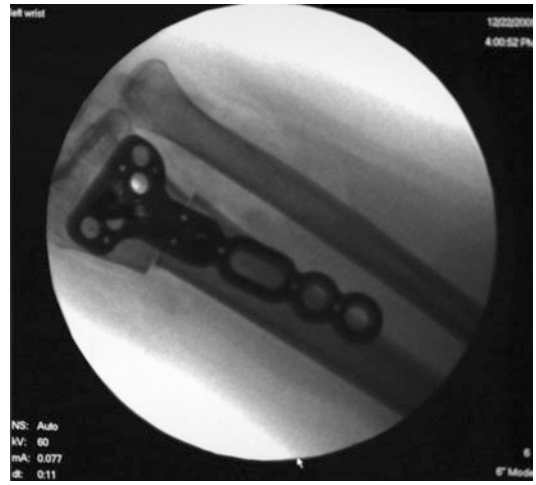

Fig. 10 Post-operative X-ray appearances

It is important at this stage that bone levers are passed around the radius to protect the soft tissues on the dorsal side. The osteotomy is made by way of an oscillating saw and completed by both osteotome and rongeur. As to the width of the bone to be excised, this can be calculated from pre-operative X-rays. The aim is to produce neutral ulnar variance and as a consequence 2 mm is usually enough.

Once this section of bone has been fully removed the plate is then re-attached to the pre-drilled distal holes. With compression the proximal holes are then drilled and the appropriate screws inserted. Finally, any additional distal screw-holes can be filled. All of this is done under x-ray control. At the end of the procedure it is important to check that the plate is in the correct alignment and the screws themselves are not overlong. Protruding screws on the dorsum can be a source of injury to the extensor tendons. It is also important to check that the distal radiao-ulnar joint is now in neutral variance and that movement that in pronatio-supination is free and unhindered (Fig. 10).

The wound is then irrigated and haemostasis obtained, the skin is closed and a drain is left in situ.

The drain is removed at 24–48 h and the skin sutures at 2 weeks. For pain relief, the forearm is splinted for 2 weeks. Thereafter the patient is given a removable splint and exercises to mobilize the distal radio-ulnar and radio-carpal joints.

If the patient already has neutral ulnar variance, then radial shortening is obviously

contra-indicated. In these circumstances the author has used both a scapho-trapezio-trapezoid (STT) fusion [26] as well as capitate shortening [24]. The latter seems particularly useful as it does not appear to diminish wrist movement as markedly. A third alternative is the radial closing-wedge osteotomy as described by Tsumura et al. [22]. This allowed decompression of the lunate fossa, yet does not alter the biomechanics of the distal radio-ulnar joint.

Operative Treatment: Salvage

Salvage procedures include partial or total wrist fusion or, as an alternative, proximal row carpectomy. Many types of intercarpal arthrodesis have been used to treat Kienböck's disease, including scapho-lunate-trapezio-trapezoid, scapho-capitate, radio-lunate as well as scapho-lunate-capito-triquetral. With this type of partial fusion at least some wrist movements can be retained although results can be unpredictable.

The choice between total wrist fusion and proximal row carpectomy is often more difficult. There is no doubt that in someone who wishes to undertake heavy manual work a total wrist fusion is a sensible option. Specifically it eases the pain, increases strength and function but of course abolishes movement at the radio-carpal joint. Sometimes this loss is not fully appreciated by the patient and a trial period in a cast may be of benefit.

Proximal row carpectomy on the other hand again eases pain and the patient will retain some movement. Generally however the wrist will be weaker and there may in some cases be long-term deformity. This is therefore a better procedure for patients who do not undertake heavy manual work, but are involved in clerical, light assembly etc. and wish to retain some movement.

Operative Treatment: Alternative Procedures

Wrist arthroplasty is still in its infancy. Whilst its use in patients with bilateral inflammatory arthritis of the wrist is established, its use for other diagnosis is still to a significant degree controversial. Certainly for an active patient in their 30s it could not be envisaged that a total wrist replacement, at least the currently available designs, would last for 30–40 years.

Denervation of the wrist as popularised by Buck-Gramcko [3], who recommended a full denervation of the radio-carpal joint, has also been used to treat this condition. Whilst in some cases there is no doubt that this procedure can result in a reduction in pain, this is unpredictable.

Other clinicians have attempted to replace the lunate bone in isolation. Most notable was Swanson who developed both silastic and titanium replacements. More recently pyrocarbon devices have become available, although again there are no long-term results.

Results

Conservative Management

Little is known about the natural history of Kienböck's disease. It is however assumed that from the onset of the disease, the lunate will ultimately collapse and fracture. As a result, the carpus itself will collapse and the scaphoid assume a hyperflexed position. Finally and somewhat later, because of the altered biomechanics, the wrist becomes arthritic [9]. Whilst this progression was demonstrated by Keith et al. [8], there is undoubtedly a great variation in rate, with some patients progressing rapidly to stage 3b and others never apparently passing stage 3a. This progression, however, can be monitored clinically by the DASH score as well as loss of palmar flexion of the wrist and radiologically by an increase in the radio-scaphoid angle.

In 1998 Delaere et al. [5] compared the outcome of a group of patients treated operatively by various techniques and a similar group treated conservatively after more than a 5 year follow-up. Generally the outcome in both was similar. As a consequence they concluded that surgical intervention should be carefully considered.

Joint Levelling

Ulnar lengthening has been undertaken for Kienböck's disease for many years. In 1968 Tillberg [19] reported his results in 10 wrists with an average follow-up of 13.5 years. They reported good clinical results with all of the patients being satisfied and no evidence of osteo-arthritis.

In 1996, Trail et al. [21] reported results from the Mayo clinic of 20 patients at a mean of 11 years following surgery. Clinical and radiological evaluation revealed good long-term results, with all patients complaining of less pain than before surgery and with statistically significant increases in range of motion and grip strength. Unfortunately, radiologically a significant number of patients were found still to have lunate fractures and fragmentation.

Radial shortening osteotomy was first described by Hulten in 1935 [13]. Since then results have been reported widely. In 1984 Razemon reported good results with 28 radial shortening procedures, 12 of which were followed up for more than 10 years. A further follow-up of between 18 and 26 years confirmed this outcome. This has been further studied by Almquist and Burn [1] who reported satisfactory results as did Quenzer et al. [12]. Indeed in the latter series a third of patients demonstrated some lunate healing. They also felt that concomitant lunate re-vascularisation or vascularised bone grafting may improve results further. In 2009, Takahara [16] reported their results of radial shortening in patients with Kienböck's disease with negative ulnar variance, as well as an opening-wedge osteotomy in patients that were ulna-neutral or ulna-positive. Salmon et al. [14] presented a comparative study between conservative management and radial shortening. They concluded that the patients treated by radial shortening had less pain and better grip strength at follow-up than those managed conservatively. Indeed, in some patients with stage 3 disease treated conservatively there was a rapid deterioration to carpal collapse. Radial shortening whilst not reversing this trend, did appear to slow the process.

The results of radial closing wedge osteotomy were described by Wada et al. [25] in a 14 year follow-up. They reported good long-term results in all patients despite radiological progression. In addition the radiological parameters did not seem to change.

Of the alternative procedures the results for scapho-trapezio-trapezoid arthrodesis in Kienböck's disease have been mixed. In 1985 Kirk Watson et al. reported their results in 16 cases, all of which received satisfactory pain relief at 20 months follow-up. In some cases a silastic lunate replacement was also used.

Conversely Van den Dungen [23] reported an increased loss of mobility and longer rehabilitation in patients treated by this surgical technique as compared to conservative treatment.

Bone Grafts

There are numerous reports, often in small series, of patients who have undergone various locally-vascularised bone grafts. In 2005 Daecke et al. [4] reported a 12 year follow-up of the use of vascularised os pisiform to re-inforce the lunate in Kienböck's disease. Their results reported an improvement in pain, range of motion and grip strength. Radiologically, however, of the 20 patients, 11 were unchanged and 6 had progressed. Unfortunately osteoarthritis was found in seven. In the majority, however, the transfer did appear to prevent lunate collapse.

The use of the 4,5 extensor compartmental vascularised bone graft for the treatment of Kienböck's disease was reported upon by Moran et al. [11]. Whilst follow-up was short, there was an improvement in grip strength and pain. Radiologically, there was no further collapse and an MRI scan did reveal evidence of revascularization and improvement in the T2 and/or T1 signal.

Finally, the results of free vascularised iliac crest bone grafts was described by Arora et al. (2007) [2], who were able to show definite osseointegration of the graft in the majority of patients with an improvement in clinical parameters. In addition radiologically restoration of the carpal height was demonstrated.

Partial or Total Wrist Fusion

In 2001 Takase and Imakiire [17] reported a long-term follow-up of lunate excision and intercarpal arthrodesis for advanced Kienböck disease. The arthrodesis used was a modified Graner procedure, an arthrodesis of all intercarpal joints except those of the trapezium and pisiform. In this small series, they reported a diminution in pain, with recovery of grip strength to 80 % on the unaffected side. However X-ray changes of osteoarthritis were seen in all patients.

A different view was expressed by Tambe et al. [18], who compared a small group of patients who had limited carpal fusions against a smaller group of total wrist fusions. The visual analogue pain score, patient satisfaction and functional scores were better in the total wrist group, whilst range of motion and grip strength were better with a limited carpal fusion; although this was not statistically significant. Of greater importance however, four patients that is 30 % of the limited carpal fusion group underwent further surgery for non-union. As a consequence they concluded that total wrist fusion should be offered earlier to patients with advanced stages of the disease.

Proximal Row Carpectomy

The long-term results following proximal row carpectomy were reported by Tomaino et al. [20], who reported the results of 23 wrists at an average of 6 years after surgery. One of the principal indications for surgery being Kienböck's disease. In this series there was a high satisfaction rate for pain relief and function, with 60 % retained motion compared to the contralateral side and 79 % grip strength compared to the contralateral side. Radiocarpal arthritis did develop in three patients (15 %) but only one required surgery, in this case arthrodesis.

Alternate Procedures

The results of denervation of the wrist were described by Schweizer et al. [15], who reported a retrospective review of 71 complete denervations of the wrist in 70 patients with an average follow-up of 9.6 years. The principle indication was Kienböck's disease. They reported a long-term improvement in two-thirds of patients and complete or marked pain relief in half.

The role of silicone replacement arthroplasty was assessed by Lichtman et al. [10]. They reported satisfactory results in 14 out of 20 wrists. They did feel however it should be done earlier in the diagnosis, that is, in the early Lichtman stages.

Summary

Kienböck's disease or avascular necrosis of the lunate bone is an uncommon condition affecting the wrist of young adults. The diagnosis should be considered in an individual who presents with an insidious onset of continuing pain, stiffness and weakness of the wrist. The diagnosis is usually confirmed by a plain X-ray, although bone scans can be used in the early stages. In addition, a CT or MRI scan will give additional information, particularly with regard to the shape of the lunate, the presence of any fractures, the degree of carpal collapse as well as any other associated findings.

Classification is traditionally by the Lichtman grade. However, surgical treatment if necessary is sub-divided into reconstructional or salvage. Reconstruction should be considered if the lunate has retained a significant amount of its shape and has not become fragmented. Surgical technique's commonly used include some form of joint levelling procedure, usually radial shortening, together with the insertion of a bone graft. Lunates that are fragmented and deformed are probably best treated by salvage procedures. These include, partial or total wrist fusion or proximal row carpectomy. The former being ideal for someone who requires a strong wrist and the latter for someone who wishes to retain some movement. Finally, for the later stages, when osteoarthritis supervenes, treatment should be targeted towards the arthritic process rather than the lunate.

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