30 Arthroscopic Partial Wrist Fusion

Pak-cheong Ho

Introduction

Partial wrist fusion or limited carpal fusion is considered as a motion-preserving salvage procedure for multiple painful wrist conditions. It is a good alternative, particularly for those patients who would prefer a mobile functional wrist rather than a solid total wrist fusion [1]. The wrist consists of multiple bony linkages from the forearm to the metacarpus via the carpal bones, and this anatomical peculiarity offers an opportunity to allow fusion of the painful segments of the wrist while preserving motion in the other unaffected segments. It also helps to halt any predictable mechanical collapse of the carpal column and maintain carpal height in the carpal instability conditions due to failure of the ligament constraint or loss of the bony integrity such as in scaphoid nonunion and Kienbock's disease.

A wide variety of partial wrist fusion has been designed in the past to address problems arising from various parts of the wrist [2–5]. Essentially all carpal bones and intervals can be fused selectively, and the resulting motion loss and the biomechanical effect have been studied extensively in laboratory and in the clinical settings [6–11]. The fusion can take place between the radius and the proximal carpal row such as radiolunate fusion and radioscapholunate fusion; between the two carpal rows such as the scaphotrapeziotrapezoid fusion, scaphocapitate fusion, capitolunate fusion, triquetrohamate fusion, and the four corner fusion involving the medial carpal bones; and within the proximal carpal row such as scapholunate fusion and lunotriquetral fusion. The operations being described in the literature and commonly in use are open surgery requiring much soft tissue dissection including capsular and ligament incisions around the wrist to expose the carpal intervals. This may lead to iatrogenic stiffness of the joint on top of the mechanical constraint rendered by the selected carpal fusion. The expected loss of motion can be predicted theoretically from the biomechanical models, though in practice, the final range of motion retained clinically will also rely on the degree of soft tissue contracture and the amount of compensatory hypermobility of the adjacent mobile segments. Thus, it is desirable to minimize surgical insult to soft tissue so as to maximize the motion preservation which is always the interest of both the patients and the surgeons.

Arthroscopic intervention in partial wrist fusion has potential advantages of a minimal surgical damage to the supporting ligaments and the capsular structures of the wrist while allowing an unimpeded view to most articular surfaces of the joints and the important soft tissue elements. This ensures a more accurate staging of the arthritis and facilitates clinical decision making on the most appropriate choice of fusion. The remaining carpal motion can be maximized and postoperative pain reduced, which favors rehabilitation. There is also cosmetic benefit with the minimal surgical scar.

This chapter describes our pioneer experience in the past 15 years in developing this surgical concept and technique for various clinical conditions.

Indications and Contraindications

The main indication for a partial wrist fusion is the painful arthritic conditions of the wrist which affect part of the articulating system and the patient would like to have adequate pain control as well as preservation of a useful functional arc of motion. This is best indicated in posttraumatic arthritis and osteoarthritis. Common indications include scapholunate advanced collapse (SLAC), scaphoid nonunion advanced collapse (SNAC), Kienbock's disease, post-distal radius fracture radiocarpal joint arthrosis, and scaphotrapeziotrapezoid (STT) arthritis. Chronic painful carpal instabilities with or without secondary arthritic change are also good indications. These include chronic

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lunotriquetral instability, capitolunate instability, palmar midcarpal instability, and radiocarpal translocation. In inflammatory arthritis such as rheumatoid arthritis and crystal deposition disease, the disease progression should be optimally controlled by the pharmacological mean and should not be at an active proliferative phase. This can avoid a rapid deterioration of the clinical improvement due to a progressive involvement of the unfused segments of the wrist. Patients with multiple joint involvement of the same upper limb may have stronger desire to preserve motion over the wrist to compensate for the stiffness over the other joints. Arthroscopic version of partial wrist fusion is a particular good option for patient conscious of a surgical scar and would like to have less postoperative pain and a potential faster rehabilitation.

Partial wrist fusion is contraindicated when there is an active ongoing sepsis over the wrist joint, panarthritis involving all or most compartments of the wrist, and rapidly progressive inflammatory arthritis at a proliferative stage. Partial wrist fusion is also not a guarantee for pain relief. The potential advantage of partial wrist fusion in preserving a useful arc of motion may be offset by the risks of nonunion or by a continuing pain despite a successful fusion [12]. Nagy and Büchler reviewed a cohort of 15 cases of radioscapholunate fusion and reported a nonunion rate of 27% [13]. Nearly half of them showed secondary degenerative changes of the midcarpal joint, two of which were progressive. Four patients had continuing symptoms despite a sound radiological union of the partial wrist fusion. Revision of total wrist fusion was required in 33% of cases ultimately. Thus, those patients who prefer a more guaranteed outcome on the pain control, do not want multiple surgical procedures, and do not bother a loss of wrist motion may be better candidates for a total wrist fusion. Chronic smoker has higher incidence of nonunion after partial wrist fusion and required more revision surgery to achieve a union. Alternative for pain control treatment such as a wrist denervation can be considered. Total wrist arthroplasty can be considered in the older patients with limited functional demand. Accompanying distal radioulnar joint pathology would not be altered by the partial wrist fusion and needs to be tackled separately or concomitantly. Arthroscopic partial wrist fusions are technically demanding procedures and should not be lightly taken by surgeons without much experience in therapeutic arthroscopy of the wrist. Patients with preexisting extensor tendon pathology over the wrist region may have higher incidence of tendon complications associated with complex arthroscopic wrist reconstruction procedures. Severe arthrofibrosis, joint contracture, and long-standing carpal collapse or wrist deformity may also pose additional difficulty and risk for the surgeons in using the arthroscopic approach.

Technique

The general principles in all forms of arthroscopic partial wrist fusion should include the following steps:

1. Set up and instrumentation
2. Arthroscopic surveillance for final staging of the disease
3. Cartilage denudation
4. Correction of carpal malalignment
5. Provisional fixation of the fusion intervals
6. Augmentation of the fusion segment(s) with bone graft or bone substitute in selected indications
7. Definitive fixation

General Approach

Set Up and Instrumentation

The operation is typically performed under general anesthesia for convenience and patient comfort in harvesting the bone graft if it deems necessary. It can be done under regional anesthesia if bone substitute is employed, or when no bone graft or substitute augmentation is needed. Either injectable or small granule form of the bone substitute is suitable for the purpose. There is a tendency of not using any bone graft or bone substitute augmentation if a rigid fixation device such as cannulated compression screws can be applied to the fusion site, and the fusion surfaces are congruent enough without excessive dead space. C-arm fluoroscopy should be available in all cases for intraoperative assessment. The list of essential instruments includes a motorized full-radius shaver and burr system of diameters ranging from 2.0 to 3.5 mm, small angled curette and ring curette, 2.5 mm suction punch, radiofrequency thermal ablation system, K-wires, and small cannulated screw system.

The patient is put in supine position while the operated arm is supported on a hand table. Either side of the iliac crest region is draped for bone graft harvesting depending on the patient's preference. An arm tourniquet is applied, but need not be inflated routinely. A tight application of the tourniquet without inflation leads to venous engorgement and can induce more troublesome bleeding. Most of the procedures can be done without the use of a tourniquet. Piñal advocates the use of dry arthroscopy to avoid the problem of swelling and the extravasation of fluid, but the use of tourniquet becomes mandatory throughout the procedure which may take extended time [14]. A vertical traction of 4–6 kgf is applied through plastic finger trap devices to the middle three fingers for joint distraction via a wrist traction tower. We employ continuous saline irrigation and distension of the joint by using a 3-liter bag of normal saline solution suspended at 1–1.5 m above the operating table and instill with the aid of gravity to maintain a clear arthroscopic view. Infusion pump is not necessarily and is potentially harmful in causing an extravasation of fluid. In wrist arthroscopy, it is mainly the distraction device that keeps the joint opened, not the fluid irrigation like in the shoulder joint.

Arthroscopic Surveillance

We perform routine inspection of both radiocarpal joint through 3/4 portal and midcarpal joint through MCR portal using a 2.7- or 1.9-mm video arthroscope. The aim of the examination is to establish a precise arthroscopic staging of the pathology. Adrenaline solution of 1 in 200,000 dilution is injected to the portal site skin and capsule to reduce bleeding associated with incision [15] (Fig. 30.1). Intra-articular injection is optional and may reduce bleeding associated with the arthroscopic procedures. The outflow is established at 6U portal just volar to the ECU tendon using an 18G needle. In general, all portals should be marked after careful palpation with surgeon's thumb tip and the wrist being distracted on the traction device before saline was injected intra-articularly.

Once the arthroscope is being inserted, particular attention is paid to assess the status of the interosseous ligaments, the degree of synovitis, and the articular cartilage condition of the joints intended to be fused and the other uninvolved joint compartments of the wrist. The latter is essential to determine whether the proposed fusion is appropriate or not. The dorsal rim of the radial styloid is a common site of occurrence of the early SLAC or SNAC wrist arthritic changes and should be assessed in all cases by rotating the 30° forward slanting lens downward to reach the area. The frequently associated localized posttraumatic synovitis in this area may obscure the observation of cartilage condition. The synovial growth needs to be eliminated by using a 2.0-mm shaver or a radiofrequency probe inserted from 4/5 portal. It may be necessary to swap the portal of the arthroscope and instrument in order to obtain a better attacking angle of the instrument for a more efficient synovectomy. The ulnocarpal joint should also be routinely inspected and the status of TFCC ascertained. Any central perforation of the TFCC without peripheral involvement should be debrided of any unstable flap tear at the same operation to avoid possible new source of pain after the definitive index procedure.

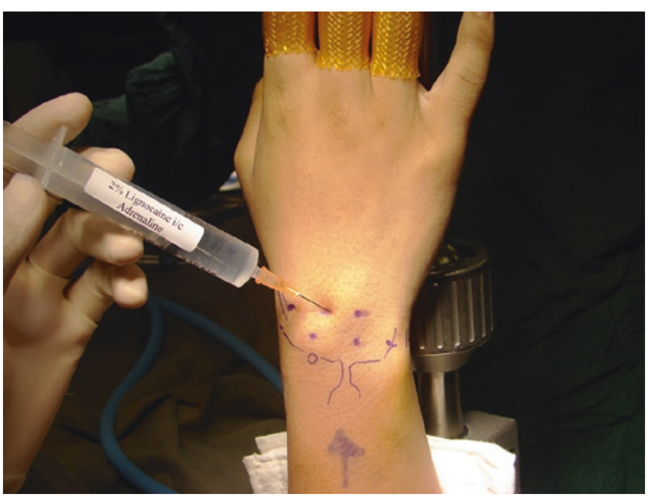


Fig. 30.1 Lignocaine 2% with adrenaline solution in 1:200,000 dilution is injected to portal sites for hemostasis effect

The midcarpal joint is approached through the MCR portal. Routinely the STT joint, scaphocapitate joint, capitolunate joint, and triquetrohamate joint are inspected for cartilage lesion and synovitis. The scapholunate and lunotriquetral joints are assessed for stability with a 2-mm probe introduced from the MCU portal. Any instability is graded according to the Geissler classification. Synovial overgrowth should be debrided by using a shaver or radiofrequency probe to adequately expose the underlying cartilage area for assessment of the true extent of chondral damage and subchondral bone exposure. In posttraumatic arthritis, difficulty may be encountered when developing the radial portal at the midcarpal joint due to the intra-articular adhesion and periarticular soft tissue contracture. Under this circumstance, one should not hesitate to shift to the midcarpal ulnar portal where joint space is usually more generous. Once the joint is entered, the other portal can be developed more easily by applying an 18G needle through the skin under direct vision. This greatly helps the localization of any difficult portal. A prerequisite for a successful radiocarpal fusion is a relatively intact articular surface at the midcarpal and STT joints. If significant arthritic change is present, one may need to abandon the planned procedure and consider other salvage option such as total wrist fusion. Two accessory portals may also be recruited during any midcarpal procedure. The triquetrohamate (TH) portal can be located by palpating the tendon of ECU and moving distally until the palpating finger reaches the hamate bone. The portal is then located at the axilla between the ECU tendon and the hamate. It is most useful as an outflow portal. The scaphotrapeziotrapezoid (STT) portal is situated about 1 cm radial and slightly distal to the MCR portal just ulnar to the EPL tendon slightly distal to the MCR portal. The portal is located at the junction between the scaphoid, trapezoid, and trapezium. Care should be taken in avoiding injury to the radial artery which is radial to the EPL tendon.

Cartilage Denudation

The articular surfaces of the joint compartments to be fused are then prepared. The extent and depth of cartilage denudation should be precisely controlled using a 2.9-mm arthroscopic burr. In debriding the carpal interval of the same carpal row, such as lunotriquetral or capitohamate interval, a smaller burr such as 2 mm sized should be used to cater for the narrower joint space to avoid excessive cartilage and subchondral bone removal. Either forward or reverse blade rotation mode should be adopted at a speed of 2000–3000 rpm. Oscillating mode is not as effective as compared to the unidirectional mode. One should be cautious about the jumping phenomenon when using a burr to attack a particularly sclerotic bone surface. The burr may get caught in the area of hard subchondral bone during the high-speed revolution. The resultant force will bounce the burr off the bone and may lead to accidental damage of the articular surface of the surrounding or opposing carpal bones. To have better control of the instrument, the surgeon is recommended to hold the arthroscopic burr near the far end with the surgeon's thumb and index finger, while using the middle finger to firmly anchor the burr over the skin around the portal site (Fig. 30.2). There should be maximal preservation of the subchondral bone so as to maintain carpal height. Burring is completed when the subchondral cancellous bone with healthy punctate bleeding is reached. This phenomenon can be easily observed if a tourniquet is not used during this process (Fig. 30.3). Usually, bleeding is limited and can be well controlled with the hydrostatic pressure applied through the irrigation system. If bleeding is profuse, one may further elevate the suspension of the instilling saline bag to increase the hydrostatic pressure, or use the coagulation mode of the radiofrequency apparatus. During the burring process, suction is switched on and off intermittently to remove any accumulated bone debris which may block the visual field. If suction is applied continuously during the burring process, excessive air bubbles drawn in will severely compromise the visibility of the operating site.

Fig. 30.2 To have better control of the instrument, the arthroscopic burr is being held near the far end with the surgeon's thumb and index finger, while the middle finger firmly anchors the burr over the skin around the portal site

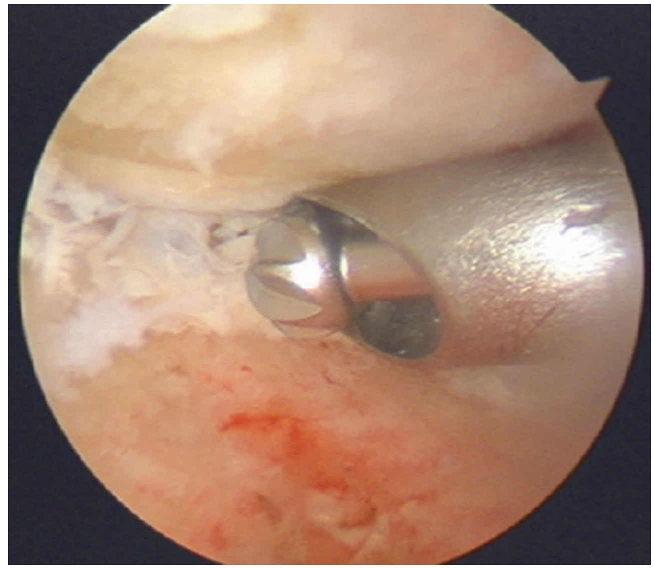


Fig. 30.3 Punctate bleeding can be readily seen from the subchondral bone during burring without the use of tourniquet

Correct Carpal Deformity

DISI deformity is commonly present in many posttraumatic wrist arthritis conditions. It is prudent to correct the deformity as far as possible during the process of partial wrist fusion involving the capitate-lunate joint in order to maximize the motion and to reduce abnormal loading through the lunate fossa. A close reduction can be accomplished by correcting the radiolunate angle to zero degree using a K-wire to transfix the radiolunate joint with the wrist in moderate flexion and slight ulnar deviation (Fig. 30.4). A 1.1-mm K-wire is introduced percutaneously through a small stab wound over the distal radius slightly proximal to the sigmoid notch level, aiming at the level between the 3/4 and 4/5 portals. A fine tip hemostat or stitch scissor should be used to dissect bluntly the extensor tendons to avoid iatrogenic injury or tethering of the extensor tendons during the introduction of K-wire through the skin. The precise location of the insertion point and insertion angle should be guided by an image

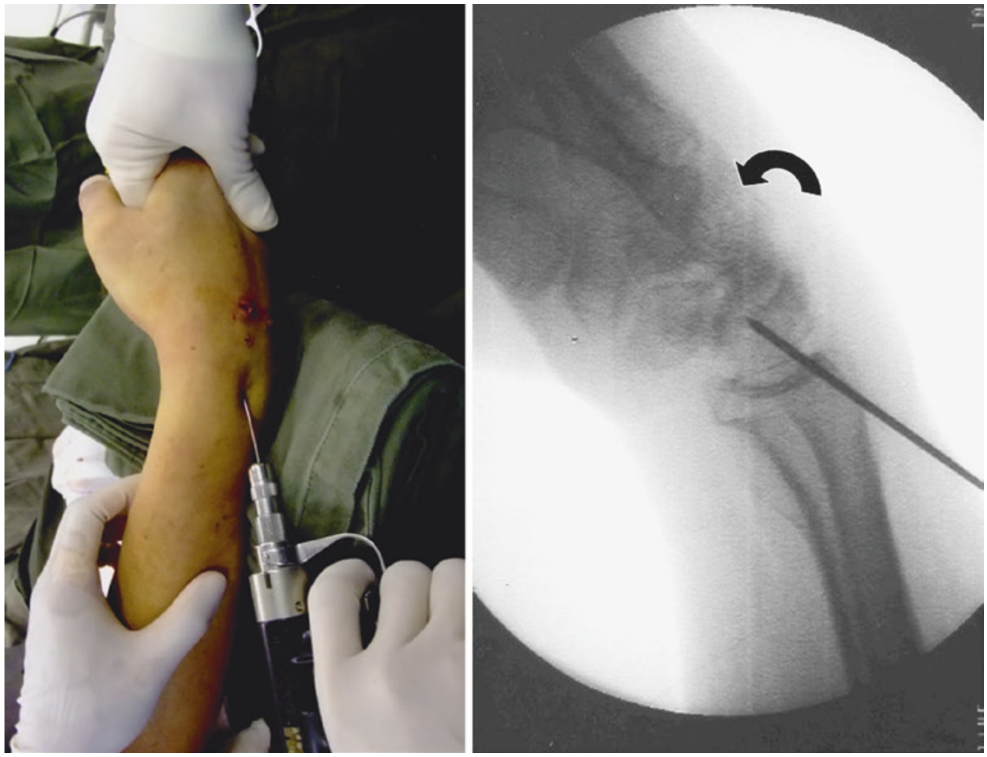


Fig. 30.4 DISI deformity of the lunate can be closely reduced by flexing the wrist and transfixing radiolunate interval at an anatomical alignment before reduction of other carpal bones in relation to lunate

intensifier both in the anteroposterior and lateral projection. The K-wire should not perforate through the distal cortex of lunate so as to leave a space at the capitate-lunate joint. Before the final fusion progress, the other carpal bones are realigned manually in relation to proper lunate position.

Provisional Fixation of the Carpal Fusion

The wrist is dislodged from the wrist traction tower and is placed horizontally over a hand table for the provisional fixation. The carpal interval(s) to be fused is temporarily fixed with 1.0 or 1.1 mm K-wire percutaneously using a powered driver in an anatomical position as far as possible. Alignment is confirmed with an intraoperative image intensifier. The K-wires can be used as definitive fixation device or they can be used as the guide pins for the subsequent conversion into percutaneous cannulated screw fixation. The pins are then withdrawn to free from the joint to be fused while they are maintained in position in the carpal bone or distal radius. Externally the pins should be protected with pin caps to avoid accidental injury to the surgeon's hand in the remaining process. The joint is then ready for grafting with autogenous cancellous bone or bone substitute.

Augmentation of the Fusion Segment(s) with Bone Graft or Bone Substitute

Autogenous bone graft or bone substitute is frequently required to fill up the voids between the articular surfaces to be fused. As the vascularity and the bone quality of the fusing bones are usually adequate, cancellous chip graft from

Fig. 30.5 Foley catheter blocking technique to avoid spillage of bone graft/substitutes to the uninvolved space

iliac crest may not be essential and there is an increasing role of using bone substitute to reduce the potential donor site morbidity with similar outcome. Both injectable form and small granule form are suitable for the purpose. In order to prevent spillage of the graft inside the joint to the undesirable compartments, special Foley catheter balloon blocking technique has been developed (Fig. 30.5). A French size 6 Foley catheter with a stylet on is introduced through the arthroscopic portal. The tip of the catheter is usually cut short to allow better placement of the balloon. Advancement of the catheter into the joint can be facilitated by grasping the tip of the catheter using a small arthroscopic grasper introduced from a third portal. Once the balloon portion of the catheter is completely inside the joint as monitored through the arthroscope, it can be inflated with saline solution until the joint compartment away from the fusion interval is largely obliterated by the balloon. The balloon remains inflated during the arthroscopic bone graft process so that redundant cancellous graft or bone substitute will not fall into and be trapped in other compartments not going to be fused. Reducing fluid inflow is also a useful trick to avoid graft spillage.

An arthroscopic cannula is introduced through the appropriate portal directly opposing the fusing surfaces. If autogenous graft is to be used, cancellous bone graft is harvested from the iliac crest using either trephine technique or an open approach through a small incision. The bone graft is then cut into small chips using scissor and delivered through the cannula with a slightly undersized trocar with a flat end such as the bone biopsy trocar into the joint cavity (Fig. 30.6). Trocar with roundish end is not effective enough. Too exact fitting of the trocar in the cannula will cause an easy trapping of bone graft substance between the trocar and cannula wall and may lead to delivery problem. So a slightly undersized trocar is more desirable. The bone graft is impacted with the trocar till satisfactory volume of graft is achieved (Fig. 30.7). This process requires two assistants to execute smoothly. One assistant helps to maintain the position of the arthroscope to provide optimal vision of the fusion site. The operating surgeon controls the arthroscopic cannula and trocar. A second assistant is responsible to deliver the bone graft or bone substitutes into the opening of the cannula in small volume every time. The operating surgeon then drives the bone

Fig. 30.6 Bone graft is delivered through a cannula with a slightly undersized trocar of flat end such as the bone biopsy trocar into the joint cavity

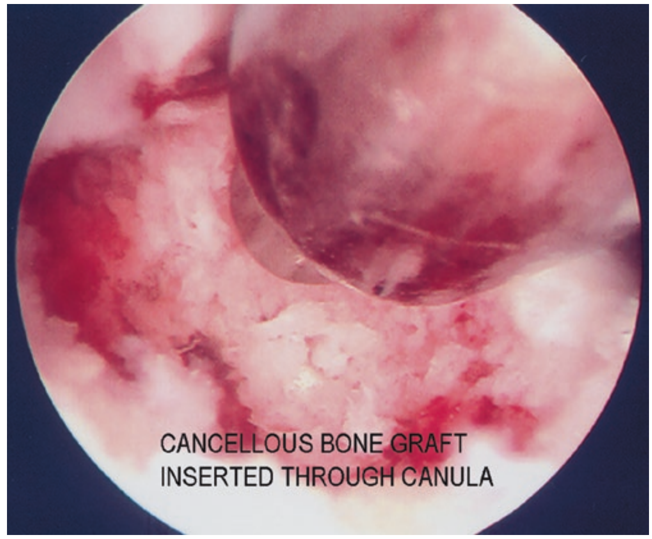


Fig. 30.7 Impaction of graft with blunt trocar at fusion site

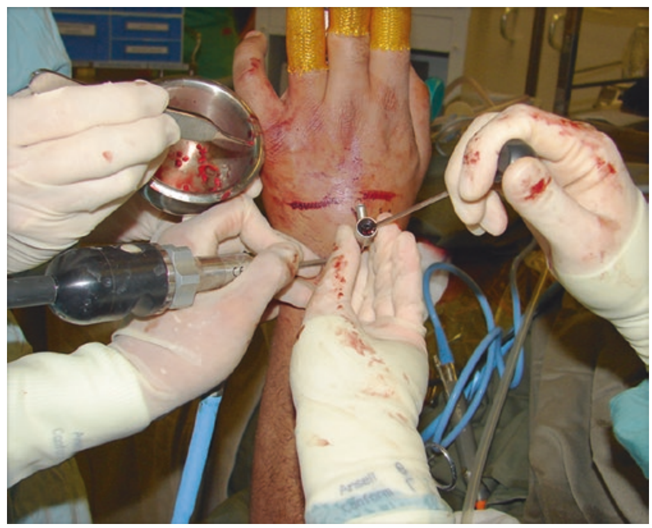


Fig. 30.8 With the help of two assistants, the operating surgeon controls the arthroscopic cannula and trocar and drives the bone graft or substitute into the fusion site under direct arthroscopic monitor

graft or substitute into the fusion site under direct arthroscopic monitor (Fig. 30.8). The speed of the process can be enhanced by using a cannula of wider bore such as 4.5 or 5 mm so that each time more graft can be accommodated. If injectable bone substitute is to be used, joint irrigation should be ceased and all joint fluid evacuated with suction. A wide bore needle connecting the syringe containing the bone substitute is inserted through appropriate portal to reach the fusion site. Injection of the bone substitute can then be performed under direct vision till the cavity is filled up completely. If necessary, intraoperative fluoroscopy can help to confirm the completeness of the filling process.

Definitive Fixation

The wrist is taken off from the traction tower again and placed in the hand table. Definitive fixation is performed by driving the K-wires across the bony interval to be fused and in a correct carpal alignment. If cannulated screw is preferred, the K-wires will then serve as the guide pins. After measuring the length of the screw required, the pin tract is drilled using a cannulated drill bit. Stable internal fixation can then be achieved with compression screw using appropriate percutaneous cannulated screw system, preferably a headless screw system to avoid screw head impingement. The final carpal alignment, screw position, and length should be assessed by using an image intensifier. In older patient with osteoporotic bone, multiple K-wires fixation is preferred over screw fixation to avoid hardware problem, such as the protrusion of screw tip into the joint (Fig. 30.9). Percutaneous K-wires should be cut short and buried underneath the skin. They are removed under local anesthesia when the bone healing is complete. Exposing pins outside skin may predispose to pin tract infection. The wrist is then immobilized with a plaster slab.

Specific Fusion Technique and Rehabilitation

STT Fusion

STT fusion is commonly indicated in stage I or II SLAC wrist, Kienbock's disease stage IIIa or IIIb, and STT joint arthritis [16–18]. It is frequently performed together with a radial styloidectomy, which can also be accomplished under an arthroscopic mean. The best indication for arthroscopic STT fusion is STT joint arthritis, with or without association with SLAC wrist. Under such circumstance, there is usually no scaphoid malalignment and hence no DISI deformity needed to be correct.

Radiocarpal joint arthroscopy should be routinely performed to look for arthritic changes over the radioscaphoid and radiolunate joints. Arthritic change in the former compartment may make the radial styloidectomy a necessary accompanying procedure, while change in the latter compartment may constitute a contraindication of the procedure.

Arthroscopic STT fusion is then performed at the midcarpal joint. The STT portal is often required to provide a direct access to the STT joint. The arthroscope is inserted in the MCR portal and directed toward the STT joint by climbing up the slanting articular surface of the scaphoid over the waist portion opposing the capitate till the scaphotrapezoid-capitate junction is reached. The latter is signified by an inverted Y-shaped joint interval, which I call it as "Mercedes Benz" sign (Fig. 30.10). In STT arthritis condition, the joint is frequently obliterated by synovial overgrowth and joint debris (Fig. 30.11). They need to be cleared up with a shaver and/or radiofrequency probe before the articular cartilage condition can be verified. The joint space may also be contracted with the periarticular soft tissue fibrosis. Joint entry

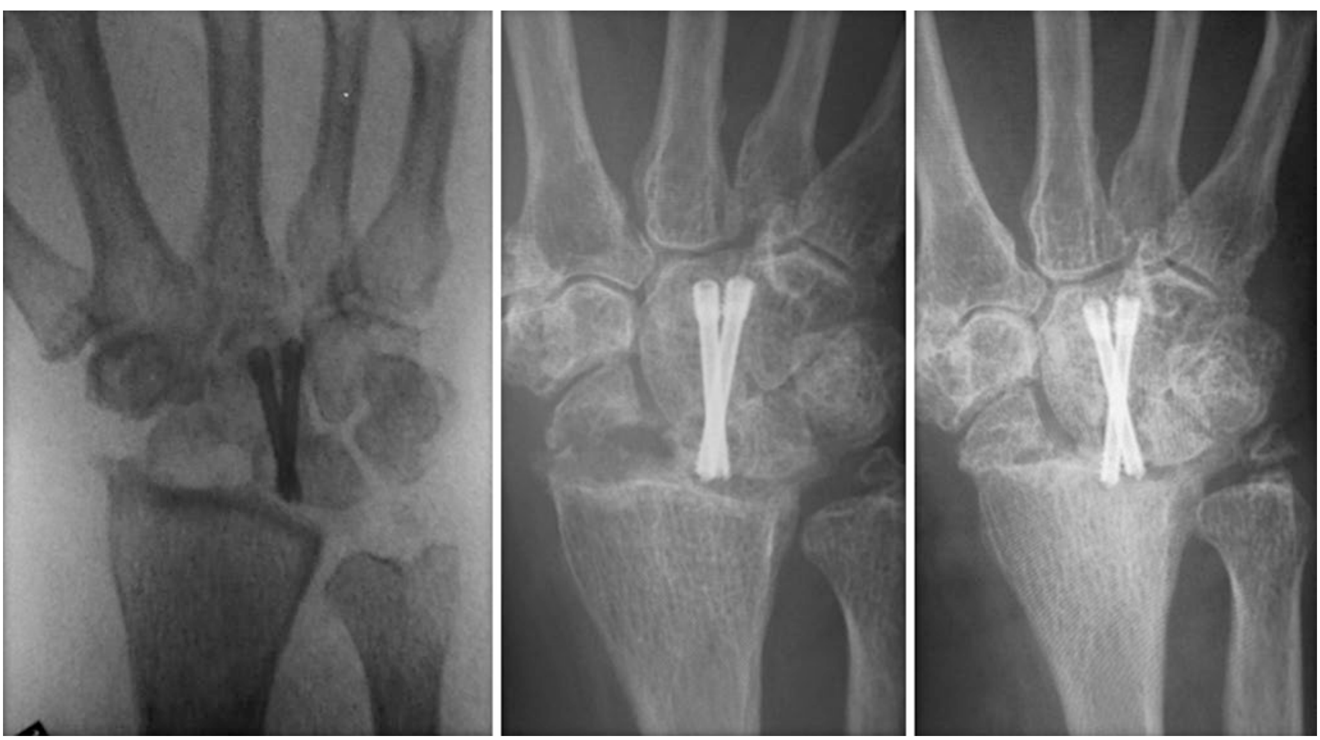


Fig. 30.9 Self-tapping headless screw may protrude into the joint gradually during healing process of the fusion site in old patient with osteopenic bone

can be facilitated by using a smaller arthroscope such as 1.9 mm. Sometimes the joint space in the whole radial compartment of the midcarpal joint may be compromised and one should not hesitate to start the joint exploration through the ulnar midcarpal portal, which is always less affected under such circumstances. Nevertheless, joint space usually gets enlarged after a period of joint debridement procedure and manipulation to allow sufficient access for the subsequent grafting procedure with bigger instruments. The arthritic joint surface is then debrided of the remaining articular cartilage till subchondral bone is exposed. Initially the trapezium may be difficult to reach as it is situated in deeper space at the STT joint. As long as the cartilage surface of the distal scaphoid and trapezoid is removed with arthroscopic burr, there is progressively more space for the burr to reach the surface of the trapezium. Due to the relatively tight space, bleeding from bone ends may obscure the operative field and tourniquet may be required to control bleeding at this junction temporarily. The proximal part of the articular surface between the trapezium and trapezoid should also be denuded of cartilage with an arthroscopic burr. However, complete take down of the articular surface is probably not necessary as normally the TT joint is very tight and stable.

Once the articular surface for fusion is well prepared, a percutaneous fixation of the STT joint can be performed. Fixation can be in the form of K-wires transfixing scaphotrapezial, scaphotrapezoid, and trapeziotrapezoid joints. I prefer to employ rigid fixation using a cannulated screw with compression inserted from trapezium to scaphoid percutane-

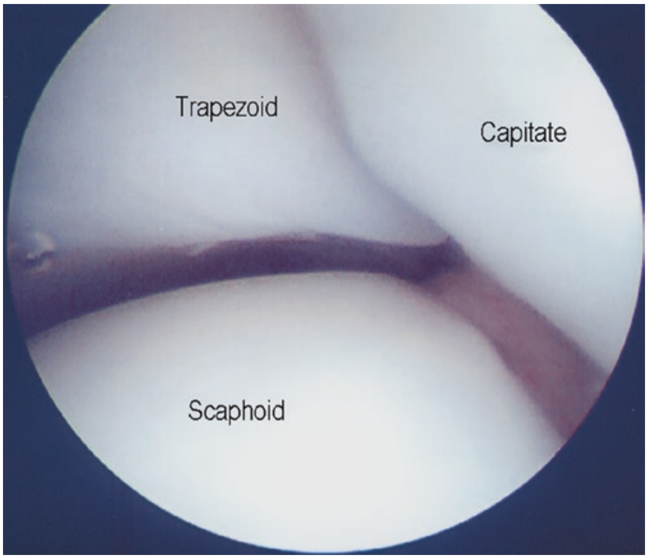


Fig. 30.10 Mercedes Benz sign at junction between capitate, trapezoid, and scaphoid

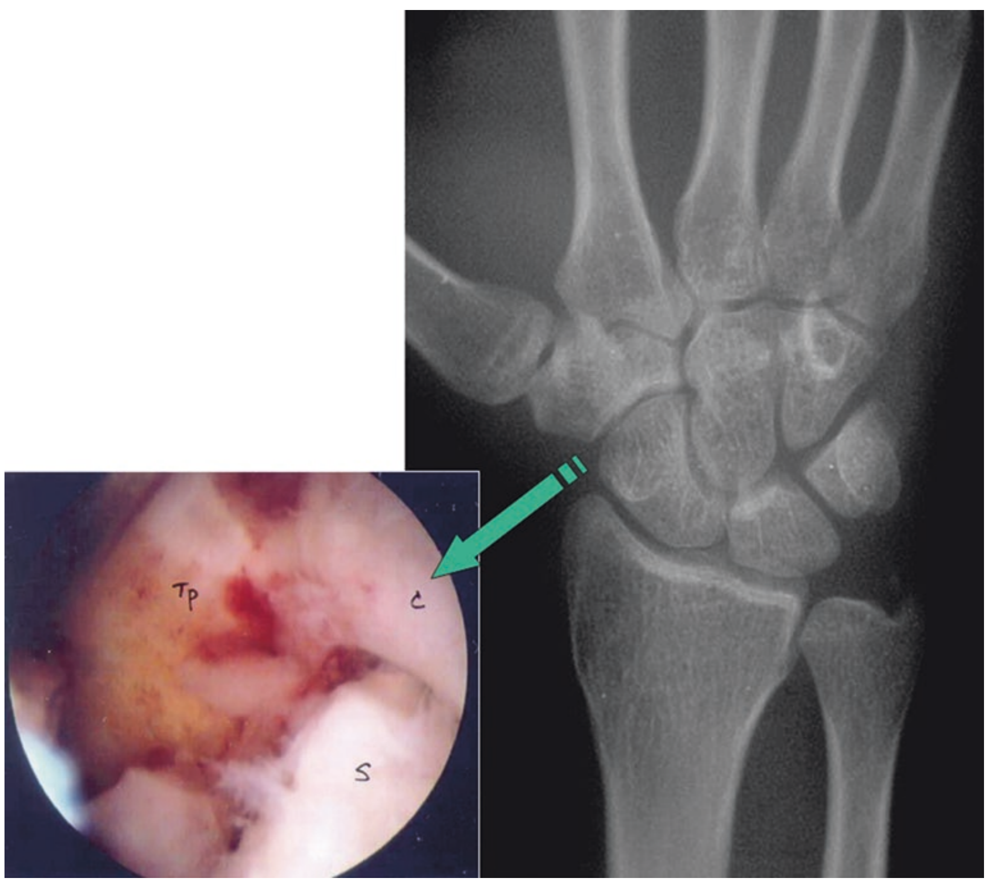


Fig. 30.11 Radiological and arthroscopic view showing typical posttraumatic STT joint arthritis with synovial overgrowth and eburnation at joint surface

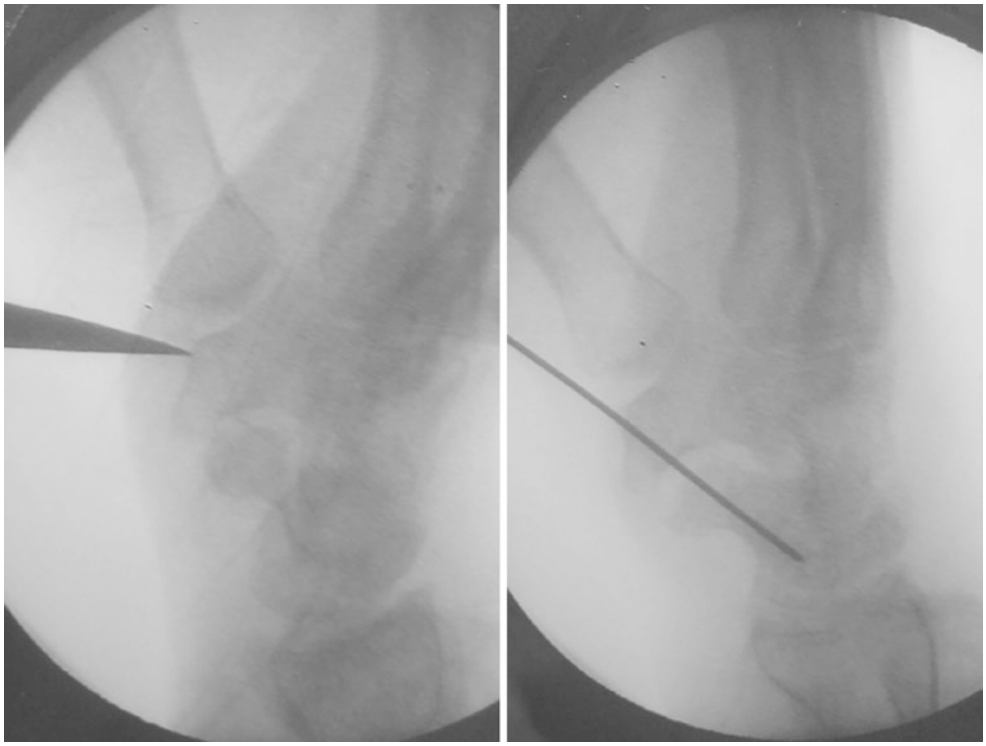


Fig. 30.12 Intraoperative X-ray view showing placement of starting awl over the distal tubercle of trapezium and the guide pin insertion across scaphotrapezial joint

ously. Fixation of the scaphotrapezoid and trapeziotrapezoid joints then becomes nonessential. With the hand placed horizontally in hand table, a guide pin is inserted through a small stab wound at junction between base of first metacarpal and the trapezium under an image guidance with the aim toward the proximal pole of the scaphoid (Fig. 30.12). Alignment should be confirmed by at least four radiological views of AP, lateral, semisupinated AP, and semipronated PA view. If scaphoid is abnormally flexed and pronated due to scapholunate instability, a 1.6-mm K-wire can be inserted percutaneously to be used as joystick to correct the alignment of scaphoid. With the arthroscope in MCR portal, a small probe can also be inserted through STT portal to assist the reduction of scaphoid alignment by hooking onto the distal part of the scaphoid to extend and derotate the scaphoid. The K-wire inserted through trapezium can then be driven through to reach the proximal scaphoid.

The arthroscope is then inserted again into the joint through MCR portal to verify the position of K-wire (Fig. 30.13). If the joint space at STT joint becomes too tight to allow bone grafting through an arthroscopic cannula, the K-wire can be withdrawn from the scaphoid but remains attached to the trapezium. Autogenous bone graft or bone substitute can be inserted through a small cannula as described earlier to fill up the void (Fig. 30.14). The K-wire is then driven back into the scaphoid till the subchondral surface of proximal scaphoid is reached. Length of the inserted portion of the K-wire is measured. The screw length should be 2 mm short of the measured length to reduce the possibility of perforation of the proximal articular surface of scaphoid. The K-wire is then driven further proximally, perforating the proximal pole of scaphoid and exiting outside skin near the 3/4 portal of radiocarpal joint. The tip of the K-wire is grabbed with a hemostat. This trick helps to prevent accident

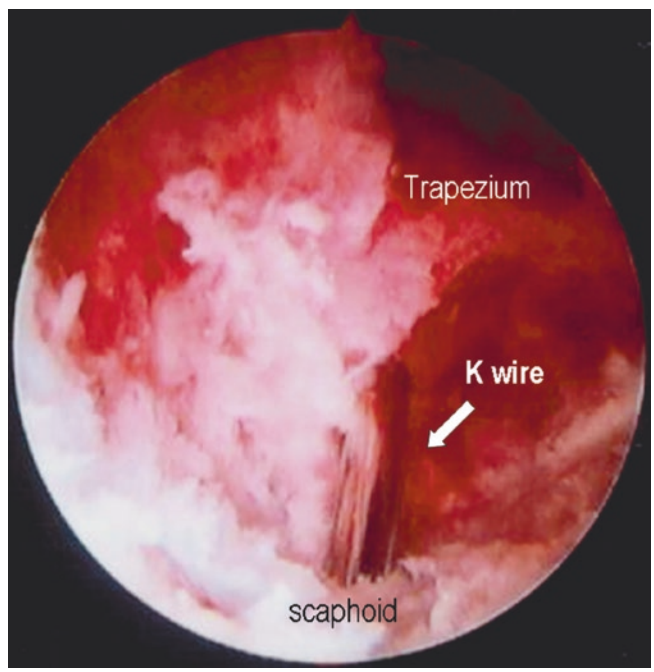


Fig. 30.13 Verification of the guide pin position at the STT joint as viewed through the arthroscope

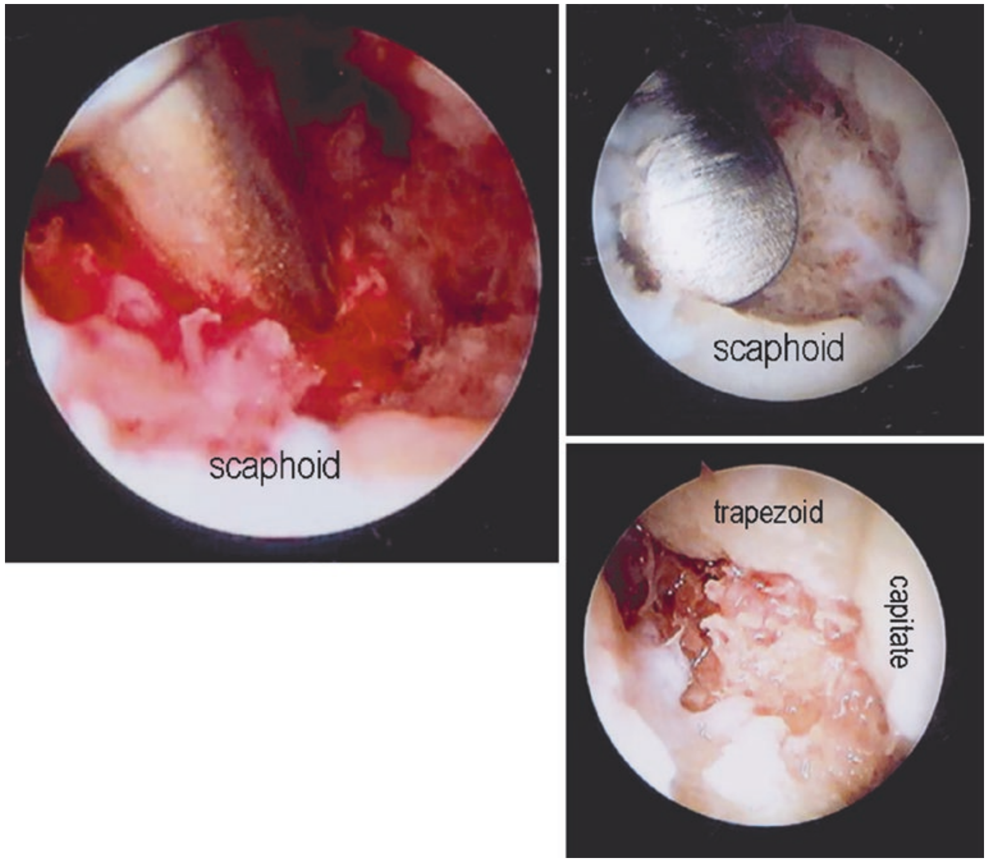


Fig. 30.14 Delivery of autogenous bone graft through cannula to the fusion site, impaction, and final appearance

pull off of the K-wire during subsequent drilling process with the small cannulated drill. The bone is then drilled with a cannulated drill bit and finally the trapezioscaphoid joint is transfixed with an appropriate cannulated screw with compression for added stability (Fig. 30.15). The guide wire can be removed afterward. Final alignment of the screw should be confirmed using an image intensifier. The midcarpal joint is then surveyed with an arthroscope to check for any spilled-out graft material, which should be removed by using a mosquito grasper or flushed out from the cannula with saline.

Wounds are closed with steri-strips and a comfortable bulky dressing is applied supported with a short arm plaster slab. The slab is changed to a removable scaphoid splint after the first week. Active mobilization of the wrist is allowed out of splint under supervision of a hand therapist. Passive wrist mobilization and strengthening exercise can be offered when radiological and clinical union is evidenced, usually around 10–12 weeks postoperative (Fig. 30.16).

Four Corners Fusion

Four corners fusion is indicated when there is significant periscaphoid arthritis in the presence of a relatively intact radiolunate joint (Fig. 30.17). Under these circumstances, the scaphoid is usually removed surgically as a concomitant procedure with the four corners fusion. Presence of severe arthritic change at the midcarpal joint will exclude the alternative option of proximal row carpectomy and makes the operation a procedure of choice [19, 20]. For pathology that does not involve radioscaphoid arthritis, the indications include midcarpal instability, isolated midcarpal arthritis, or lunotriquetral dissociation with fixed volar intercalated segmental instability alignment of the lunate. When performing four corners fusion in cases without radioscaphoid arthritis, Taleisnik favored scaphoid inclusion [21] and Weiss et al. preferred scaphoid retention [22]. In a cadaveric study carried out by Kobza et al. [10], it was shown that simple four

Fig. 30.15 Final wound appearance and progress of radiological changes showing early union at 5 weeks and consolidation over 3 months postoperative

corners fusion with scaphoid retention led to a significant decrease in extension, radial deviation, and ulnar deviation. Four corners fusion with scaphoid excision not only allowed significantly greater radial deviation but also led to significant increase in radiolunate contact area and the mean contact pressure. However, the clinical impact was not known.

We reported four cases of arthroscopic four corners fusion with scaphoidectomy in 2008 [23]. The operation should begin with a surveillance of the radiocarpal joint to confirm an intact radiolunate articulation and preferably an intact proximal articular surface of triquetrum. Arthroscopic scaphoidectomy is then performed from the midcarpal joint. The operation can be performed without a tourniquet provided that the portal sites and joint space are infiltrated with adrenaline solution in lignocaine. With the arthroscope introduced from the MCU portal, an arthroscopic burr of 2.9 mm is inserted into MCR portal and directed toward the proximal and midscaphoid region. The scaphoid is burred at high speed from the articular surface down to the core cancellous bone. Bone debris is removed by intermittently applied suction. To avoid accidental damage of the adjacent articular surfaces to be preserved, a shell of cartilage can be left intact until majority of the cancellous bone is removed. This shell of cartilage can help to separate the burr from the adjacent carpal bone during the burring process (Fig. 30.18). This can be removed piecemeal at the end of the scaphoidectomy procedure by using a small pituitary rongeur or an arthroscopic punch (Fig. 30.19). When taking out the larger piece of bone fragment, it is advisable not to use excessive violence in order to avoid damage to the attaching ligament and soft tissue structure. One trick is to firmly grip on the bone fragment with the small rongeur using both hands while to twist

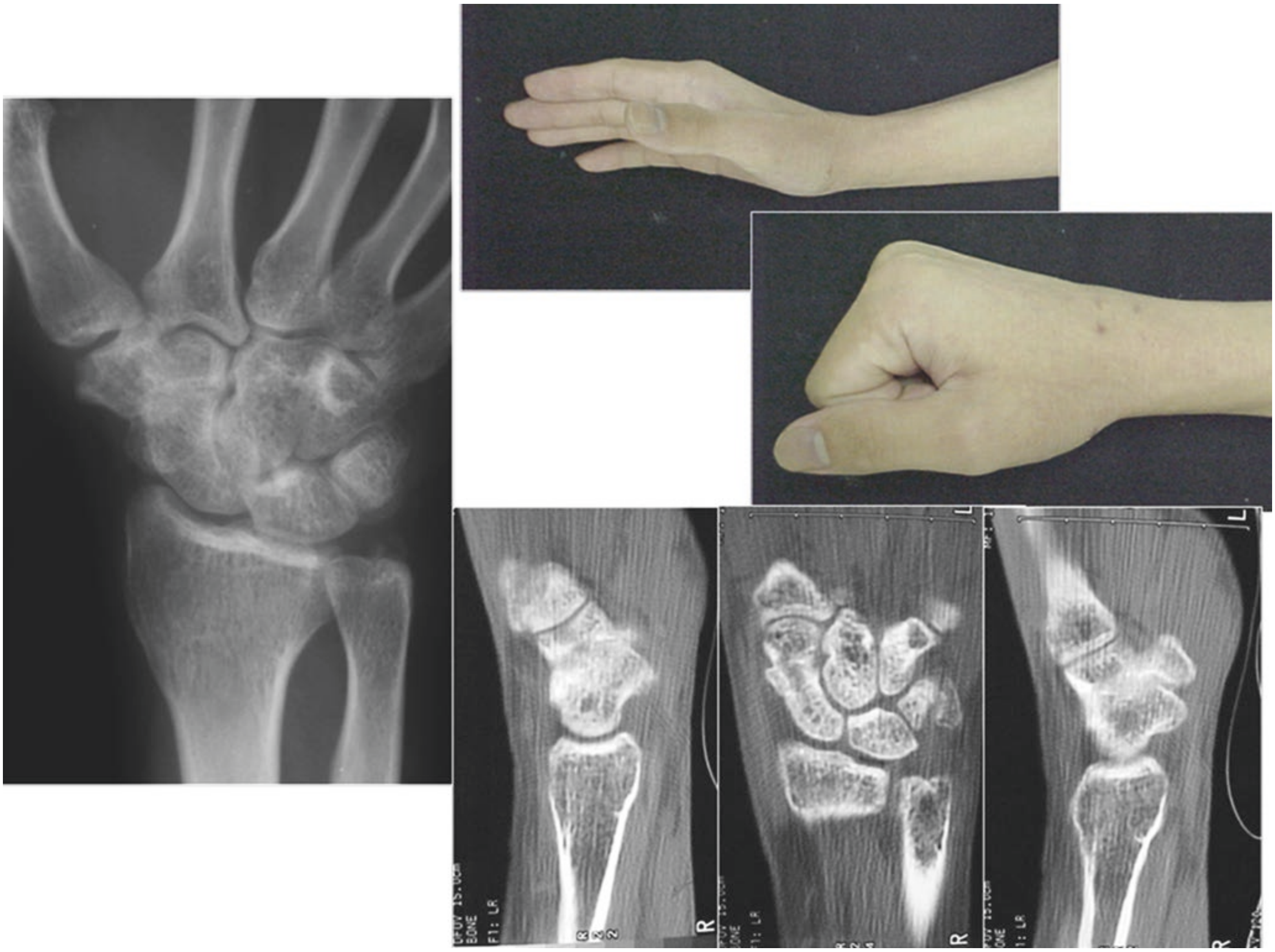


Fig. 30.16 X-ray, CT, and clinical features confirming solid union of the STT joint fusion

around its own axis and maintain a gentle pulling force. The fragment will gradually lose its connection to the soft tissue and can be delivered smoothly out of the joint. During the delivery process, the surgeon has to maintain a sustained and firm grip on the bony fragment or otherwise it may get lost in the juxta-articular or subcutaneous tissue plane. Under such situation, the surgeon may be forced to enlarge the surgical wound in order to remove the retained bony fragment, which is not desirable (Fig. 30.20). In order to speed up the process, an arthroscopic burr of progressive increase in size such as 3.5 mm and even 4.5 mm can be used when there is more space opened up after part of the scaphoid is removed (Fig. 30.21). The speed of scaphoid excision can often be doubled or even tripled. Alternatively a small osteotome can also be used to break the bone into piecemeal for easier removal. Extreme care has to be exercised during insertion of the larger burr or osteotome to avoid iatrogenic injury to the extensor tendon and cutaneous nerve. The distal few millimeters of the scaphoid can be left in situ so as to preserve the scaphotrapezial ligament. The distal scaphoid tubercle does not normally articulate with the radial styloid and hence its preservation will not cause impingement pain postoperatively.

Once scaphoid is cleared, attention can be paid to the fusion of the midcarpal joint at the four corners region. The arthroscope is now inserted through MCR portal, while the MCU portal is reserved for the arthroscopic instruments. The articular surface between the capitate, lunate, triquetrum, and hamate is denuded of cartilage with 2.9 mm burr. The joint surface of the lunotriquetral joint is also burred. I do not routinely burr the articulation between hamate and capitate as the joint is very rigid normally.

After an adequate cartilage destruction, provisional fixation is performed under an image intensifier's guide. If there is significant ulnar translocation and DISI deformity of the lunate and radial subluxation of the capitate off the lunate

Fig. 30.17 A 47-year-old manual worker with SLAC wrist stage III undergoing arthroscopic scaphoidectomy and four corners fusion at September 2000

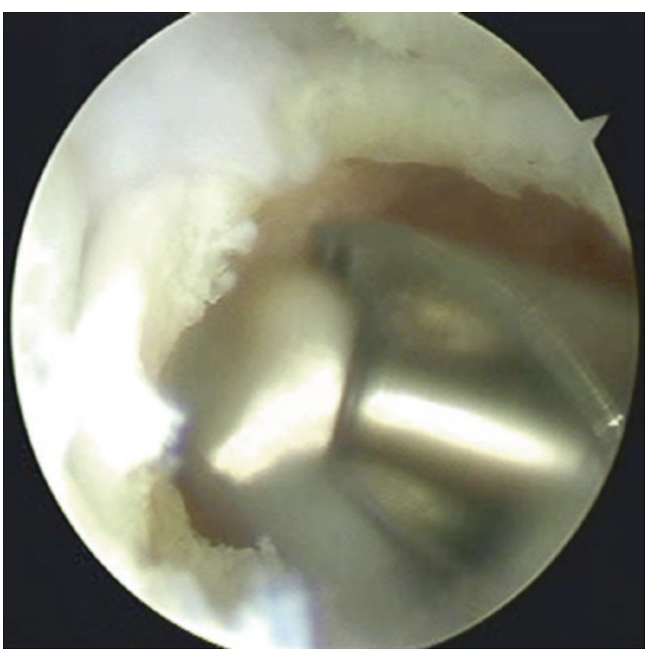


Fig. 30.18 Shell of cartilage left intact during burring of scaphoid to protect other uninvolved articular surfaces

margin, the lunate is reduced by gentle flexion and radial translation of the wrist so as to restore the normal radiolunate relationship. The aim is to have at least half of the lunate sitting over the distal radius. The lunate is then fixed to the radius with a percutaneous K-wire of 1.1 or 1.6 mm inserted from the distal radius.

The capitate is then reduced by ulnar translation of the wrist so that it sits as much as possible on the distal lunate articular surface (Fig. 30.22). A percutaneous K-wire is inserted from the dorsal surface of the capitate at the distal junction with the base of the third metacarpal under an image guide (Fig. 30.23). The ministab wound should be bluntly dissected to avoid iatrogenic injury to the extensor tendon. With the help of a lateral projection on the image guide, the K-wire is driven across the capitolunate joint to anchor into the lunate. The angle of attack has to be acute enough in order to catch the central part of the lunate to have a better purchase of the bone. It is most crucial to obtain a good surface contact of the capitolunate joint as the key point of the operation is to achieve solid fusion of the CL joint to avoid late collapse of the midcarpal joint and hence loss of the carpal height.

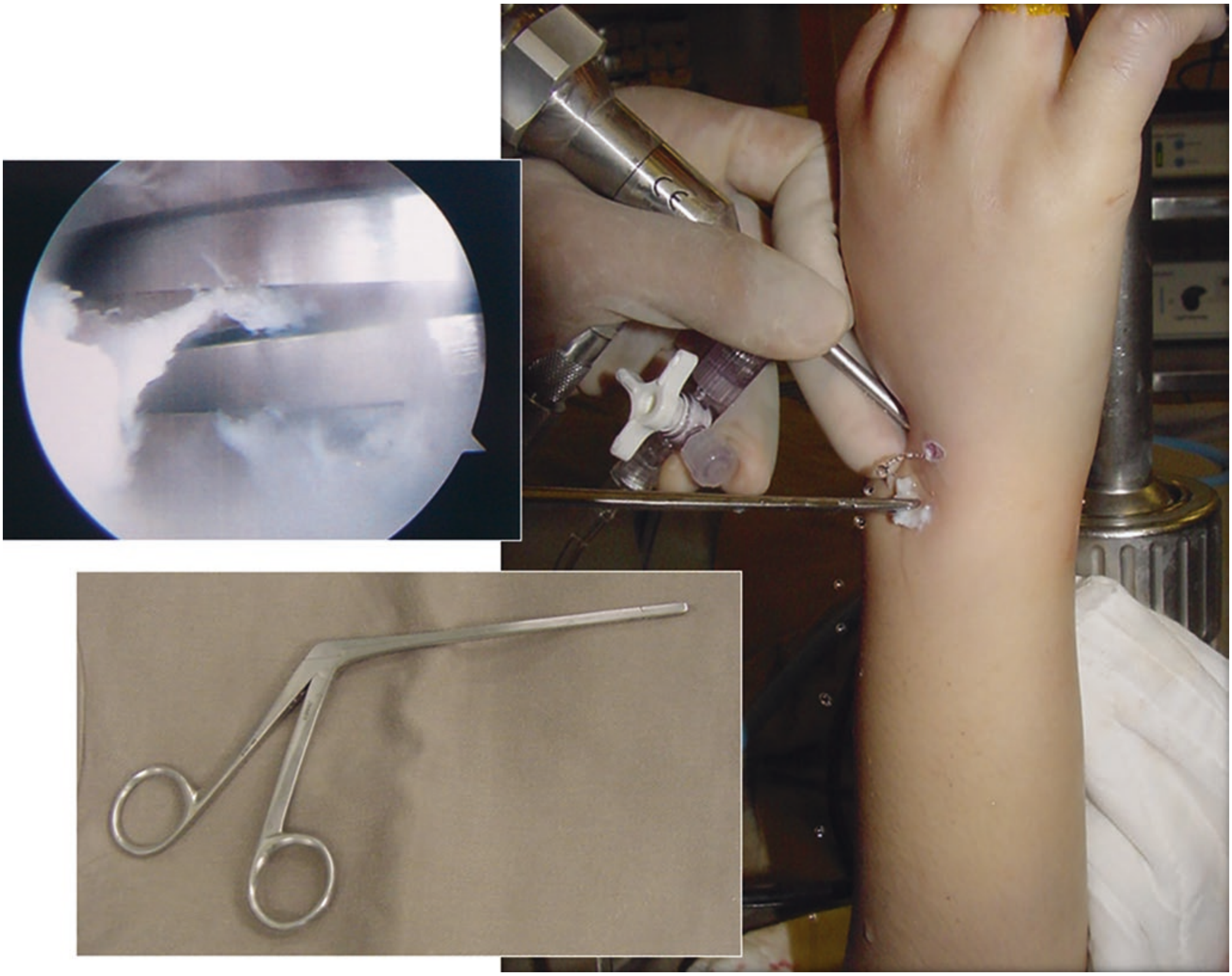


Fig. 30.19 Cartilage shell removed in piecemeal using small pituitary rongeur inserted through portals

If satisfactory alignment can be achieved, the K-wire is withdrawn from lunate while still attaching to the capitate. This is then followed by the bone grafting procedure at the midcarpal joint as described in session before. With the arthroscope held at MCR portal, the cannula can be inserted through the MCU portal for bone graft or substitute delivery. If scaphoidectomy is included, a French size 6 Foley catheter is inserted via the 3/4 portal to completely obliterate the empty space left after the scaphoidectomy procedure. The balloon is inflated while bone graft or substitute is being delivered to the ulnar midcarpal space (Fig. 30.24). The catheter can be removed after the bone grafting procedure, or can be left in situ for a day or two to serve as a surgical drain.

After completion of the bone grafting, the K-wire over the capitate is driven back to lunate at the reduced position. Length of the K-wire inserted is measured. This is followed by drilling of bone with a cannulated drill bit and the final insertion of a headless self-tapping cannulated screw to fix the capitolunate joint. The screw tip should reach no more than 2 mm from the proximal surface of the lunate to avoid screw tip protrusion and iatrogenic damage to the radiolunate articulation. To avoid loss of reduction during the drilling action, an additional K-wire can be inserted to the CL interval for temporary fixation. One has to be sure that the screw is completely buried in the capitate so that it will not cause impingement to the extensor tendons. Lateral and oblique X-ray views should demonstrate that the screw does not project beyond the proximal articular surface of the lunate so that no scratching of the articular surface of the distal radius will occur. This can also be checked with a gentle passive movement of the wrist after the fixation procedure, or more definitely with an arthroscopic evaluation at the radiocarpal joint.

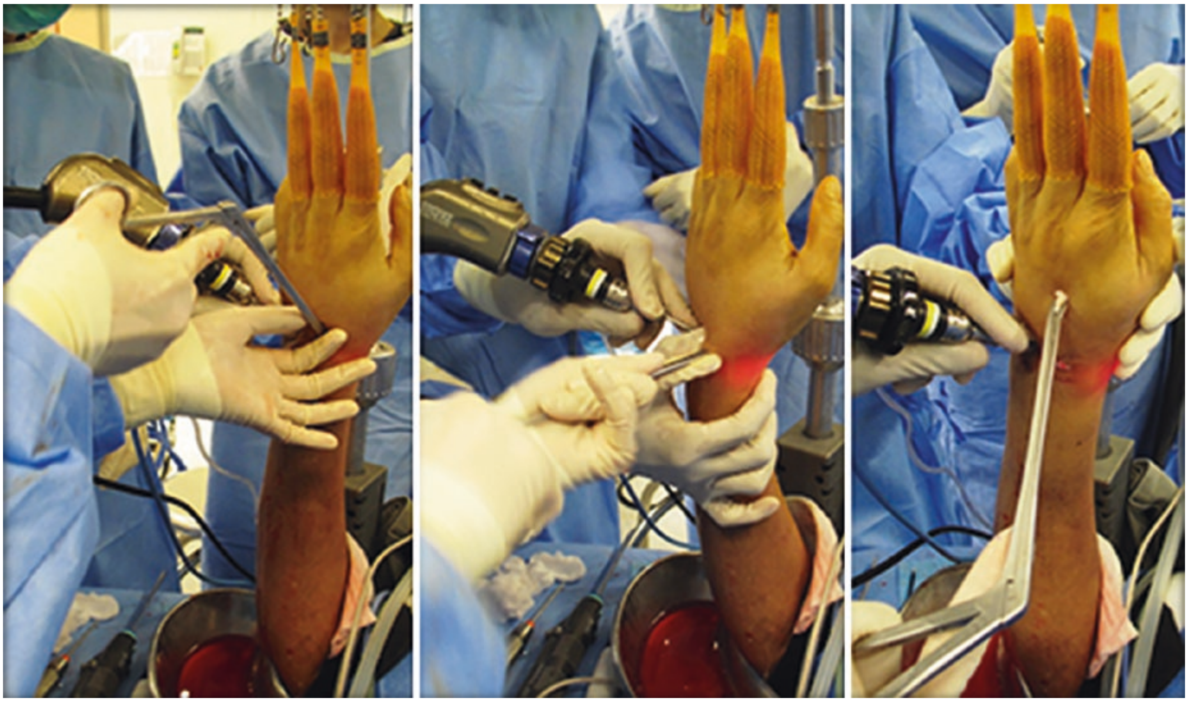


Fig. 30.20 The surgeon firmly grips on the bone fragment with the small rongeur using both hands while to twist around its own axis and maintain a gentle pulling force. The fragment will gradually lose its connection to the soft tissue and can be delivered smoothly out of the joint

Fig. 30.21 Use of large 4.5-mm arthroscopic burr helps to speed up the burring process

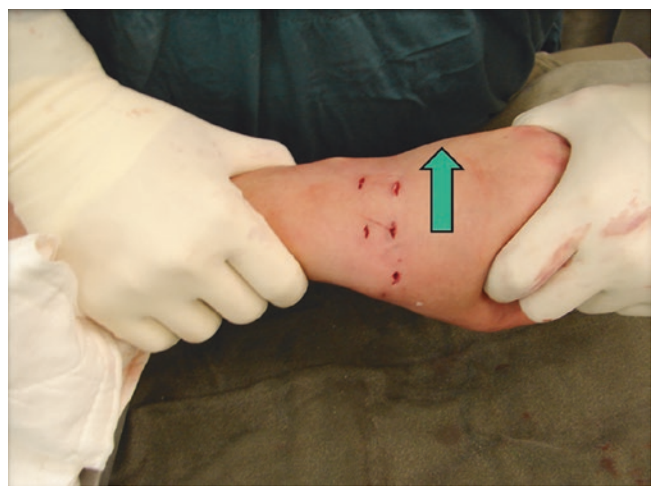


Fig. 30.22 The capitate is reduced by ulnar translation of the wrist so that it sits as much as possible on the distal lunate articular surface

The lunotriquetral joint and the capitohamate joint are then fixed with percutaneous K-wires through small stab incisions (Fig. 30.25). If the positions of the K-wires are satisfactory, headless screws are inserted from ulnar aspect of the hand to fix the carpal intervals (Fig. 30.26). Structures at risk include the dorsal branches of ulnar nerve, EDM, and ECU tendons. Blunt dissection of the stab wounds should be a routine before the insertion of guide wire to avoid iatrogenic injury to these important structures. In order to reduce the chance of hitting onto the screw fixing capitolunate joint, the guide wire for

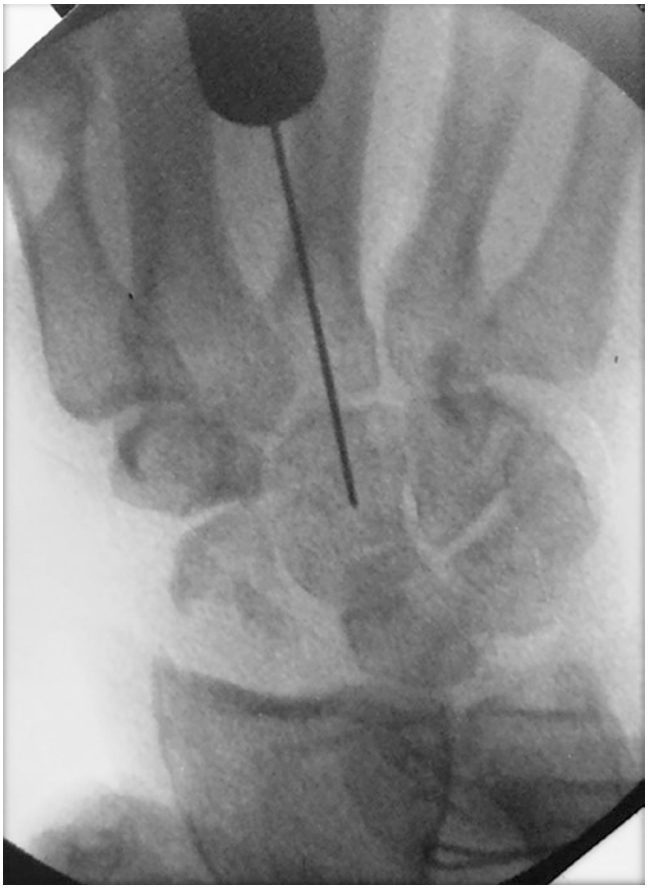


Fig. 30.23 Guide pin inserted through distal capitate to transfix capitolunate joint

capitohamate fusion should aim at the more volar aspect of the capitate, while that of the lunotriquetral fusion should aim at the more dorsal aspect of lunate.

After solid fixation of the four corners bones, any K-wire over the radiolunate joint can be left in situ for 2 weeks. The wire end is cut short and bent outside the skin. Wounds are approximated with steri-strips and a comfortable bulky dressing is applied supported with a short arm plaster slab (Fig. 30.27). The plaster slab is changed to a removable wrist splint after the first week. After removal of the K-wire over the radiolunate joint, active mobilization of the wrist can be initiated out of splint under the supervision of a hand therapist. Passive wrist mobilization and strengthening exercise can be offered when radiological and clinical union is evidenced, usually around 10–12 weeks postoperative (Figs. 30.28, 30.29 and 30.30).

Capitolunate Fusion

Capitolunate (CL) fusion and scaphoidectomy are now the preferred solution for me in managing stage II or III SLAC or SNAC wrist condition, unless there is concomitant arthritis at the ulnar midcarpal joint. This allows a shorter operating time and preservation of the relatively normal ulnar component of the midcarpal joint, while adequately preventing carpal collapse after the removal of the scaphoid in arthritic condition. CL fusion has historically bad reputation for high nonunion rate due to the limited bony fusion surface and masses. Nevertheless, Slade and Bomback demonstrated a high union and satisfaction rate with an arthroscopic assisted CL fusion, accountable by the minimal invasive method and the rigid percutaneous fixation [24]. The more conservative bone resection also eliminates the potential drawback of triquetral hamate impingement.

The operation begins with a surveillance of the radiocarpal joint to confirm an intact radiolunate articulation. Arthroscopic scaphoidectomy can then be performed at the midcarpal joint as described earlier. Once scaphoid is cleared, attention can be paid to the fusion of CL joint. The arthroscope is now inserted through MCR portal, while the MCU portal is reserved for arthroscopic instruments. The articular surface between the capitate and the lunate is carefully denuded of cartilage with 2.9 mm burr, while those of the triquetrum and hamate should be carefully protected and preserved. For type I lunate, the whole distal articulating surface of the lunate should be debrided. For type II lunate, the typical small ulnar facet need not be debrided as it will not be involved in the fusion process. If the ulnar facet is of considerable size and proportion, one may consider more aggressive flattening of the articular surface by removing the central wedge in between the two facets before attempting the fusion. However, the chance of subsequent triquetrohamate impingement may become higher such that one may consider switching to a formal four corners fusion.

If there is significant ulnar translocation and DISI deformity of the lunate and radial subluxation of the capitate off the lunate margin, the lunate should be reduced and fixed to the radius temporarily as described earlier.

The wrist is taken off from the wrist tower. A small stab wound is being made over the distal dorsal surface of the capitate at the junction with the radial aspect of the base of third metacarpal (see Fig. 30.13). The ministab wound should be bluntly dissected to avoid iatrogenic injury to the

Fig. 30.24 A French size 6 Foley catheter is inserted via the 3/4 portal to completely obliterate the empty space left after the scaphoidectomy procedure

Fig. 30.25 The lunotriquetral joint and the capitohamate joint are fixed with percutaneous K-wires

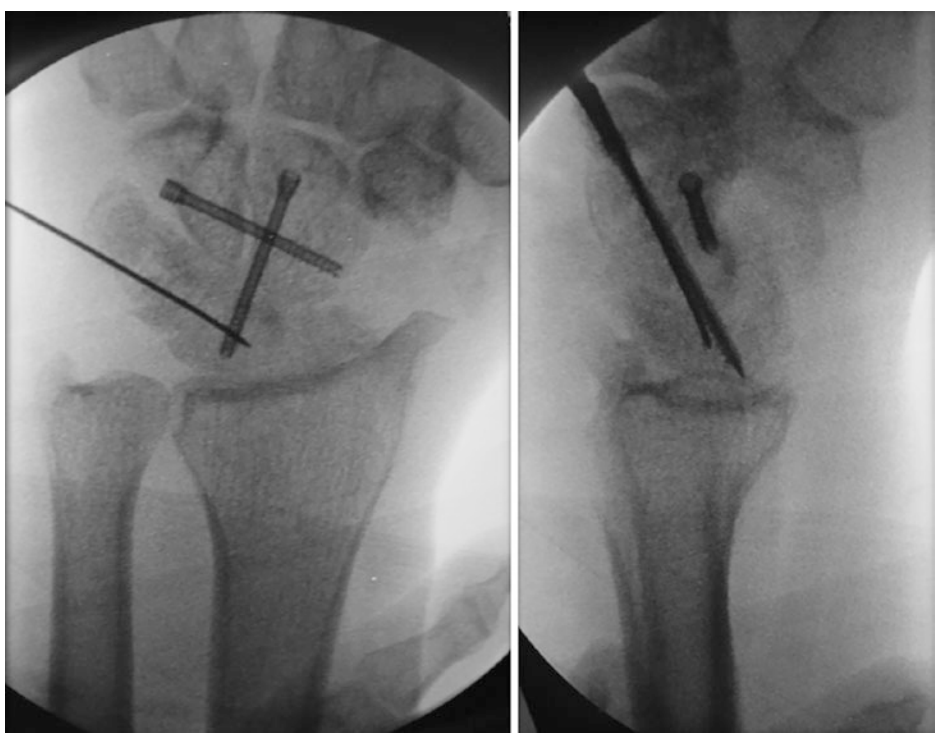


Fig. 30.26 Fusion of the four corners bones with percutaneous headless screws

Fig. 30.27 Arthroscopic wounds are closed with steri-strips without stitch

extensor tendon until the bony cortex is reached. With the help of an anteroposterior and lateral projection under an image intensifier, a guide wire of a small cannulated screw system is inserted and driven across the capitate toward lunate and parallel to the radial border of capitate. A small metal awl is helpful to establish the entry point over the capitate prior to the insertion of the guide pin (Fig. 30.31). The angle of attack has to be acute enough with an aim to catch the central part of the lunate to have better purchase of the bone. Before the first guide wire is being fired across the CL joint, the second one should be placed to the ulnar side of the capitate-metacarpal joint. With a second small stab wound over the distal dorsal surface of the capitate at the junction with the ulnar aspect of the base of third metacarpal, the guide wire is driven across the capitate, with an aim to catch the dorsal third of the lunate at the CL junction. The slightly different angle of attack of the two guide pins can avoid crowding of the screws upon final definitive fixation.

With the two pins on the capitate, the capitate is manually reduced to the lunate by ulnar translation of the wrist so that it sits as much as possible on the distal lunate articular surface (Fig. 30.32). The pins are then driven through the lunate until they reach the subchondral surfaces (Fig. 30.33). It is most crucial to obtain good surface contact of the capitolunate joint as the key point of the operation is to achieve a solid fusion of the CL joint to avoid late collapse of the midcarpal joint and hence loss of the carpal height.

In CL fusion, the articular congruency achieved between the capitate and lunate is typically very good. There is no

Fig. 30.28 The 47-year-old manual worker with SLAC wrist stage III as shown in Fig. 30.17 undergone arthroscopic scaphoidectomy and four corners fusion showed solid fusion 3 months postoperative

need for added bone graft or substitute. Conversion of the K-wires fixation with cannulated screws is then followed as described previously (Fig. 30.34). Lateral and oblique X-ray views are taken to confirm that no screw should project beyond the proximal articular surface of the lunate (Fig. 30.35). The stability and range of motion of the wrist can be checked under fluoroscopic guidance. Passive finger movement should be checked to confirm no impingement by the screws.

Wounds are then closed with steri-strip and a comfortable bulky dressing is applied supported with a short arm plaster slab. The slab is changed to a removable wrist splint after the first week, when gentle active mobilization of the wrist can be initiated out of splint under supervision of hand therapist. Passive wrist mobilization and strengthening exercise can be offered when radiological and clinical union is evidenced, usually around 8–10 weeks postoperative (Figs. 30.36 and 30.37).

Radioscapholunate Fusion

Radioscapholunate fusion is indicated for severe painful posttraumatic arthritis involving the whole radiocarpal joint, while the midcarpal joint is relatively preserved [25] (Fig. 30.38). For inflammatory arthritis, the disease should not be at the height of progression and better be adequately controlled with medication [26]. It has been shown that an accompanying distal scaphoidectomy procedure can help to improve midcarpal motion especially on ulnar radial deviation [27]. This can also be accomplished by arthroscopic mean.

A general surveillance of the midcarpal joint to confirm its relative integrity is a prerequisite for a successful radioscapholunate fusion. Arthroscopic distal scaphoidectomy can also be performed at the same time. With the arthroscope placed at the MCU portal, a 2.9-mm burr is inserted into the MCR portal and directed toward the distal scaphoid portion articulating with the trapezoid. Burring of the scaphoid is started at this point toward the distal pole from dorsoulnar to volar-radial direction. Caution has to be taken to avoid iatrogenic damage to the articular cartilage of trapezoid, trapezium, and capitate. The junction between capitate, scaphoid, and trapezoid forms the landmark of the proximal extent of resection. A shell of cartilage can be left intact until majority of the cancellous bone of the distal scaphoid pole is removed. This shell of cartilage can help to separate the burr from the adjacent carpal bones during the burring process. This can be removed piecemeal at the end of the distal scaphoidectomy procedure by using a small pituitary rongeur or an arthroscopic punch. The STT portal can also be employed to facilitate burring of the most distal part

Fig. 30.29 Postoperative scar condition and range of motion of wrist at 3 months

of the scaphoid. At the end of the procedure, there should be a void opposing the trapezium and trapezoid bone, while the waist of scaphoid is preserved and is articulating with capitate. The precise extent of distal scaphoid resection can be checked with intraoperative fluoroscopy (Fig. 30.39).

After the distal scaphoidectomy is complete, the arthroscope can be directed to the radiocarpal joint. The remaining articular cartilage of the radiocarpal joint is denuded. With the arthroscope in 3/4 portal, a 2.9-mm burr is inserted into 4/5 portal and both the lunate fossa and the proximal surface of the lunate are debrided of articular cartilage. The degree of cartilage denudation should be well controlled so that no excessive subchondral cancellous bone is being removed. Burring is completed when the subchondral bone with healthy punctate bleeding is reached. This phenomenon can be easily observed if tourniquet is not used during this pro-

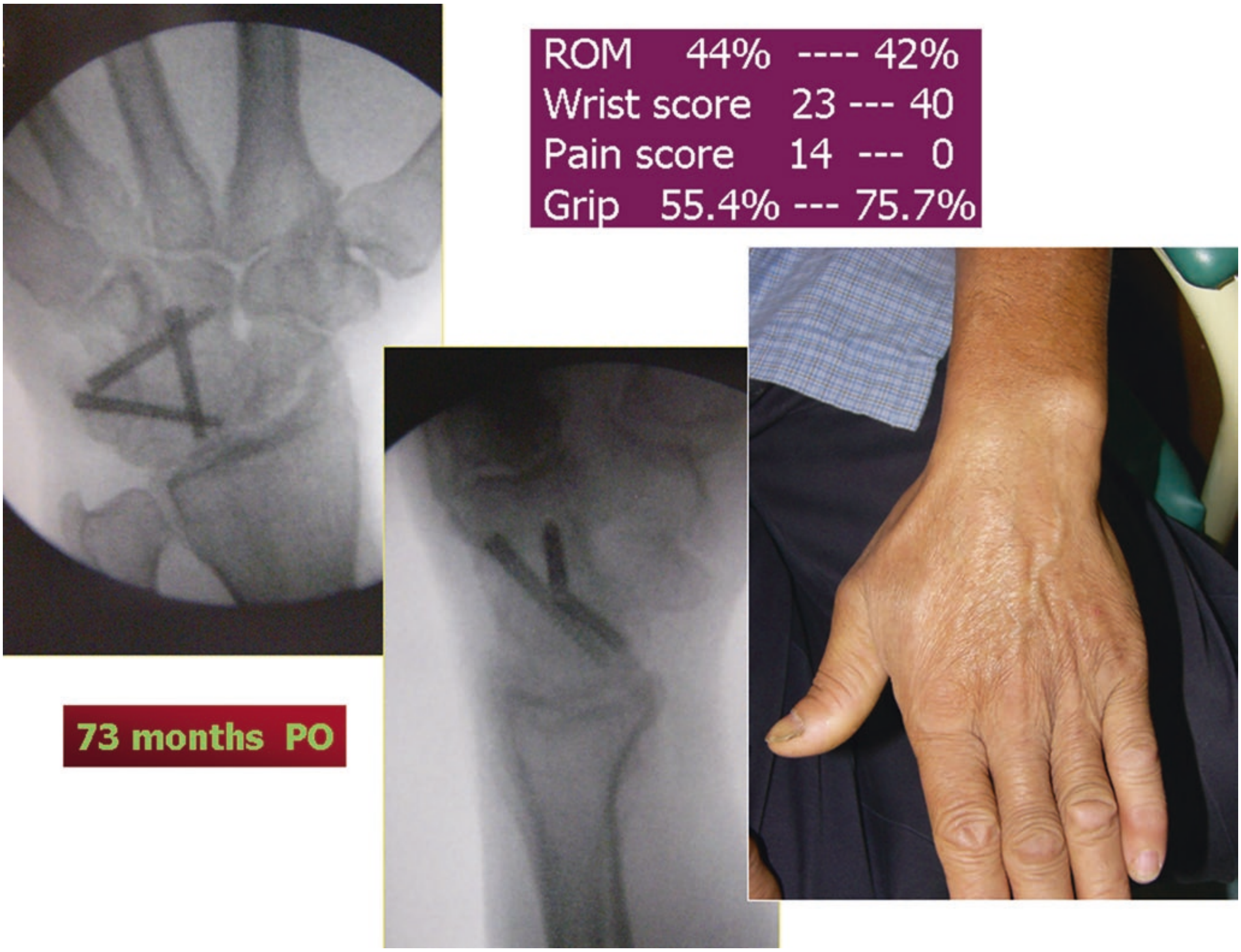


Fig. 30.30 Final follow-up at 73 months postoperative: Wrist ROM similar to preoperative (42% vs. 44% of opposite wrist), full wrist function score, no pain, grip power increased from 55.4% to 75.7% of opposite side. Scar was invisible

cess. Usually, bleeding is limited and can easily be controlled with hydrostatic pressure applied through the irrigation system. If bleeding is profuse, one may use the coagulatory role of radiofrequency apparatus. Use of a tourniquet is optional depending on the degree of bleeding. During the burring process, suction can be switched on and off intermittently to remove any accumulated bone debris which may block the visual field. If suction is applied continuously during the burring process, excessive air bubbles drawn in will severely compromise the visibility of the operating site. The portals are then switched so that the burr is introduced from the 3/4 portal to have a better clearance of the articular cartilage of the proximal scaphoid and the scaphoid fossa including the radial styloid area.

After completion of the burring process, the hand is taken off the wrist traction tower and placed horizontally on the operating hand table. An image intensifier is moved in. Percutaneous K-wires are inserted from distal radius to transfix the radiolunate and radioscaphoid joint (Fig. 30.40). A small longitudinal incision is made at the distal radius about 2 cm proximal to the midpoint between the 3/4 and 4/5 portals. This is corresponding to the direct articulation between radius and lunate. The extensor tendons are bluntly dissected off from the potential wire insertion point using a fine-pointed stitch scissor. With the wrist placed in neutral position both in flexion-extension plane and radioulnar deviation plane, two 1.1 mm K-wires are inserted using a protective sheath one after the other from distal radius to fix the lunate. If small cannulated screw is being used, the guide pin is inserted in the same manner. One or two guide pins are used according to the size of the carpal bone. The two wires should aim at the radial and ulnar border of the lunate so as to have even purchase of the bone. The radiolunate angle should be maintained at zero degree. This requires

Fig. 30.31 A small metal awl inserted through a stab wound at the ulnar border of the base of the third metacarpal and the capitate to establish an entry point for the guide pin

Fig. 30.32 The wrist is manually ulnar translated to reduce the capitate as much as possible to the distal articular surface of the lunate

Fig. 30.33 Two pins are inserted percutaneously under image intensifier to transfix the capitolunate joint

confirmation using both AP and lateral view of X-ray. On the lateral projection, the wire should target on the anterior horn of the lunate bone. To optimize the bone purchase, the angle of insertion of the K-wire should be quite acute at 20–30° with reference to the long axis of the forearm. Another incision is made over the radial styloid at the bare area between the first and second extensor compartments. After careful blunt dissection of the superficial branches of radial nerve, the two K-wires or guide wires are inserted in sequence to transfix the distal radius to the scaphoid. After verification of the wire position, they can be back out from the carpal bones while attaching to the distal radius. The protruded ends of the K-wire are capped to avoid injury to the surgeon. The wrist is then put back to the wrist traction tower for the arthroscopic grafting procedure.

With arthroscope introduced at 4/5 portal, an arthroscopic cannula is inserted through 3/4 portal to reach the radial side of the scaphoid fossa. Autogenous bone graft or bone substitute can be inserted to fill up the radial side of the radioscaphoid joint. As the fusion surfaces are usually well vascularized,

Fig. 30.34 Cannulated drill is inserted through the percutaneous pin to prepare track for the cannulated screw

I prefer the use of bone substitute to reduce donor site morbidity on the patient (Fig. 30.41). To achieve better vision on the operative field, the tourniquet is inflated at this junction to reduce bleeding inside the joint (Fig. 30.42). When the radioscaphoid joint is half filled with bone substitute, the arthroscope is switched to 3/4 portal and the cannula is inserted at the 4/5 portal. Grafting process is continued at the radiolunate joint. To prevent spilling of the graft to the ulnocarpal compartment, a size 6 Foley catheter is inserted through the 6R portal and is inflated with saline so as to obliterate the space there.

When the grafting procedure is complete, the hand is again taken off the tower and tourniquet deflated. Under image guide, the K-wires are driven back into the carpal bones just short of the articulating surface at the midcarpal joint. For posttraumatic arthritis in the younger patients, I prefer using percutaneous compression screws to enhance fusion rate. After measuring the length of the inserted portion of the K-wires, the wire tracks are drilled with cannulated drill bit. Definitive fixation is performed with 3.0 mm cannulated screws with the head firmly anchored over the dorsal cortex of the distal radius. Alternatively, a headless cannulated screw system can also be used (Figs. 30.43 and 30.44). X-ray is required to confirm that the thread of the screws should not perforate the midcarpal joint surface to impinge on the distal carpal row. This can also be verified arthroscopically. In osteopenic bone where screw purchase can be suboptimal, the four K-wires can serve as the defini-

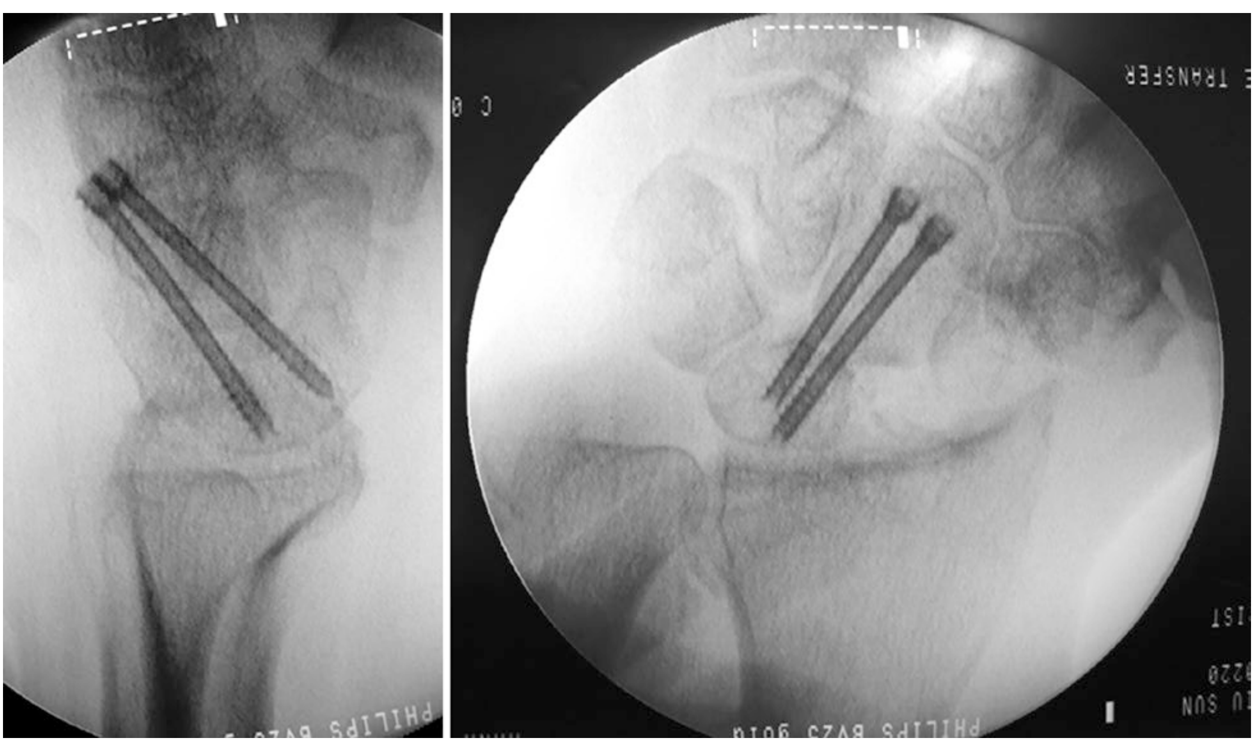


Fig. 30.35 The position of the two headless cannulated screws is being checked radiologically to ensure no violation of the articular surface at the radiolunate joint

Fig. 30.36 A 55-year-old man with SLAC wrist stage III underwent arthroscopic scaphoidectomy and capitolunate fusion. X-ray at 12 months postoperative showed solid fusion and good carpal alignment

tive mean of fixation (Figs. 30.45, 30.46 and 30.47). They are cut short and buried underneath skin. The wrist should be moved gently to confirm the smooth articulation at the midcarpal joint and a stable fixation at the radiocarpal joint. The incision wounds are then opposed with steri-strips or simple stitches. Comfortable compression dressing with a short arm plaster slab is applied. It is changed to a removable wrist splint at 1–2 weeks of time. For K-wire fixation cases, active mobilization of the wrist is initiated after the fusion is united radiologically and clinically. The K-wires can be removed under local anesthesia through the original skin incisions. For compression screw fixation cases, gentle active wrist mobilization can be started at 2 weeks postoperative under supervision. More vigorous mobilization can be performed when radiological and clinical union is achieved.

Radiolunate Fusion

Radiolunate fusion is most commonly utilized in rheumatoid arthritis where there is painful ulnar translocation of the carpus at the radiocarpal joint. In posttraumatic situation, it is indicated when the articular cartilage destruction is confined to the radiolunate joint, such as in postdistal radius die-punch fracture (Fig. 30.48).

The operation is essentially similar to radioscapholunate fusion, except that the radioscaphoid joint is spared. In addition, distal scaphoidectomy is not necessary. Thus, during the burring procedure, the articular surface of the proximal scaphoid and scaphoid fossa should be well protected. During the graft insertion procedure, a second Foley catheter can be inserted at the 1/2 portal to obliterate the space at the

Fig. 30.37 Clinically the patient got 35° extension and 40° flexion at the wrist. Operative scars were inconspicuous

radioscaphoid articulation so as to isolate the space at the RL joint (Fig. 30.49). The arthroscope is placed at the 3/4 portal, while the bone substitute is delivered to the radiolunate joint through a cannula at the 4/5 portal (Fig. 30.50). The fixation can be accomplished by two K-wires or two compression cannulated screws inserted percutaneous from distal radius as described earlier (Figs. 30.51 and 30.52). In patient with significant ulnar-positive variance, an accompanying ulnar shortening osteotomy is performed to unload the ulnocarpal joint as well as to avoid potential ulnocarpal impaction after the radiolunate fusion which may shorten the proximal carpal row. The postoperative care and rehabilitation is same as radioscapholunate fusion as described earlier. However, the period of immobilization may need to be extended due to the limited contact area between lunate fossa and proximal lunate. Postoperatively close radiological monitoring is essential to determine the pacing of rehabilitation (Figs. 30.53, 30.54, 30.55, 30.56, 30.57, 30.58, 30.59 and 30.60). The author favors the granule form of bone substitute rather than injectable form, though the latter is very convenient for administration through the arthroscopic cannula.

Lunotriquetral Fusion

Lunotriquetral (LT) fusion is indicated for symptomatic chronic LT instability with or without ulnocarpal impaction syndrome [28, 29]. In the latter condition, ulnar shortening osteotomy is often an accompanying procedure to decompress the ulnocarpal joint. In the absence of secondary chondral damage, an alternative option of LT ligament reconstruction can be considered, since failure to unite is common in surgical fusion of the LT joint, according to the literature. In a meta-analysis of the outcome of intercarpal arthrodesis conducted by Siegel and Ruby, the overall reported nonunion rate in 81 patients of a total of 143 cases of LT fusion by open surgery in seven clinical series was 26% [6]. Where reported, 46% of patients has persistent postoperative symptom. Sennwald et al. also found disappointing high rate of pseudarthrosis of 5% in 23 patients receiving LT fusion [30]. In their open procedures from a dorsoulnar approach, they recommended the routine use of corticocancellous bone graft to enhance union. They cautioned about prolonged rehabilitation with 6 months out of

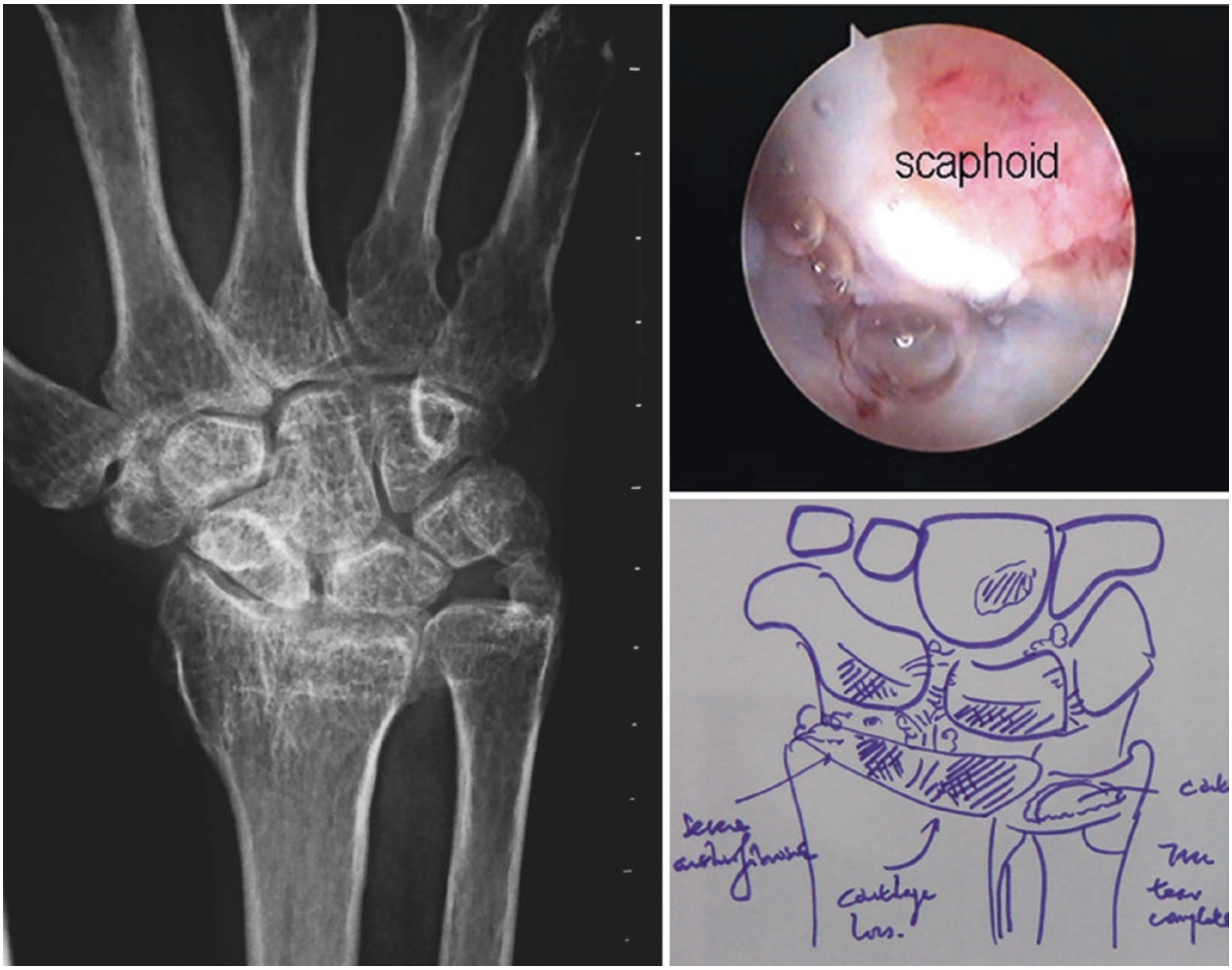


Fig. 30.38 Postdistal radius fracture arthrosis of the radiocarpal joint with complete eburnation of scaphoid and lunate fossa confirmed with arthroscopy. The midcarpal joint was preserved

work at best and the significant loss of grip power particularly in male subjects, which might force them to change their job nature.

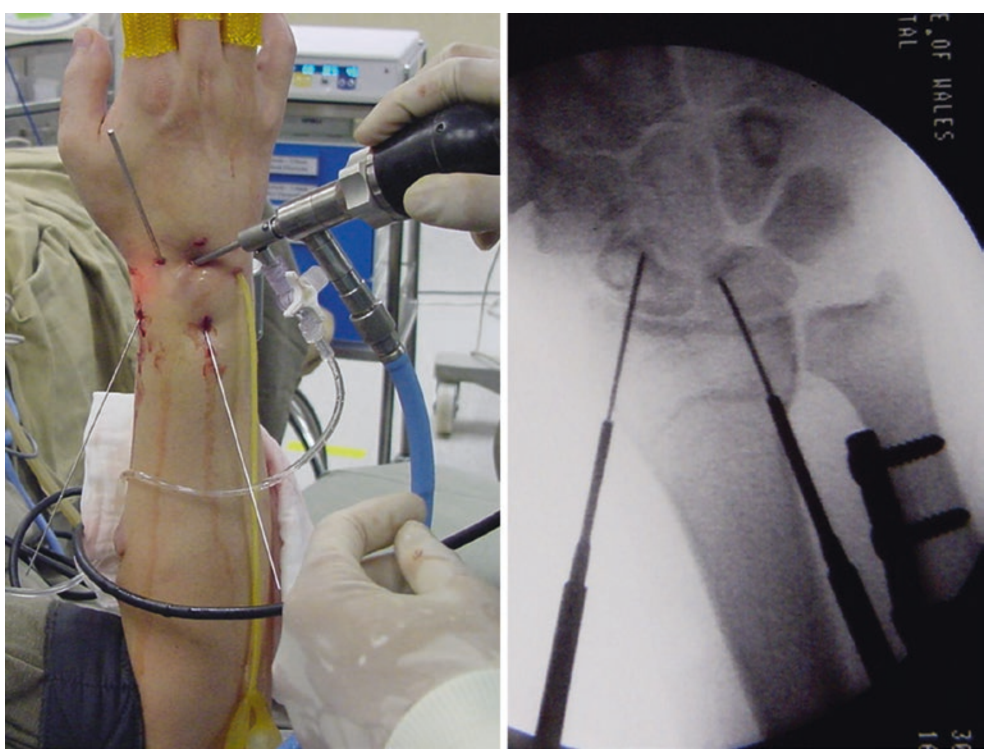
Arthroscopic fusion of the LT joint can be performed with midcarpal arthroscopic approach (Fig. 30.61). Routine radiocarpal joint arthroscopy is performed to evaluate the status of the TFCC, associated chondral lesions of the ulnar head, proximal lunate and triquetrum, and the LT ligament. If significant chondral lesion is present at the carpal bone surface, ulnar shortening or arthroscopic Wafer procedure should be done in association with the LT fusion procedure.

The arthroscope is then directed to the midcarpal joint. With the arthroscope placed at the MCR portal, a small probe is inserted at the MCU portal to reach the LT joint to confirm instability. This is then replaced by a 2.0- or 2.9-mm arthroscopic burr and debridement of the articular cartilage is performed from distal to proximal direction (Fig. 30.62). Attention should be paid at the dorsal aspect of the joint by rotating the 30° forward slanting lens to a downward position. Difficulty may be encountered in burring this portion as the angle of attack of the burr is frequently restricted by the dorsal soft tissue of the wrist. A small angled curette or ring curette may be useful in removing the cartilage at this area.

When burring is complete, provisional fixation of the LT interval is performed. A small wound is made opposing the ulnar surface of triquetrum and blunt dissection is performed to free the overlying terminal branch of the dorsal sensory branch of ulnar nerve. Under an image guide, a guide wire is inserted from the triquetrum across the LT joint to reach the lunate bone. The length of the guide wire is measured. Whenever feasible, two parallel guide pins are inserted to aim for two cannulated screws. If alignment is satisfactory, the guide pins are withdrawn from the lunate to free the joint space. The joint gap is then filled with bone graft or bone substitute through a cannula inserted at the MCU portal. The former is preferred as nonunion of the

Fig. 30.39 X-ray showing the extent of distal scaphoidectomy in patient receiving arthroscopic radioscapholunate fusion (*circle of dotted line*)

Fig. 30.40 Arthroscope being inserted into the radiocarpal joint after the two percutaneous K-wires were back out from the joint



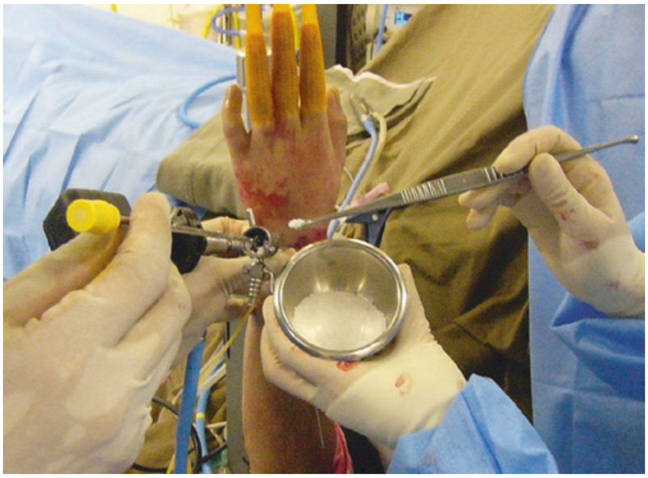


Fig. 30.41 Fine granules of artificial bone substitutes are being inserted into the radiocarpal joint space through a cannula before the definitive bony fixation

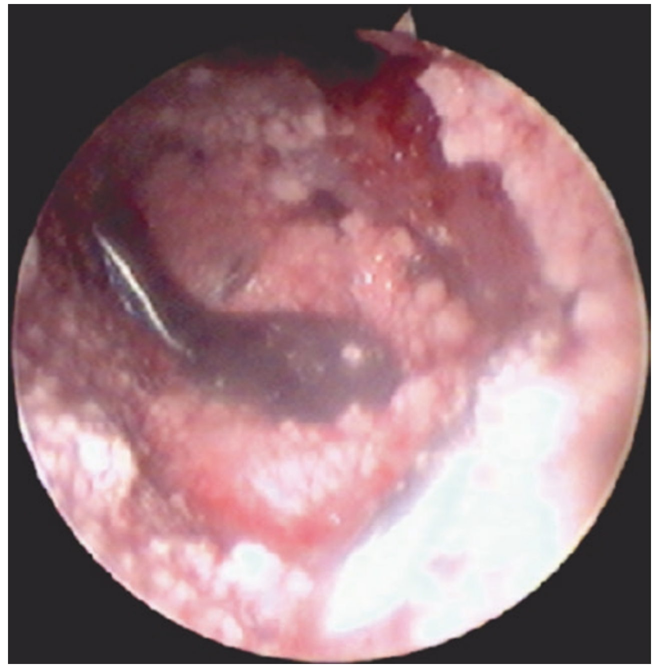


Fig. 30.42 Bone substitute granules are being impacted with a small impacter monitored through the arthroscope

Fig. 30.43 Intraoperative X-ray shows the final fixation of radioscapholunate intervals with two percutaneous AO screws. Noted that the ulnar shortening was performed before the indexed procedure

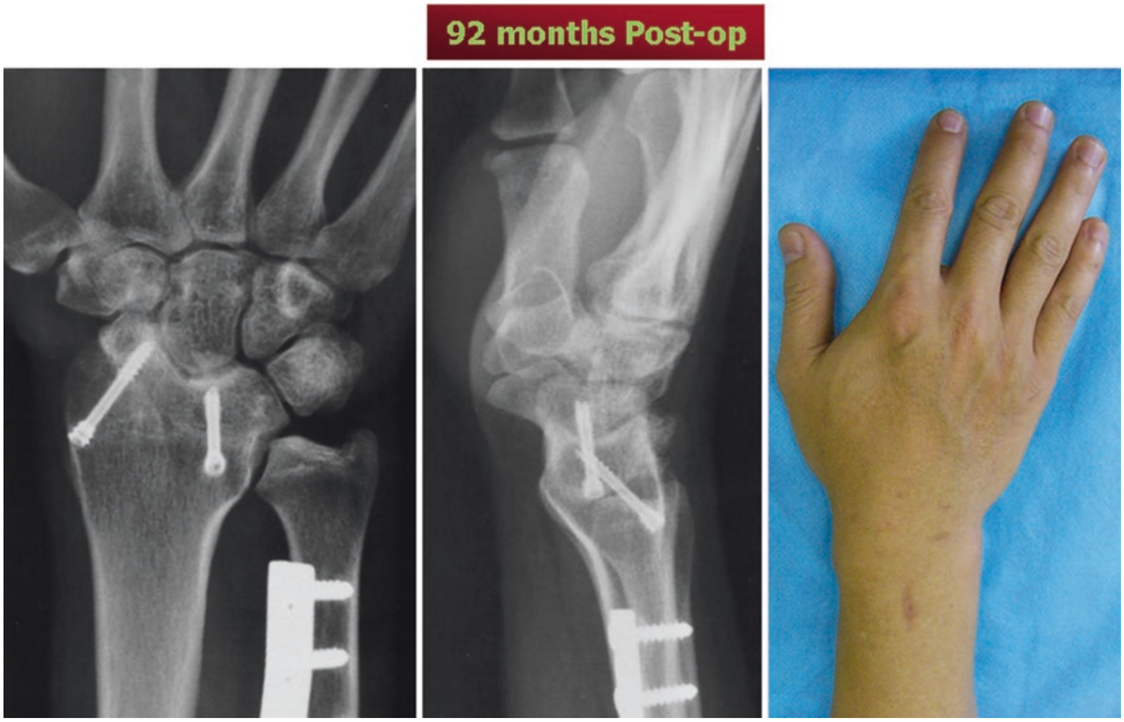


Fig. 30.44 Solid union of radioscapholunate fusion site at 92 months postoperative. Surgical scar was minimal

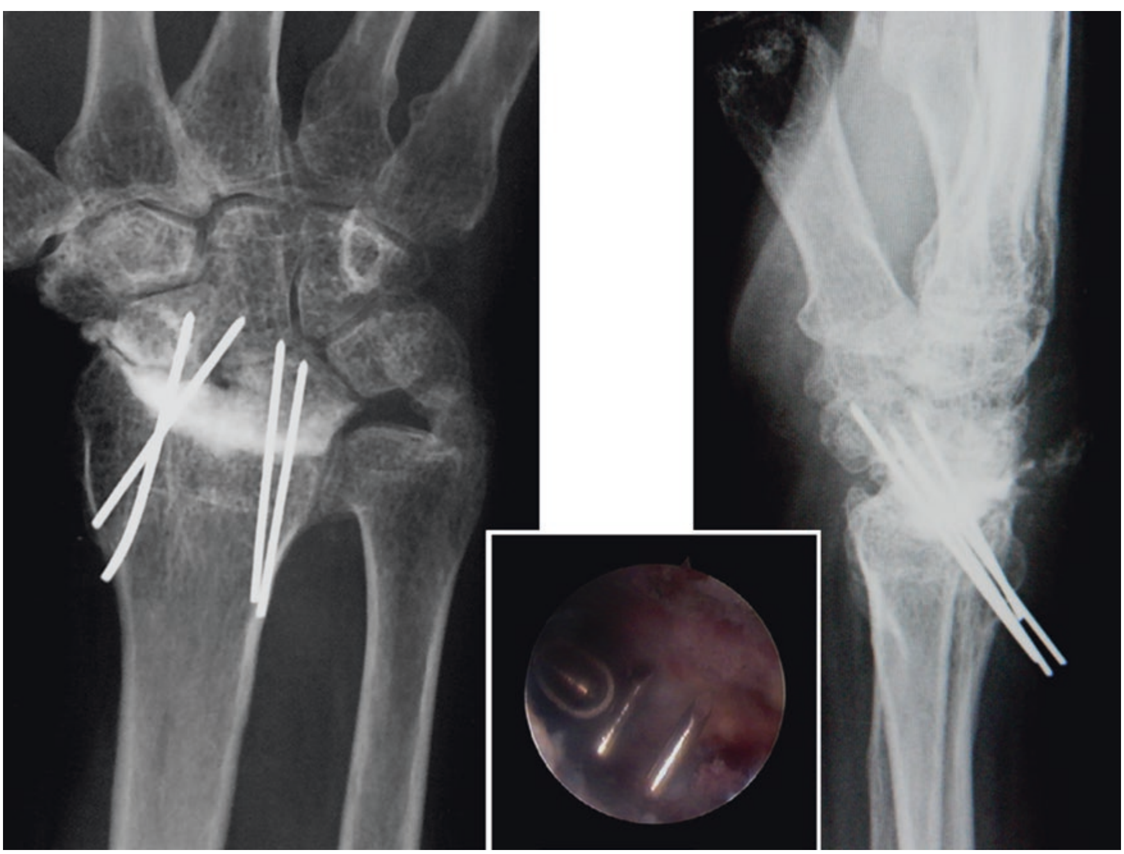


Fig. 30.45 A 51-year-old lady with posttraumatic radiocarpal joint arthrosis for 4 years. Arthroscopic radioscapholunate fusion with four K-wires and bone substitutes was done. Position of K-wires could be verified through arthroscopy at radiocarpal joint

Fig. 30.46 X-ray at 7 months postoperative shows good fusion; scars on patients are minimal

Fig. 30.47 Solid radioscapholunate fusion at 88 months postoperative. There was also spontaneous lunotriquetral fusion. Midcarpal joint was preserved. Patient had no pain

Fig. 30.48 A 34-year-old man with severe painful postdistal radius fracture arthrosis at radiolunate joint

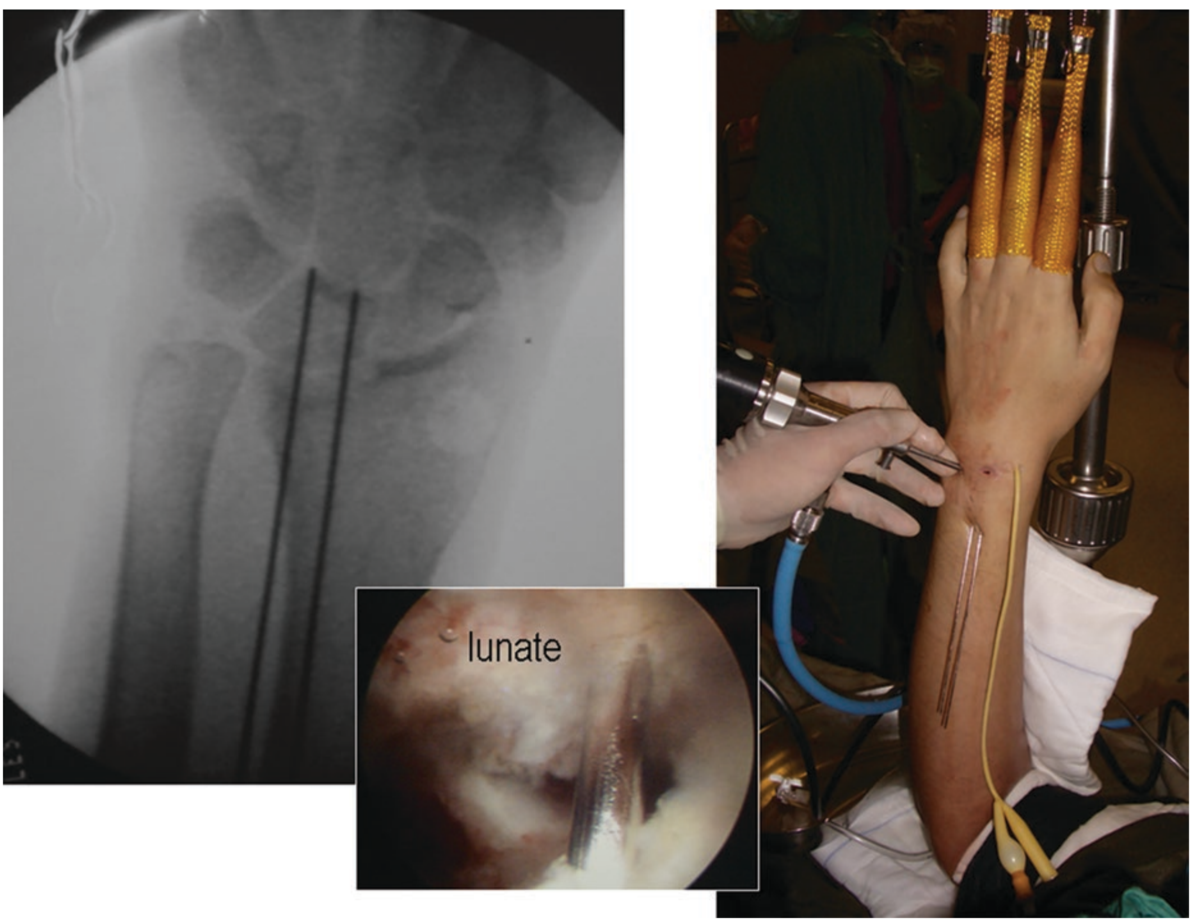


Fig. 30.49 Percutaneous pinning of the radiolunate joint under X-ray and arthroscopic guidance. A Foley catheter had been placed to obliterate the space at the radioscaphoid joint

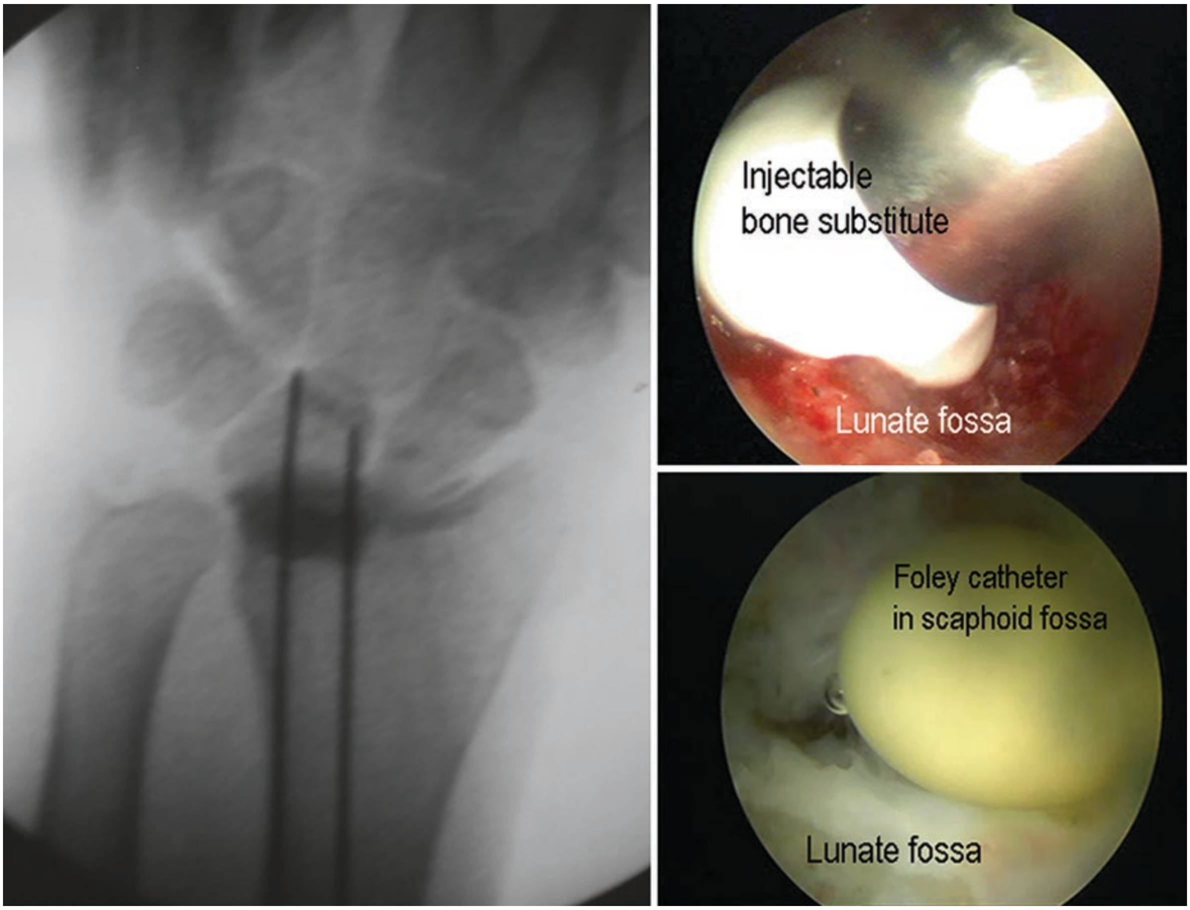


Fig. 30.50 Filling of radiolunate joint space with injectable bone substitute. Spilling of bone substitutes to adjacent space was blocked with inflated Foley catheter

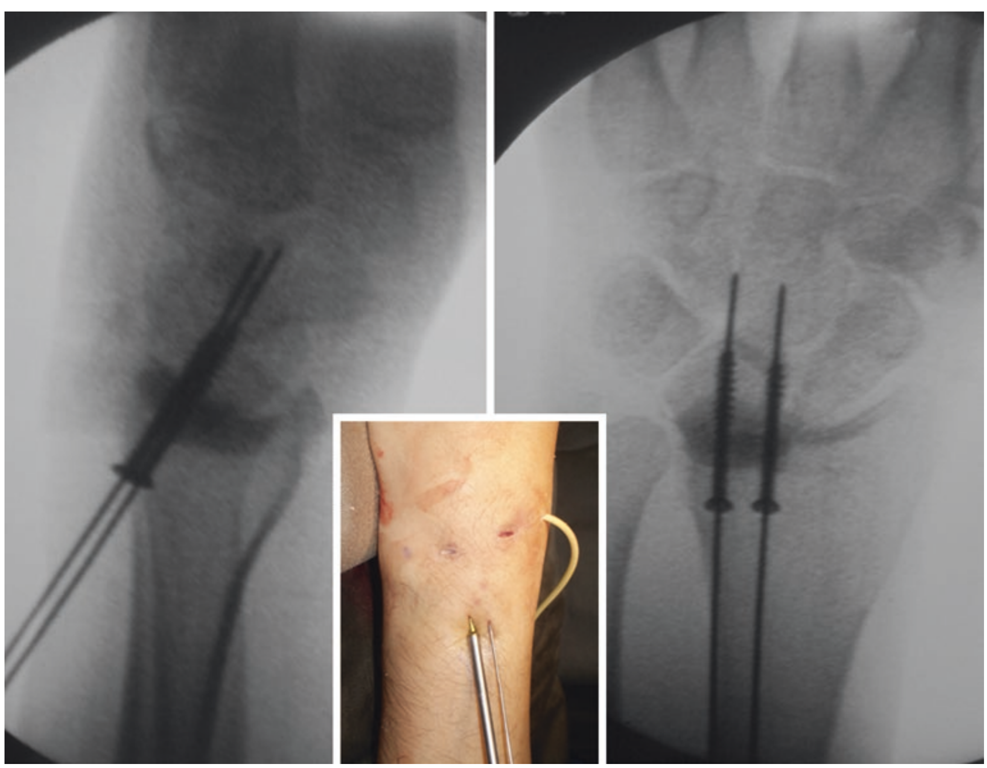


Fig. 30.51 Definitive fixation with two percutaneous AO screws at radiolunate joint

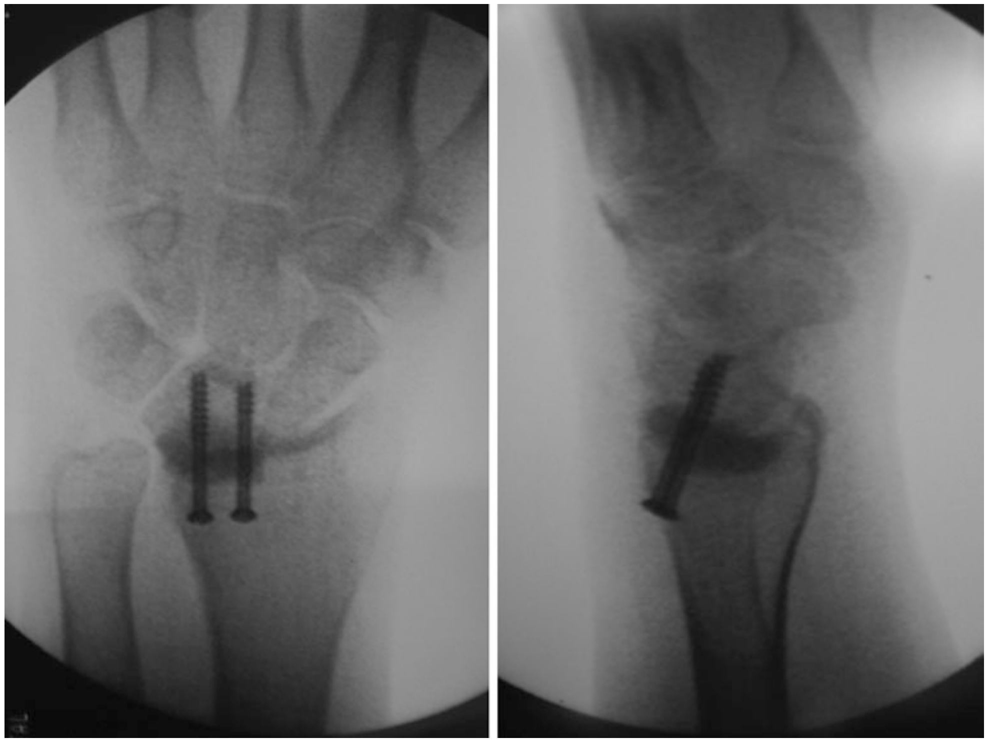


Fig. 30.52 Postoperative X-ray appearance of the radiolunate fusion with good capitolunate alignment. Noted that the bone substitutes were well contained at the radiolunate joint

Fig. 30.53 A 53-year-old lady developed severe radiolunate arthrosis without history of trauma

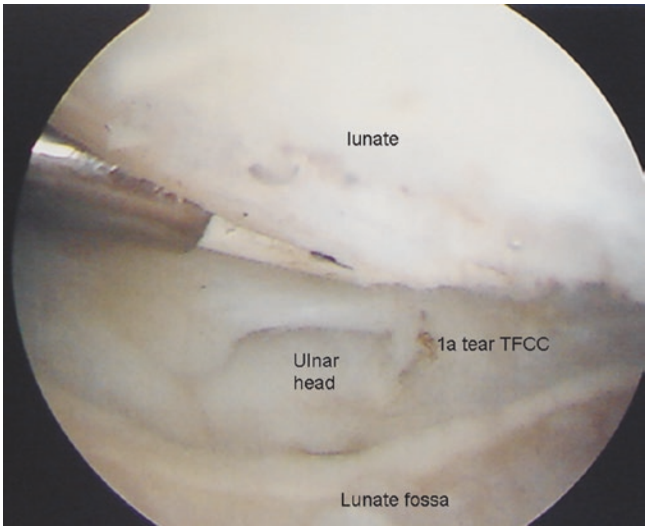


Fig. 30.54 Wrist arthroscopy shows complete eburnation of lunate fossa and proximal lunate, old 1a tear of TFCC with preserved ulnar head cartilage

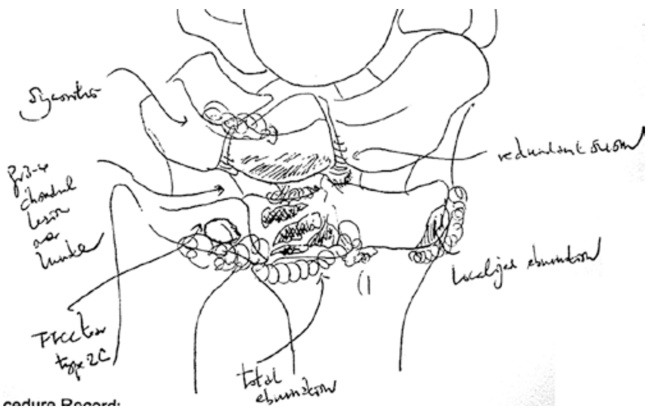


Fig. 30.55 Operative diagram depicts extent of joint pathology. There is associated small osteochondral lesion over scaphoid fossa. The midcarpal joint is normal

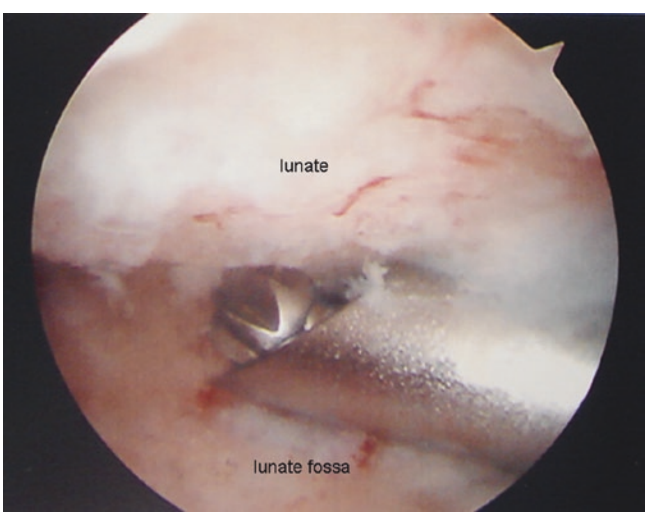


Fig. 30.56 Without tourniquet on, burring of proximal lunate revealed good subchondral punctate bleeding

fusion site is notoriously common. This is then followed by percutaneous fixation with compression cannulated screws inserted from the ulnar aspect of the hand. A cannulated drill bit is applied and a compression headless and self-tapping cannulated screw is inserted to compress the fusion site (Fig. 30.63). Preferably two screws should be inserted to obtain maximal stability of the fusion site (Fig. 30.64). Alternatively, a K-wire can be used to augment the strength of a single screw fixation if the bone is too small to accommodate two screws. All wounds are closed with steri-strips and a short arm plaster is applied to protect the fusion site until radiological union or stable fibrous union is achieved (Fig. 30.65).

Scaphocapitate Fusion

Scaphocapitate (SC) fusion is indicated in advanced Kienbock's disease as a salvage solution [31]. It is best indicated when the lunate has collapsed and the articular surfaces become fragmented, such as in Lichtman stage IIIa or IIIb situation (Figs. 30.66 and 30.67). I routinely removed the lunate since an ischemic bone can be a source of pain in the patient.

Routine surveillance of the radiocarpal joint is required to confirm an intact radioscaphoid articulation and the damaged articular cartilage of the lunate. When there is a fixed DISI deformity, the radial volar ligament and capsule can be released with the aid of shaver or radiofrequency apparatus to improve the scaphoid extension. Arthroscopic lunate excision is then performed from the midcarpal joint. With the arthroscope introduced from MCR portal, an arthroscopic burr of 2.9 mm is inserted into MCU portal and directed toward the distal surface of the lunate. The lunate is burred at high speed from articular surface down to the core cancellous bone. Bone debris is removed by intermittently applied suction. To avoid accidental damage of the adjacent articular surfaces to be preserved, a shell of cartilage can be left intact until majority of the cancellous bone is removed. This shell of cartilage can help to separate the burr from the adjacent carpal bone during the burring process. This can be removed piecemeal at the end of the lunate excision procedure by using a small pituitary rongeur or an arthroscopic punch. In order to speed up the process, arthroscopic burr of progressive increase in size such as 3.5 mm and even 4.5 mm can be used when there is more space open up after part of the lunate is removed.

Once the lunate is cleared, attention can be paid to the fusion of the scaphocapitate joint. The arthroscope is now inserted through MCU portal while the MCR portal is reserved for arthroscopic instruments. The articular surface between the scaphoid and capitate is denuded of cartilage with 2.9 mm burr with the principle as described earlier. The articular cartilage at the STT joint area should remain intact.

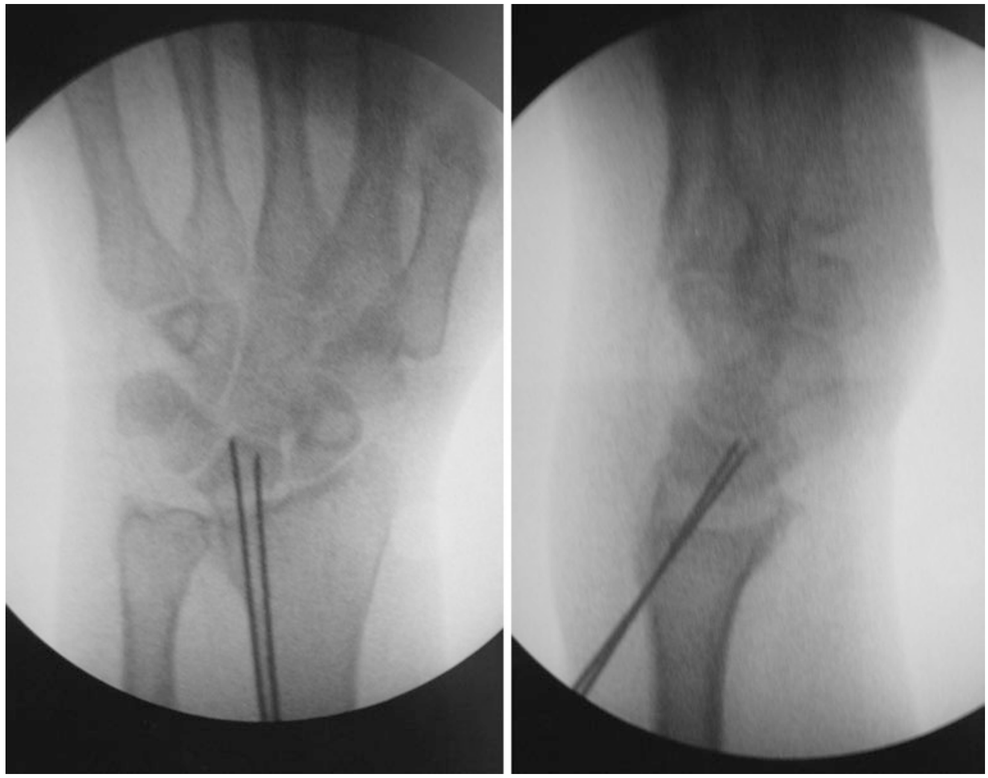


Fig. 30.57 Intraoperative fluoroscopy shows good position of the guide pins across the radiolunate joint

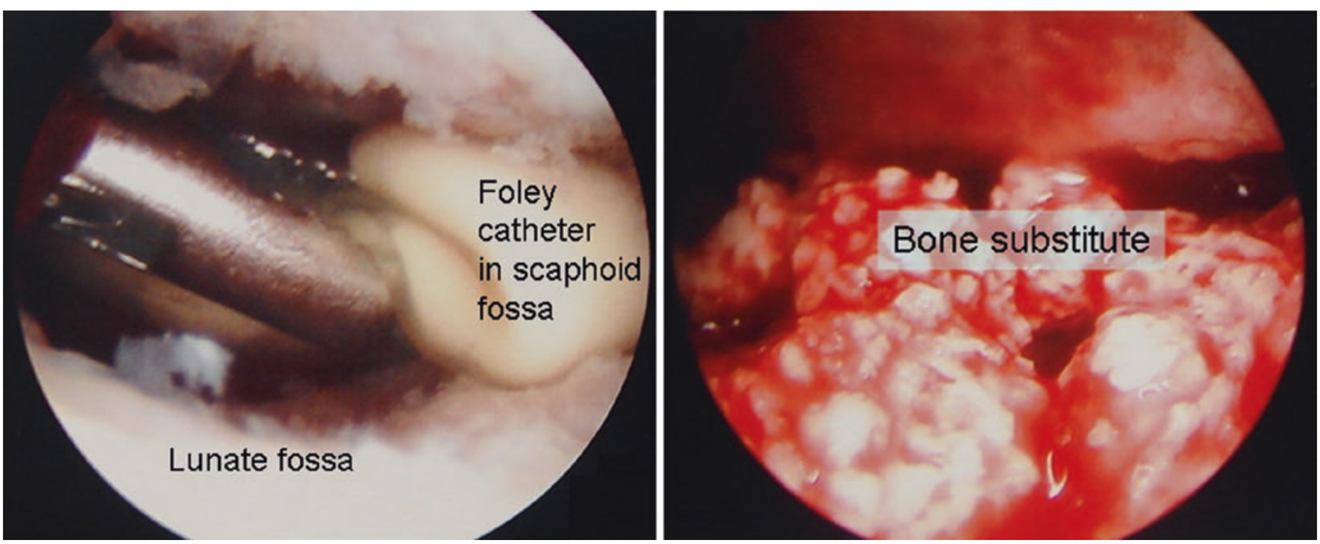


Fig. 30.58 Arthroscopic view showing position of Foley catheter at the scaphoid fossa and granule form of bone substitute at radiolunate joint space

The wrist is taken off from the wrist tower. A small stab wound is being made at the anatomical snuff box area. The ministab wound should be bluntly dissected to avoid iatrogenic injury to the radial artery and terminal branches of the radial nerve until the bony cortex of scaphoid is reached. With the help of an anteroposterior and lateral projection under an image intensifier, two guide wires of a small cannulated screw system with adequate space in between are being inserted and driven across the scaphoid toward capitate. To avoid injury to the vessel, the guide pins can be inserted through a metal sheath of a 14G angiocatheter serving as a guide.

In SC fusion, the articular congruency achieved between the scaphoid and the capitate is typically good. The use of bone graft or substitute is optional. Conversion of the K-wire fixation with cannulated screws is then followed as described

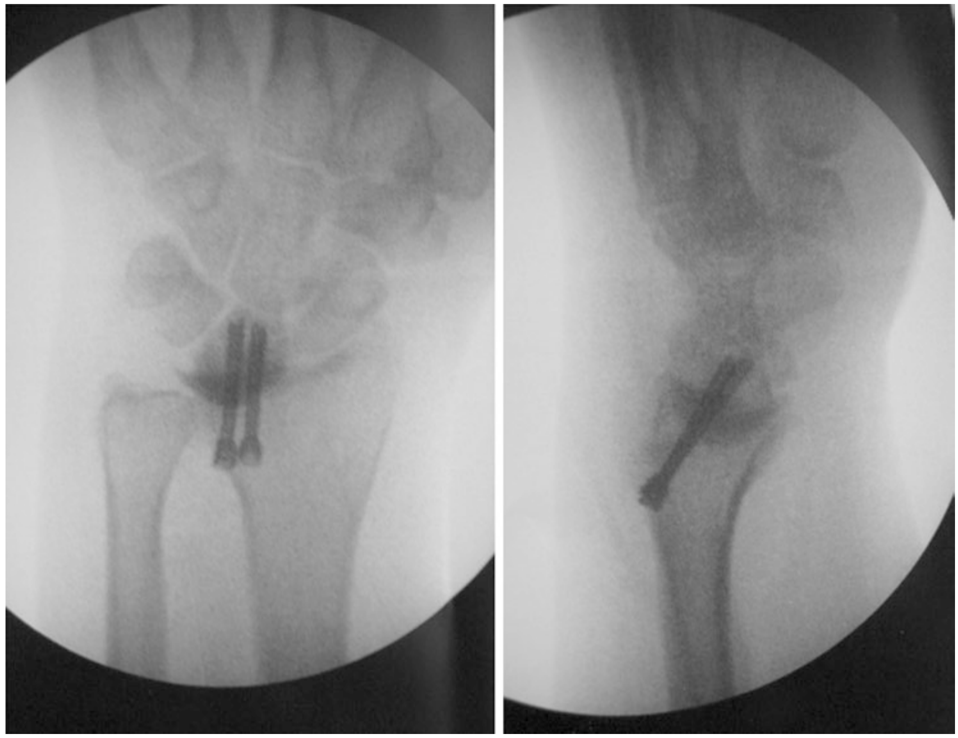


Fig. 30.59 Final definitive fixation of radiolunate joint with two percutaneous bold screws. Noted that both radioscaphoid and ulnocarpal joint were free of bone substitute due to blockage by Foley catheter

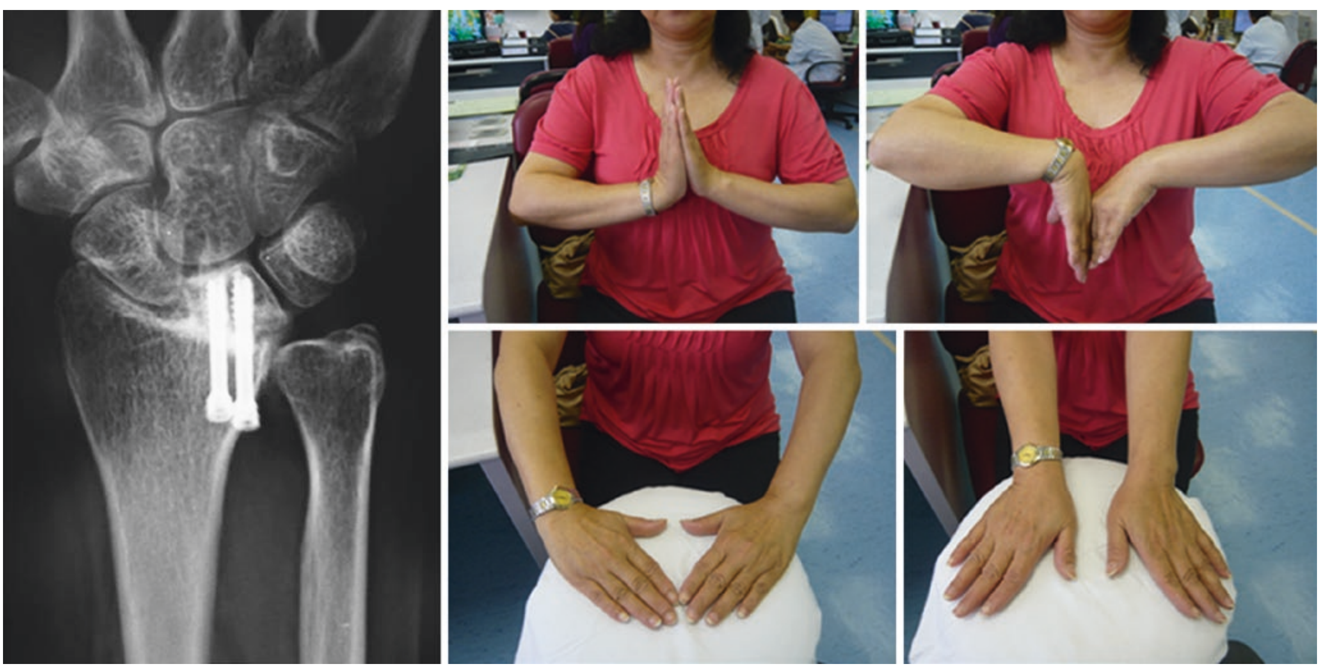
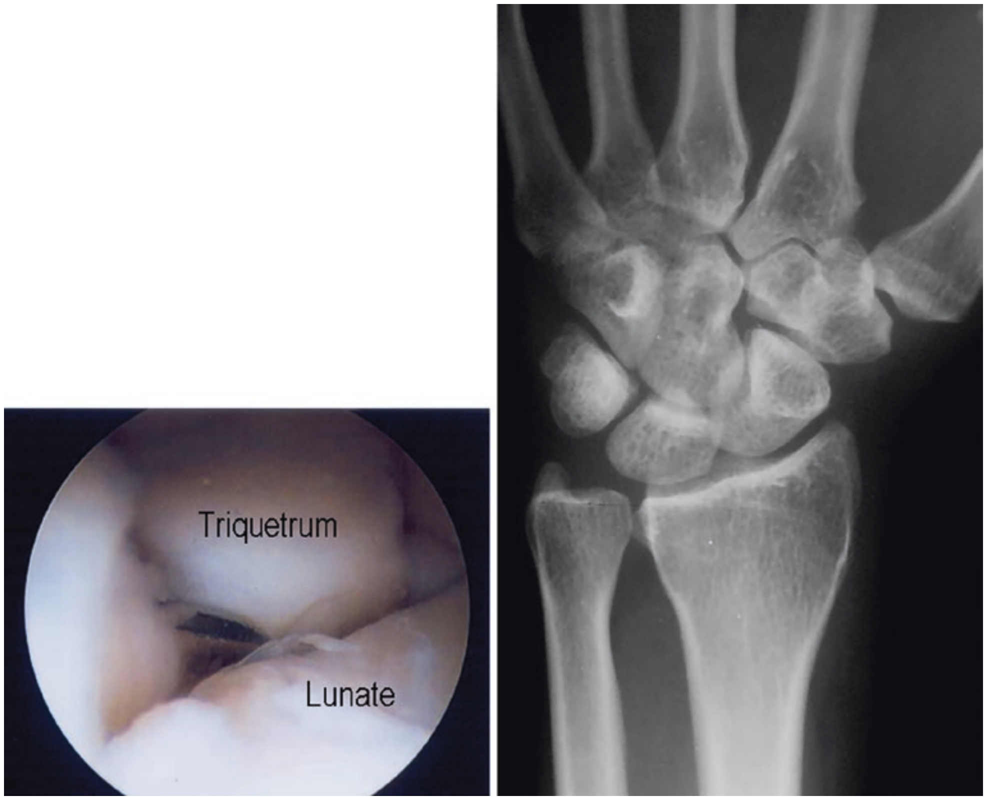


Fig. 30.60 Solid bone union at 6 months postoperative and clinical range of motion of the left wrist. Patient was pain free and returned to normal duty as office assistant

Fig. 30.61 Patient with chronic ulnar wrist pain for 2 years. X-ray reviewed an increased lunotriquetral interval. Arthroscopy confirmed Geissler grade 3 lunotriquetral instability



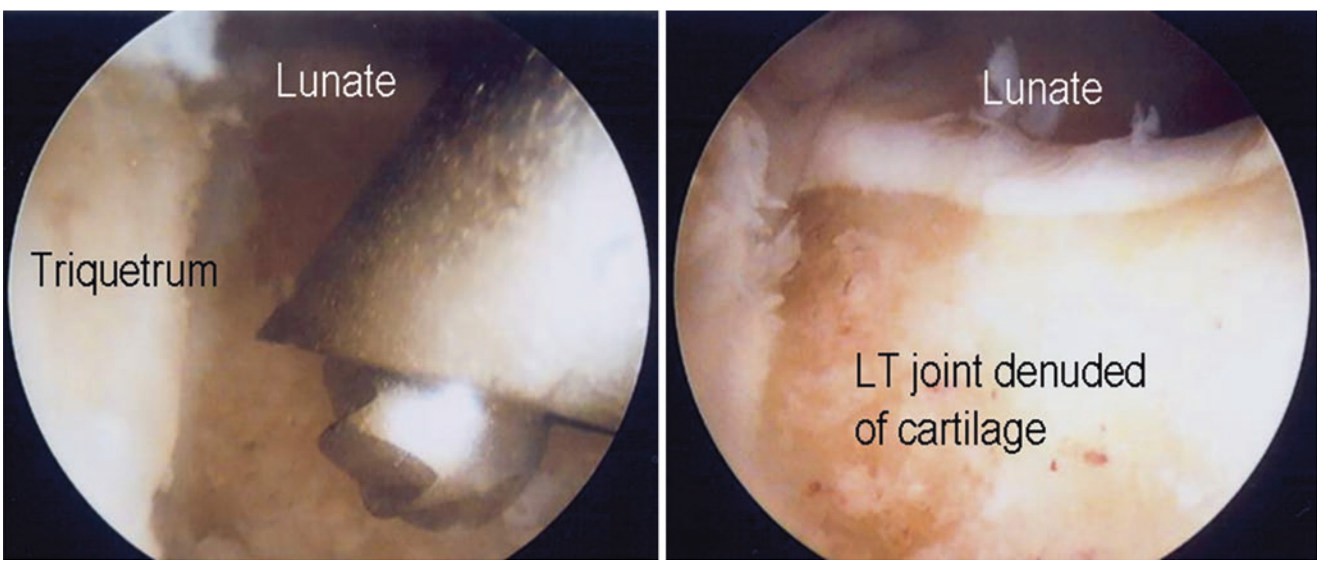


Fig. 30.62 Burring of the lunotriquetral joint before fusion

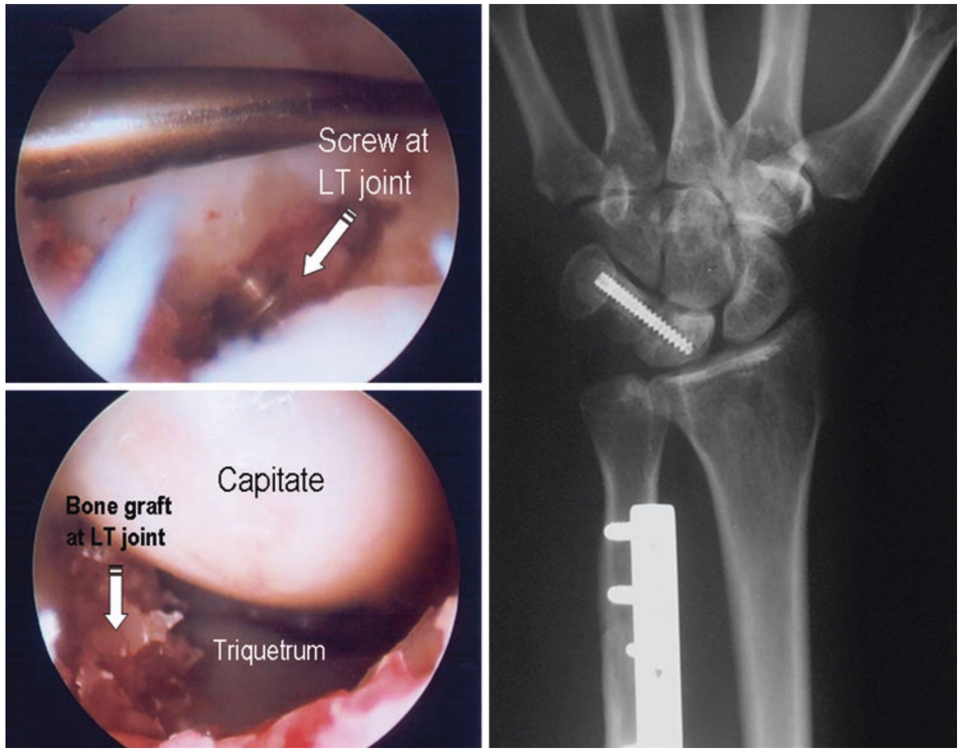


Fig. 30.63 Arthroscopic view of the screw in the lunotriquetral joint, which is eventually covered with arthroscopic bone graft. X-ray shows good fusion position

Fig. 30.64 Another patient with complete LT dissociation treated with arthroscopic LT fusion using two compression screws

Fig. 30.65 Minimal scarring over surgical wounds

previously (Fig. 30.68). Stability and range of motion of the wrist can be checked under fluoroscopic guidance.

Wounds are then closed with steri-strips and a comfortable bulky dressing is applied supported with a short arm plaster slab. The slab is changed to a removable wrist splint after the first week, when gentle active mobilization of the wrist can be initiated out of splint under the supervision of a hand therapist (Fig. 30.69). Passive wrist mobilization and strengthening exercise can be offered when radiological and clinical union is evidenced, usually around 8–10 weeks postoperative (Figs. 30.70 and 30.71).

Outcome and Complications

From November 1997 to October 2011, we had performed arthroscopic partial wrist fusion in 23 patients, including 19 males and 4 females. The indications were SLAC wrist in six, SNAC wrist in five, chronic LT instability in two, Kienbock's disease in three, posttraumatic arthrosis in five, and inflammatory arthritis in two. The average duration of symptom was 34.2 months (range 9–82 months). These procedures included STT fusion in three, scaphoidectomy plus four corners fusion in five, scaphoidectomy plus capitolunate fusion in four, lunatectomy plus scaphocapitate fusion in three, radioscapholunate fusion in four, radiolunate fusion in two, and lunotriquetral fusion in two. The average age of the patients at time of surgery was 42 (range 18–68 years old). Concomitant arthroscopic procedures were performed in

Fig. 30.66 A 22-year-old male semiprofessional tennis player with right dominant wrist Kienbock's disease stage IIIb for 5 years

Fig. 30.67 MRI images of the right wrist show severe avascular necrosis and complete fragmentation collapse of the lunate

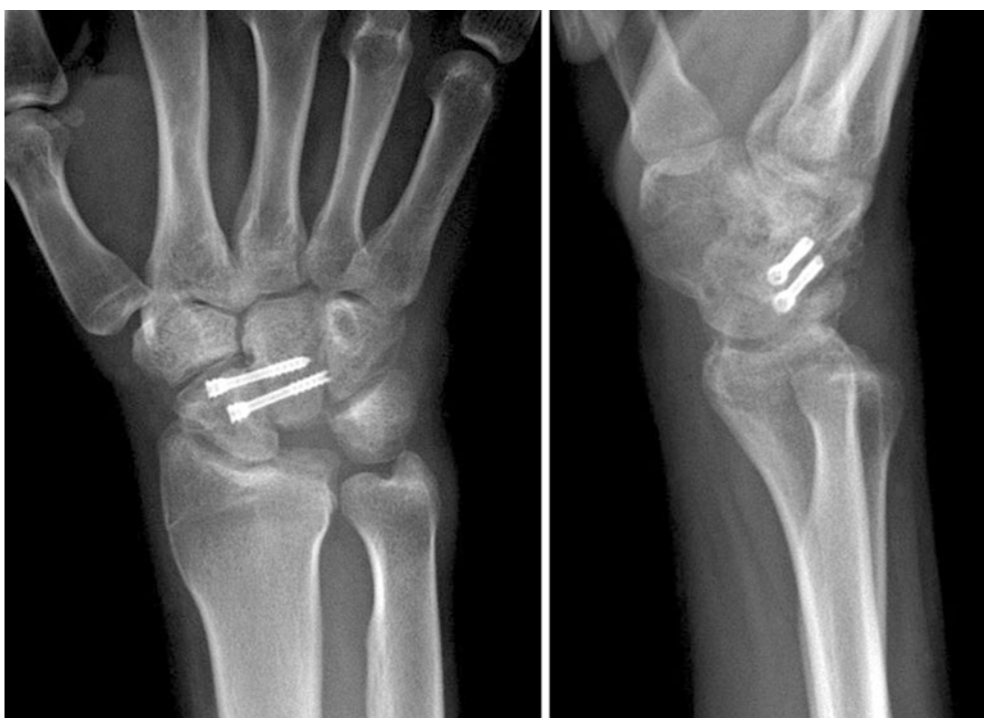


Fig. 30.68 The patient underwent arthroscopic lunate excision and scaphocapitate fusion with two headless cannulated screws augmented with injectable demineralized bone matrix at the fusion interface

four patients and they included radial styloidectomy, TFCC reconstruction with palmaris longus graft, Wafer procedure, and endoscopic carpal tunnel release. Autogenous bone graft was used in nine patients, while bone substitute was employed in another nine patients. Radiological union of the fusion site was obtained in 19 cases, stable asymptomatic fibrous union in three cases, and definite nonunion requiring revision in one case. Break down of union rate according to the surgical types is shown in Table 30.1.

Fig. 30.69 Right wrist condition at 2 weeks postoperative showing minimal swelling and scars

The median time of radiological union in the united cases was 10 weeks (range 5–50 weeks). The average follow-up time was 59.9 months (range 11–112 months). The three cases of fibrous union remained asymptomatic and no further surgery or treatment was required. It was notable that both cases of LT fusion ended up in fibrous union. Among the bony union cases, three patients had continuing pain and required further treatment including wrist fusion in two and Amandy interposition arthroplasty in one patient. Two patients required a combined anterior and posterior interosseous nerve neurectomy as secondary procedure for complete pain relief. At final follow-up, all except one patient had no pain or minimal residual pain (Figs. 30.72 and 30.73). The case of RL fusion using percutaneous screw fixation and injectable bone substitute failed to heal in 9 months despite optimal internal fixation and was revised successfully with open RL fusion using iliac crest block bone graft and plating. Intraoperatively marked osteolysis was noted at the fusion site though no evidence of infection was obtained. The final outcome was excellent (Figs. 30.74, 30.75, 30.76, 30.77 and 30.78). All arthroscopic surgical scars were almost invisible

Fig. 30.70 Solid fusion and excellent aesthetic result at 11 months postoperative

Fig. 30.71 Patient retained 45° extension and 55° flexion at the wrist. He resumed competitive tennis sport activities at 6 months postoperative

Table 30.1 Break down of union rate according to the surgical types

	Bony union	Fibrous union	Nonunion
STT fusion	2	1	
LT fusion		2	
Scaphoidectomy + four corners fusion	5		
Scaphoidectomy + CL fusion	4		
Lunatectomy + SC fusion	3		
RSL fusion	4		
RL fusion	1		1
Total	19	3	1

at the final follow-up and all patients were satisfied with the clinical result.

Complications in our small series of 23 patients were limited. Early complication included two cases of pin tract infection which responded to dressing, antibiotic, and early pin removal. There was one case of superficial second-degree skin burn due to the use of a high-speed burr without a good protective sheath, and one case of delayed union of the radioscapholunate fusion which required 50 weeks to complete the radiological union. One old and osteoporotic patient required removal of the screws at 8 months postoperation due to protrusion of screw threads at the proximal lunate articular surface.

Technically there are potential drawbacks of arthroscopic approach compared to the conventional open techniques. Use of additional bone graft or bone substitute to augment fusion may become mandatory in some cases due to inability to recycle the excised carpal bone as bone graft in situations such as concomitant scaphoidectomy. The small surgical access also limits the choice of use of implant for fixation. K-wire or cannulated screw becomes the usual armamentarium. It can be technically demanding and time-consuming for those less experienced with small joint arthroscopy. Our average operating time was 185 min. Efficiency of current commercially available instruments can also be one of the limiting factors on the speed of the operation.

In conclusion, arthroscopic partial wrist fusion is a viable option for patients suffering from posttraumatic or nonprogressive wrist arthritis who would like to preserve useful wrist motion with good aesthetic outcome. Union rate is high and complication uncommon. However, it is a technically demanding procedure with steep learning curve. Proper training in small joint arthroscopy and further improvement in design and efficacy of the arthroscopic instruments will be helpful in popularizing the technique.

Fig. 30.72 A 22-year-old man with 34 months history of chronic SL dissociation. Arthroscopic STT joint fusion was performed on November 24, 1997. Solid radiological union on X-ray and CT scan was seen 24 months postoperative

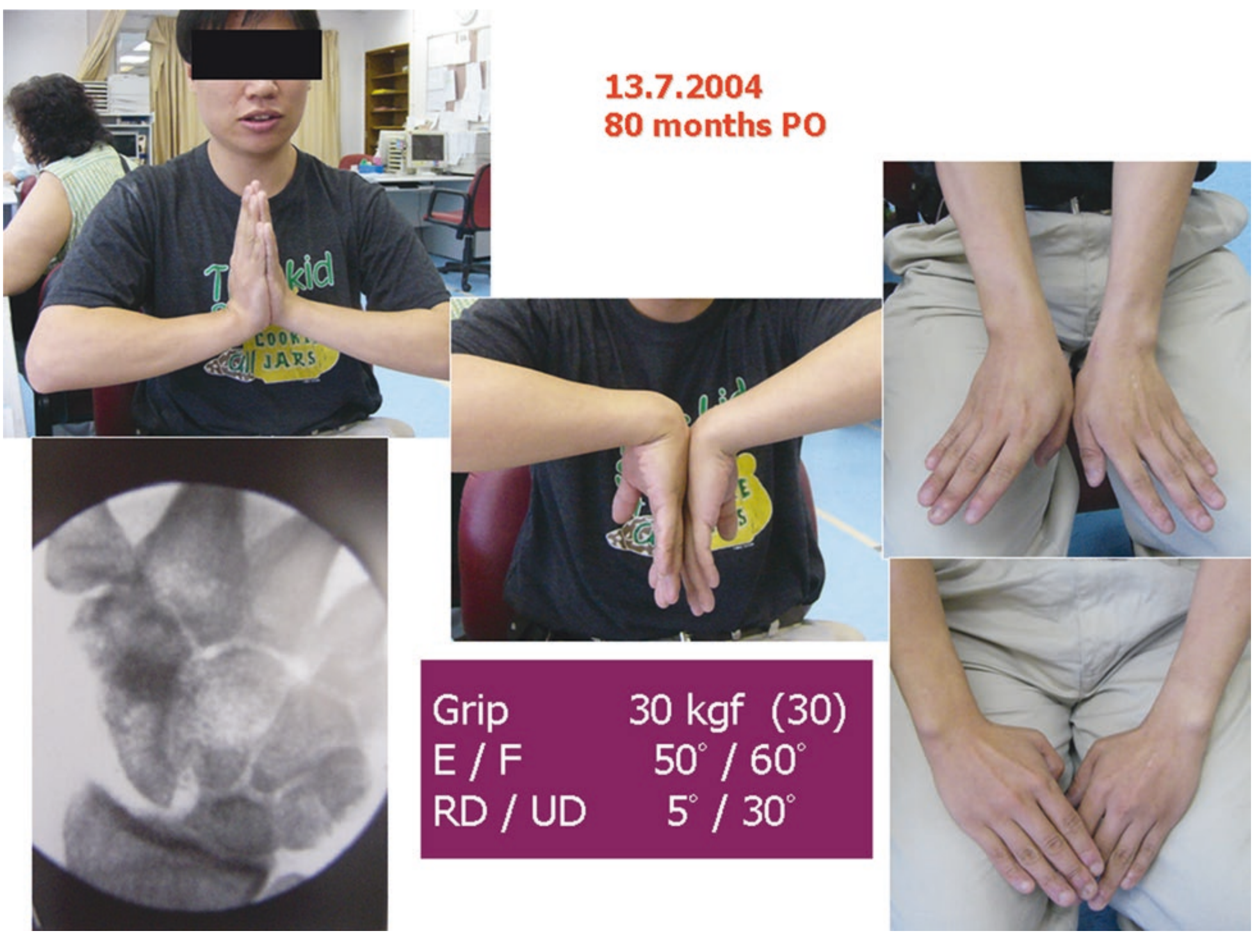


Fig. 30.73 Excellent clinical and radiological outcomes at 80 months postoperative

Fig. 30.74 A 31-year-old man with postdistal radius fracture radiolunate arthrosis. Good alignment and fixation of the arthroscopic radiolunate fusion at 6 weeks postoperative was shown

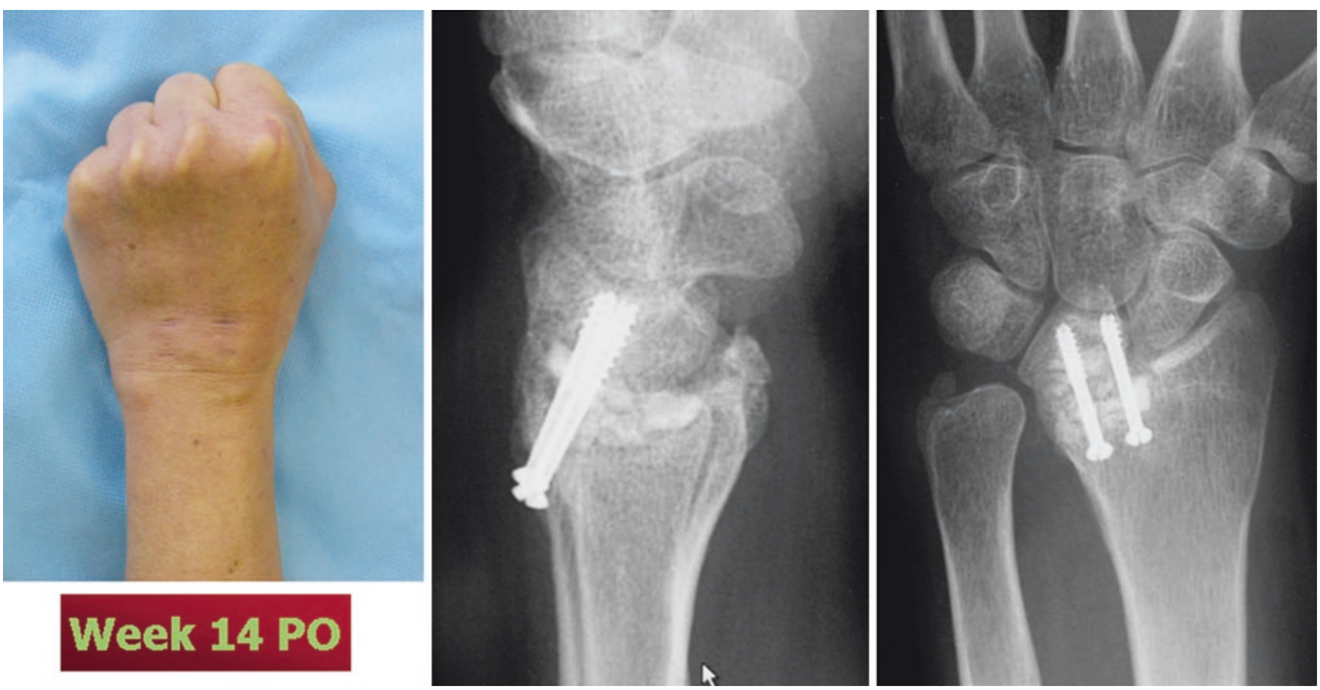


Fig. 30.75 Evidence of early osteolysis of fusion site at 14 weeks postoperative

Fig. 30.76 Definite nonunion at 9 months postoperative as shown by X-ray and CT scan

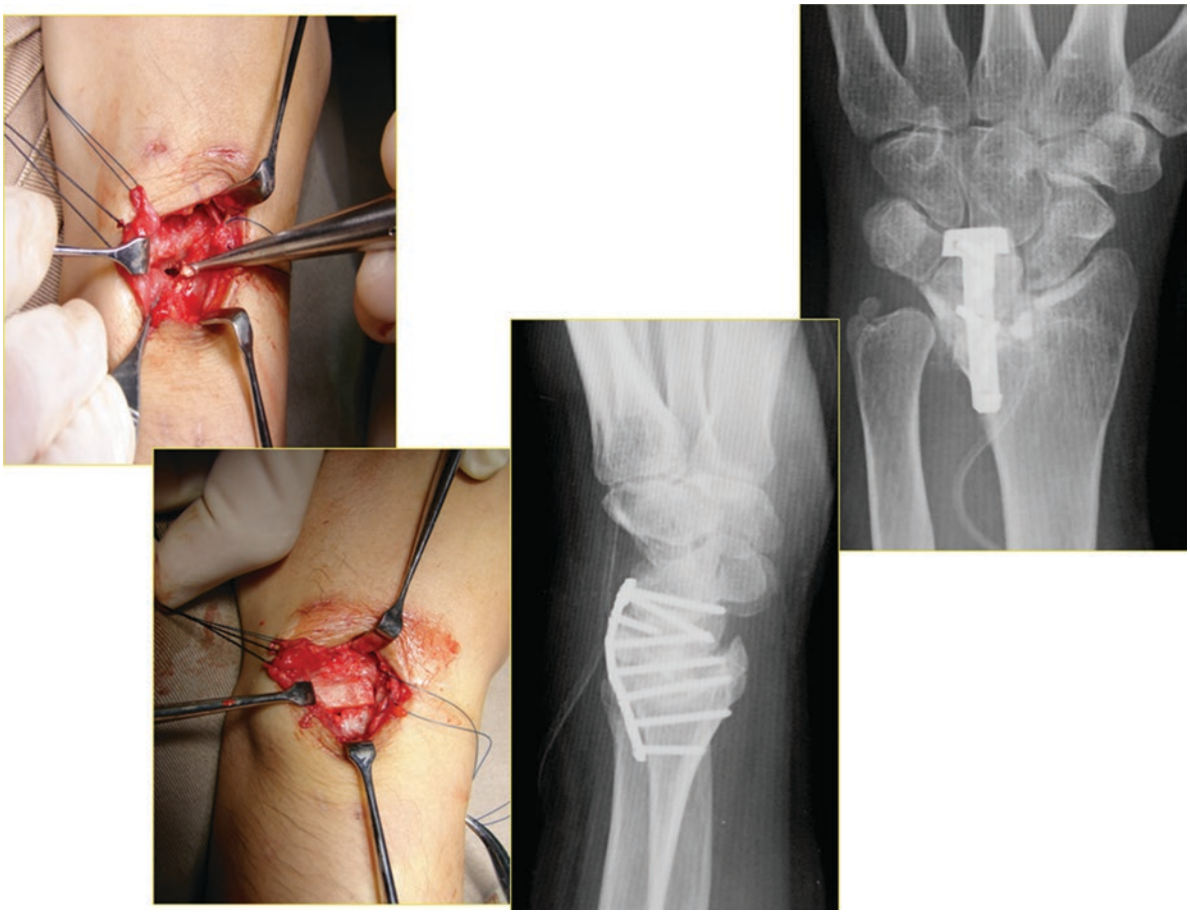


Fig. 30.77 Aseptic nonunion confirmed at revision operation with fusion converted to open iliac crest block bone grafting and plating

Fig. 30.78 Final X-ray at 8.5 years postoperative showing no ongoing arthrosis of the wrist

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