Advances in arthroscopic surgery of the wrist: from resection to reconstruction

Novosti u artroskopskoj kirurgiji ručnog zgloba: od resekcije do rekonstrukcije

Pak-Cheong Ho*, Wing-Lim Tse, Clara Wing-Yee Wong, Leung-Kim Hung

Division of Hand & Microsurgery,
Department of Orthopaedic &
Traumatology, Prince of Wales Hospital
Chinese University of Hong Kong,
Hong Kong, SAR

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Abstract. One of the major advances in wrist arthroscopy is the development of various therapeutic procedures since the 90's. Therapeutic procedures are no longer restricted to resection. More specific repair procedures and functional reconstruction involving replenishment of tissue defect and augmentation of vital structures are seen with proven value. In particular, wrist arthroscopy performed under local anaesthetic setting without tourniquet and sedation markedly reduces the risk and cost. This article highlights the common indications and applications of wrist arthroscopy, with emphasis on the latest and significant innovations in reconstructive arthroscopic surgery in Hong Kong. On the resection aspect, common procedures include joint debridement, synovectomy, ganglionectomy, capsular release and osteotomies. Reparative surgery includes ligament repair, arthroscopic assisted reduction and fixation of fracture dislocation and chondroplasty for small chondral lesions. Reconstructive surgery embraces surgical solutions tackling on osseous, soft tissue and cartilage problems. Scaphoid nonunion can be treated by arthroscopic bone grafting and percutaneous fixation with union rate of over 90 %. Partial wrist fusion can be achieved arthroscopically to maximize motion and to enhance union by preserving soft tissue and vascularity. Arthroscopic assisted reconstruction of the radio-ulnar ligaments with tendon graft can be performed to treat chronic distal radioulnar joint instability through bone tunnels in sigmoid notch and ulnar fovea. In chronic scapholunate (SL) instability, the dorsal and palmar portion of the SL interosseous ligament is reconstituted anatomically through arthroscopically assisted reconstruction with tendon graft in a box-like structure. In cartilage reconstruction, post–traumatic chondral lesion can be treated with arthroscopic osteochondral transplant.

Key words: anaesthesia; arthroscopy; indication; reconstruction; technique; wrist

Sažetak. Od uvođenja artroskopije ručnog zgloba 90-ih godina prošloga stoljeća počinje razvoj i uvođenje brojnih novih terapijskih postupaka. Zahvati više nisu ograničeni samo na resekcije, već se počinje s razvojem reparacijskih i funkcionalnih rekonstrukcija, kao što su popunjavanje defekata i augmentacija vitalnih struktura. Artroskopija ručnog zgloba izvedena u lokalnoj anesteziji i bez Torniquetove poveske značajno smanjuje i cijenu zahvata. U ovom radu istaknute su najčešće indikacije i primjena artroskopija ručnog zgloba s naglaskom na najnoviji zahvat artroskopske rekonstrukcije ručnog zgloba u Hong Kongu. Glede resekcija, najčešći zahvati uključuju debridman zgloba, sinovijektomiju, ganglionekotimiju, opuštanje zglobne čahure i oteotomiju. Reparativni zahvati uključuju rekonstrukcije ligamenata, artroskopski asistirane repozicije i fiksacije prijeloma i luksacija te hondroplastike. Rekonstruktivni zahvati obuhvaćaju zahvate na kostima, mekim tkivima i hrskavici. Nesraštanje skafoidne kosti može se liječiti artroskopski s koštanim presadcima i perkutanim fiksacijama, a uspješnost cijeljenja je veća od 90 %. Djelomične artrodeze mogu se provesti artroskopski kako bi se očuvala pokretljivost ostalih dijelova i pojačalo cijeljenje očuvanjem mekih tkiva i vaskularizacije. Artroskopski asistirana rekonstrukcija radioularnih ligamenata s tetivnim transplantatima može se izvoditi pri kroničnim nestabilnostima distalnog radioulnarnog zgloba. Pri kroničnoj skafolunatnoj nestabilnosti, dorzalni i palmarni dio SL ligamenta mogu se anatomski rekonstruirati tetivnim presadcima. Posttraumatska hrskavična oštećenja mogu se liječiti artroskopski primjenom koštano-hrskavičnih transplantata.

Ključne riječi: anestezija; artroskopija; indikacija; rekonstrukcija; ručni zglob; tehnika

***Corresponding author:**
Pak-cheong Ho, MBBS, FRCS (Edinburgh), FHKCOS, FHKAM (Orthopaedic)
Division of Hand & Microsurgery
Department of Orthopaedic & Traumatology
Prince of Wales Hospital
Chinese University of Hong Kong
Hong Kong, SAR
e-mail: pcho@orto.cuhk.edu.hk

http://hrcak.srce.hr/medicina

INTRODUCTION

One of the major advances in the wrist arthroscopy is the steady development of various therapeutic procedures since 90's. Most of the techniques are transferred or inspired from established techniques used in large joint arthroscopy through the simultaneous development of customized instrumentation adapted for small joints. The outbreak of therapeutic arthroscopy has markedly escalated the value and role of arthroscopy in the management of wrist disorder, both in acute and elective conditions. In some clinical conditions such as chronic ulnar wrist pain, wrist arthroscopy has opened up a new horizon or standard for evaluation and treatment. Similarly, in a growing number of clinical disorders such as scaphoid fracture, carpal non-union, ganglion, TFCC lesions etc, the new therapeutic procedures are going to challenge the conventional ways and thinking of surgical treatment and long term results are evolving. With time, wrist arthroscopy may gain the same status as in knee arthroscopy.

ARTHROSCOPIC TECHNIQUES AND INDICATIONS

During the past 15 years, numerous innovative techniques have been developed with specific surgical indications. With the maturation of technique and instrumentation, more complex and precise new procedures can be performed with low complications. Therapeutic procedures are no longer restricted to resection process. More specific anatomical structure repairing procedures, and to the forefront, functional reconstruction procedures involving replenishment of tissue defect and augmentation of vital structures with graft material are seen with proven clinical value. This article summarizes the techniques that we are constantly using in clinical practice in Hong Kong, some of them representing the edge-cutting advances in therapeutic arthroscopy:

- Lavage
- Joint debridement
- Synovectomy
- Ganglionectomy
- Removal of loose bodies
- Capsular release
- Osteotomy
- Ligament repair
- Arthroscopic-assisted reduction and Internal fixation
- Chondroplasty
- Bone grafting
- Partial wrist fusion
- TFCC reconstruction
- SL ligament reconstruction
- Osteochondral grafting.

Wrist arthroscopy has opened up a new horizon in treatment of wrist disorders. Advanced therapeutic procedures involve replenishment of tissue defect and augmentation of vital structures with graft, as applied in scaphoid nonunion, partial wrist fusion, ligament reconstruction in chronic DRUJ and SL instability, and osteochondral grafting for cartilage diseases.

WRIST ARTHROSCOPY UNDER PORTAL SITE LOCAL ANAESTHESIA WITHOUT TORNIQUET

It is worldwide practice that wrist arthroscopy is performed under general or regional anaesthesia with the aid of tourniquet to maintain bloodless field. Since late 1970s, Local anaesthesia using intraarticular infiltration has been advocated for both diagnostic and therapeutic procedure in knee and ankle arthroscopy with good results[1,2]. Nevertheless, the large volume of anaesthetic solution required for an effective procedure carries potential risk[3]. Rolf et al. described the technique of injecting anaesthetic solution into the portal sites alone and reported satisfactory results[4]. We have been using portal site local anaesthesia (PSLA) without tourniquet in performing wrist arthroscopic procedures since 1998. An earlier, smaller study performed at the time showed promising results. Of the 38 cases performed between May 1998 and February 1999, the success rate of PSLA was 84 %. Eighty-nine percent of patient reported satisfactory comfort and considered PSLA to be the preferred option of anaesthesia. (Yung SH, Ho PC, presented at the 13th Congress of Hong Kong Society for Surgery of the Hand. Hong Kong, 1999) Since then, wrist ar-

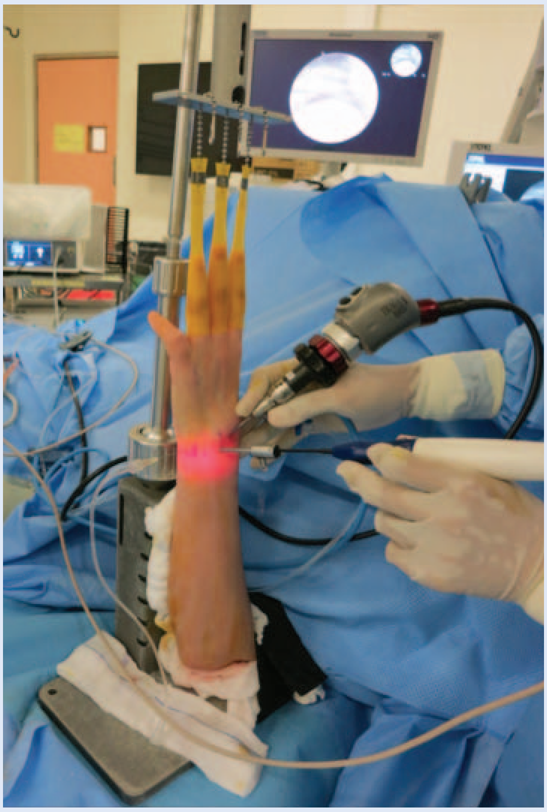

Figure 1. Standard set up of wrist arthroscopy under PSLA: three plastic finger traps, thick padding for arm and forearm, sterile traction tower with adjustable tension, no tourniquet

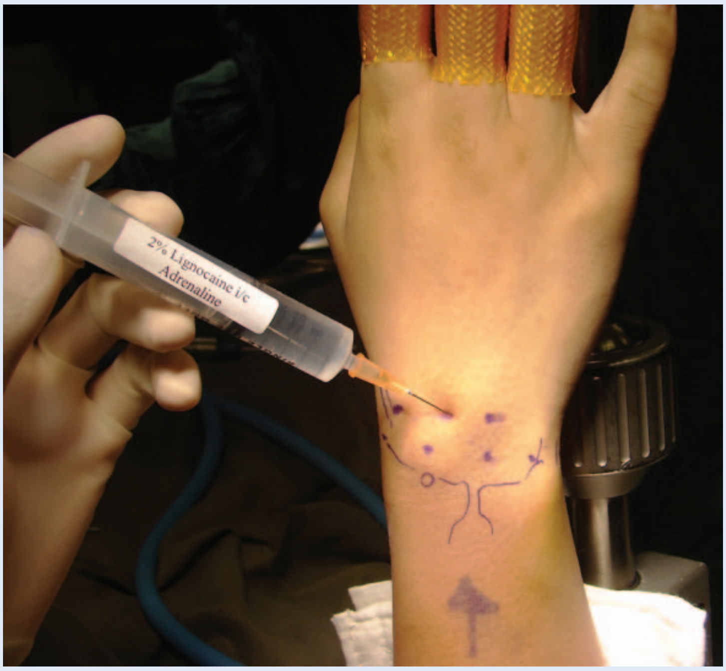

Figure 2. PSLA achieved by injecting 2 % lignocaine with 1:200,000 adrenalin solution through a 25G needle to the skin and capsular area at portal sites with or without articular infiltration

throscopy under PSLA became our standard practice.

Typically no sedation is required. It is important to maintain the comfort of the patient during the surgical procedure. The patient is positioned supine and the affected upper limb is abducted at shoulder level and supported on a hand table. The affected hand is subjected to digital traction through finger traps by using a wrist traction tower with adjustable tension spring to control the traction force. We prefer the use of plastic over metal trap as the latter is poorly tolerated by the patient when the operation is performed under PSLA. Three finger traps are used for the index, middle and ring fingers for a more even distribution of the traction force. The arm of the patient is well padded and connected to the traction tower. Usually 10-12 pounds of force is adequate (Figure 1). Under traction, the various standard portals for arthroscopy are marked on the skin through thumb tip palpation. The routine entry portal for the radio-carpal joint is 3/4 portal and the outflow is maintained at 6U portal using a 18G needle. We prefer 4/5 portal over 6R portal as the standard working portal for its more central location in the wrist, which allows easy access to both radial and ulnar side of the wrist. For mid-carpal joint examination, the mid-carpal radial (MCR) portal is usually employed as the entry portal while the mid-carpal ulnar (MCU) portal is used as outflow or working portal. The two accessory portals commonly being used for outflow or manipulation are the scapho-trapezio-trapezoid (STT) portal and the triquetro-hamate (TH) portal.

We routinely employ 2 % lignocaine with 1:200,000 adrenaline, which is injected through 25G needle into the various standard portal sites down to the level of capsule with or without intraarticular infiltration (Figure 2). The action of the lignocaine usually works quickly within 30-60 seconds. The radio-carpal joint is then distended by injecting 3-5 c.c. of saline at the 3/4 portal. Skin incision is performed using a 15T surgical blade. We prefer transverse incision along skin crease over longitudinal one for better scar healing and cosmetic appearance. It is then followed by the dilating action of the tip of a fine curved haemostat to negotiate through the overlying soft tissue outside the capsule. Egress of saline fluid is noted when the capsule is perforated, confirming the intra-articular location. An arthroscopic cannula with blunt or tapered end trocar is inserted gently through the portal. Extreme care is exercised to avoid inadvertent injury to the articular cartilage or ligamentous structures. Shape end trocar is absolutely contraindicated. The trocar is removed and a 2.7 mm or 1.9 mm video-arthroscope is inserted to the joint through the cannula. The cannula is then connected by long tubing to a 3-liter saline bag hanged at 1.5 meters above the patient using a drip post or similar device. Continuous saline irrigation with aid of gravity is provided for maintaining a clear arthroscopic view. As wrist joint distension is mainly provided by the traction apparatus and not by the saline irrigation, infusion pump is not necessary and is potentially harmful in causing extravasation of fluid. Piñal advocates the use of dry arthroscopy to avoid the problem of swelling and extravasation of fluid, but the use of tourniquet becomes mandatory throughout the procedure[5].

Patient's response is observed during the operation to monitor for any excessive discomfort or pain arising. When difficulty is being encountered during the portal establishment, it is generally due to the patient's anxiety and inadequate muscle relaxation of the forearm and hand, apart from inadequate anaesthesia. A useful trick is to look at the posture of the fingers of the patient. An extended position of the thumb and little finger, which are not included in the finger traction normally, generally indicates excessive anxiety. Under such situation, the patient should be calmed and taught to relax until the thumb and little finger assume a semi-flexed relaxing posture. A thorough diagnostic examination of both radio-carpal and mid-carpal joints is performed and therapeutic procedures are performed at the same setting for the pathology that requires immediate treatment. Standard arthroscopic instruments and equipment are employed.

We reported the result of the technique from January 2007 to December 2009 in 111 consecutive cases of wrist arthroscopy, including 68 male and 43 female patients[6]. The indications included: chronic wrist pain of unknown origin (30), post-traumatic arthritis (27), rheumatoid arthritis (5), ganglion (30), TFCC injury (14) and carpal instability (4).

The average duration of the procedures was 73 minutes (range 20-255 minutes). Five surgeons performed therapeutic procedures in these 111 cases in addition to a routine diagnostic inspection. These included: synovectomy (88), ganglionectomy (30), TFCC Repair (3), radial styloidectomy (2), partial ulnar osteotomy (4), thermal shrinkage (2), distal scaphoidectomy (1) and synovial biopsy (4). All procedures could be completed uneventfully. Ninety-eight out of 111 patients (88 %) reported satisfactory level of comfort on the procedure. Seventy-nine percent of the patients considered PSLA as the preferred mode of anaesthesia for a next operation. No complication was documented. When local anaesthesia is used without sedation, it is possible for the surgeon to communicate with the patient directly and to enroll patient actively in some decision-making during the procedure. The patient would also have a clearer understanding of his/her own pathology and the treatment rationale, which is beneficial in subsequent rehabilitation process. It is also possible to check active tendon motion and peripheral nerve function intermittently during the therapeutic procedures and thus adds safety factors for the patients (Video 1).

The various therapeutic techniques are discussed in detail as follow:

Lavage

The function of lavage mainly works through the elimination of lysozyme, joint debris and other synovial contaminants as a result of the wash-off process. Indications include pyogenic septic arthritis[7], gouty arthritis[8] (Video 2) and degenerative arthritis. Gravity-assisted fluid irrigation is usually sufficient for most situations.

Joint debridement

The technique is employed in condition where debris in the joint from various tissue origins contributes to symptoms directly or indirectly. Examples include degenerative arthritis, central TFCC tear[9], Kiënbock disease[10], partial interosseous ligament tear[11]. Various instruments such as suction punch, motorized shaver, arthroscopic knife and lately radiofrequency apparatus can be used in partial excision of central TFCC tear. Debridement of partial interosseous ligament tear has also been shown to be effective in providing symptomatic relief in case without carpal dissociation[12]. In partial excision of central TFCC tear, symptomatic improvement should be expected after excision if ulnar variance of the wrist is neutral or minus[13,14]. For ulnar positive patient, an additional ulnar recession procedure (athroscopic Wafer procedure)[15] or formal ulnar shortening[16] is frequently required for definitive treatment.

The TFCC tear is approached through the 4/5 or/and 6R portals. An arthroscopic banana knife can be introduced to complete the flap tear. A grasper can then be used to retrieve the TFCC fragment out from within the joint. Any remnant of the tear can be smoothened with a suction punch or shaver (Figure 3). The remaining portion of the TFCC, particularly the dorsal and volar marginal ligaments over the peripheral 2-3 mm, should be stable after the partial excision procedure. Because of the limited joint space, most of the commercially available arthroscopic knives cannot be placed into the joint through a protective sheath. Extreme caution and gentleness has therefore to be taken during the introduction of the knife into the joint to avoid iatrogenic injury to the overlying extensor tendons. Occasionally, a mosquito grasper can be inserted into the joint from the 4/5 portal to grasp onto the flap tear so as to facilitate the cutting action of the knife.

The emergence of small radio-frequency (RF) probe such as VAPR™ or VULCAN™ have proven to be particularly ideal in a controlled debridement of central type of symptomatic traumatic or degenerative perforation of TFCC[17]. With appropriate energy setting, the RF probe of 2.0-2.3 mm diameter can vaporize the flail portion of tear substance with high degree of precision, neatness and ease (Figure 4). The probe also has coagulation function for haemostasis purpose. The major drawback is the inevitable production of a variable amount of air bubbles during the debridement process that can significantly obscures

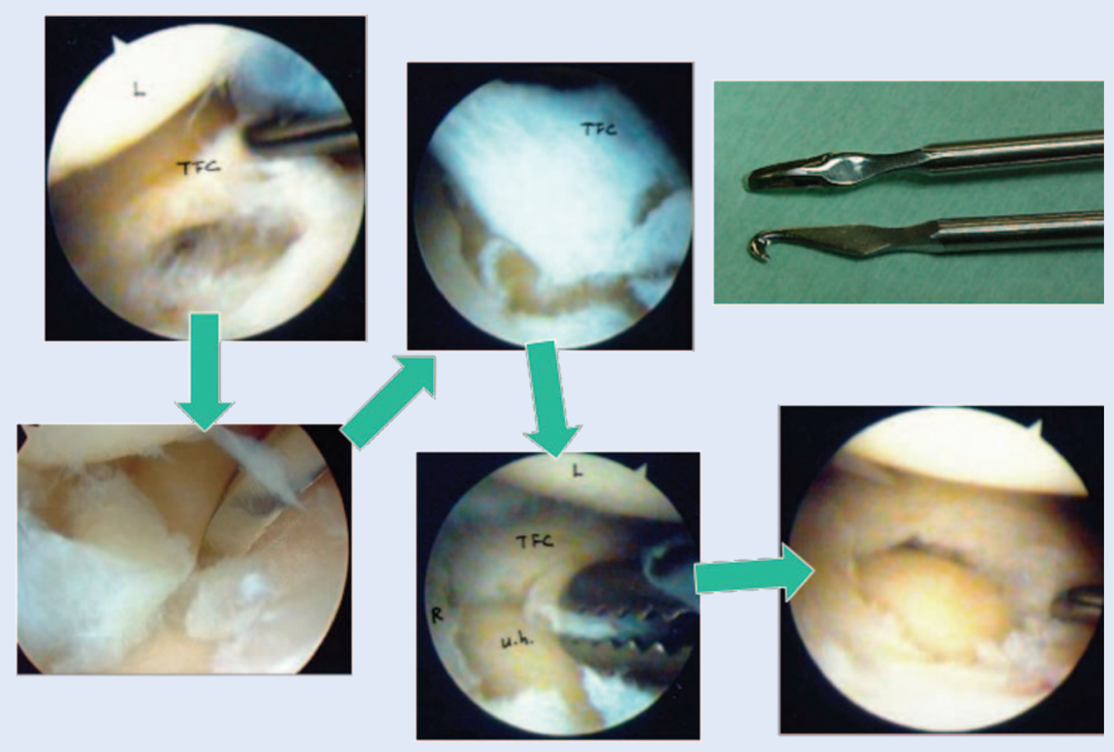

Figure 3. Traumatic central tear of TFCC debrided with an arthroscopic knife and mosquito grasper until a smooth and stable peripheral rim is obtained

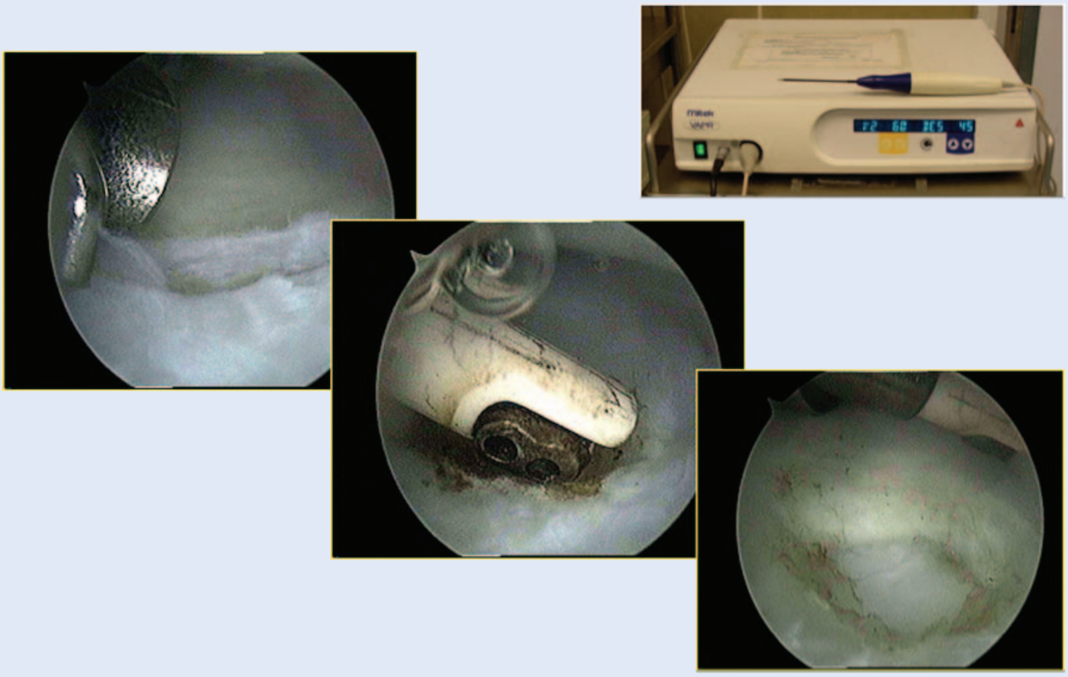

Figure 4. Debridement of traumatic central tear of TFCC using a radiofequency probe until a smooth and stable peripheral rim is obtained

the visual field within the tight space of the wrist joint. Evacuation of the bubbles can be effectively managed with the aid of a wide bore needle and appropriate manual suction using a syringe. Alternatively the RF probe can be introduced through an arthroscopic cannula that serves as a venting mechanism (Video 3). The amount of air bubbles generated varies with different models and energy settings of the RF apparatus. Another potential risk is the iatrogenic thermal damage to adjacent normal cartilage and ligament structures. It is well documented that chondrocyte death is associated with temperature of above 50 °C because of an influx of calcium. Huber et al studied the temperature profile of RF probe application in wrist arthroscopy and found that the highest measured peak temperatures were 52 °C (monopolar) and 49.5 °C (bipolar) without irrigation[18]. Continuous irrigation led to mean reduction of temperature by 7 °C for monopolar system and 5 °C for the bipolar system.

They concluded that both monopolar and bipolar RF apparatus could be safely used in wrist arthroscopy if continuous irrigation system was applied and the energy impulse did not exceed 5 to 10 seconds on each episode.

Synovectomy

The procedure is best indicated for rheumatoid arthritis and other systemic arthritis involving predominantly the wrist joint. Arthroscopic synovectomy can minimize surgical trauma and provide easy access to various wrist compartments. Adolfsson and Nylander reported the first series in 1997 on 18 wrists of 16 patients with improvement both in pain and range of motion in all patients[19]. Our evaluation of the first 23 wrists in 20 patients operated between 1997 and 1999 also generated similar good result at an average follow up of 2.5 years[20]. Lee and Park et al reported the long-term result in 56 wrists of 49 patients at a mean follow-up of 7.9 years. The mean visual analog scale score for wrist pain decreased from 6.3 to 1.7, and the mean Mayo wrist score improved from 48 to 76. Synovitis was controlled in 42 wrists (75 %) and recurred in the others at final follow up[21].

The operation can be done under regional anaesthesia or PSLA. We perform routine inspection of the radiocarpal joint through 3/4 portal using a 2.7 or 1.9 mm video arthroscope. The 4/5 portal is used for instrumentation. For cases with very

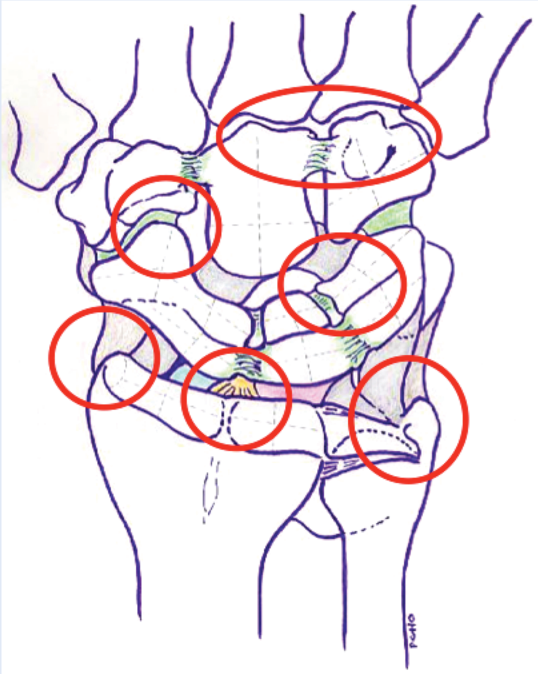

Figure 5. Common sites of synovial proliferation in wrist with rheumatoid arthritis

florid synovitis, additional access such as 1/2 and 6R portals need to be employed to allow a more thorough and extensive synovectomy. Shaving of synovium is best performed using a motorized shaver with suction at low rate of 1000-1500 rpm. The mid-carpal joint is approached through the MCR portal. Instruments are introduced from the MCU portal. Accessory portals including STT and TH portal can be used for outflow and instrumentation. Distal radioulnar joint (DRUJ) is also examined if clinical symptoms & signs of DRUJ pathology are present. Most of the time the TFCC is perforated and the DRUJ can be accessed from the radiocarpal joint. A 1.9 mm arthroscope is used if separate portals for DRUJ are required. The common sites of synovitis are depicted in figure 5. Immediate postoperative wrist mobilization is encouraged.

The introduction of small radio-frequency probe has significantly improved the efficiency of the procedure and it has become our instrument of choice since 2001. However, as the depth of heat penetration effect of the radio-frequency apparatus cannot be fully controlled, debridement of synovium at the dorsal aspect of the wrist near the extensor tendons should better be reserved for mechanical shaver in order to minimize the potential risk to the tendons, namely thermal damage. Continuous saline irrigation and restricting the time of each impulse of RF energy to 3-5 second help to avoid complication. Torn interosseous ligaments should be debrided. Subchondral cyst caused by synovial erosion can be curetted. Synovial biopsy can also be taken in case of uncertain etiology of the synovitis. Caution has to be taken not to damage the already weakened ligaments in many rheumatoid wrists during the synovectomy procedure (Video 4). Other had also reported the use of Ho: YAG Laser set at energy level of 1.2 to 1.5 j and 15 pulses per second[22].

We reviewed our long-term results in 37 wrists of 28 patients with inflammatory arthritis, age between 16 to 80 years old who underwent arthroscopic synovectomy between 1997 and 2001. (HO PC. Presented at the 68th Annual Meeting of American Society for Surgery of the Hand, Oct 2013, San Francisco). The average follow up was 11.8 years (range 9.6-14.2 years). All patients presented as monoarticular, oligoarticular or polyarticular arthritis with predominating symptoms and signs affecting the wrist joint. Patients with evidence of tenosynovitis and weakened extensor tendon were excluded. In our series, radiocarpal and mid-carpal joint could be assessed arthroscopically in all cases. Significant synovitis and cartilage damage were found within midcarpal joint in 56.8 % of cases, radiocarpal joint in 86.5 % and DRUJ in 18.9 % of cases. Arthroscopic ulnar head ablation was performed in 2 cases due to ulnar impaction syndrome. Average operative time was 98 minutes. The most consistent benefit was the relief of nocturnal pain. Pain relief was noted and maintained till final follow up. Average wrist functional score increased from 21.7 to 31.8. There was no statistical difference in pain level and functional score between cases with early and late stage disease at final follow up. No complication was noted. Two patient experienced recurrence of symptoms 3 years later who improved after another arthroscopic synovectomy.

In conclusion, our experience demonstrates that arthroscopic synovectomy of rheumatoid wrist is a safe, technically feasible and worthwhile procedure, even in advanced disease. Repeated operation is possible if the synovitis recurs. Interestingly, in patients with advanced joint involvement and extremely narrow joint space radiographically, arthroscopy is frequently feasible. This is mainly due to the fact that the capsular laxity conferred by the disease process enables sufficient joint distension upon digital traction and saline irrigation. Feasibility for operation can be predicted by performing traction test under fluoroscopic guide preoperatively to assess the joint distractability (Figure 6).

Ganglionectomy

A better term to describe the procedure is marsupialization of the ganglion since the ganglion cyst is actually not excised structurally. The principle is to abolish the "check valve" phenomenon by creating a capsular defect at the stalk portion of the ganglion cyst where the cyst communicates with the wrist joint and therefore allowing spontaneous drainage, shrinkage and resolution of the ganglion. Lee Osterman first described the technique for the typical dorsal wrist ganglion arising closed to the scapholunate joint in 1995[23]. 6R portal was used as the viewing portal. A full radius resector can be introduced from 3/4 portal to resect a 1cm defect from the dorsal capsule. The end point was to see a gush of mucinous fluid from the ganglion draining into the joint and the ganglion completely disappear externally (Video 5). In Osterman's series, complete resection was achieved in all of the 18 cases with no recurrence.

In the author's initial experience, arthroscopic ganglionectomy for dorsal wrist ganglion appeared to be more time-consuming and tedious procedure as compared to open excision, though it produced cosmetically much pleasing scar particularly for ganglion bigger than 1.5 cm in size. In order to reduce the tedium and to improve the efficiency of the procedure, we have modified the technique by applying direct digital compression to the ganglion against the ending of the shaver after the capsular reflection on the scapholunate ligament was located arthroscopically. (manual compression technique) (Figure 7). Most ganglions will rupture after 1-3 minutes of shaving. In addition, we use the 1/2 portal instead of 3/4 portal to introduce the shaver. This can avoid conspicuous scar in the most central area of the wrist. In the review of our first 21 cases of dorsal wrist ganglia, primary resection was

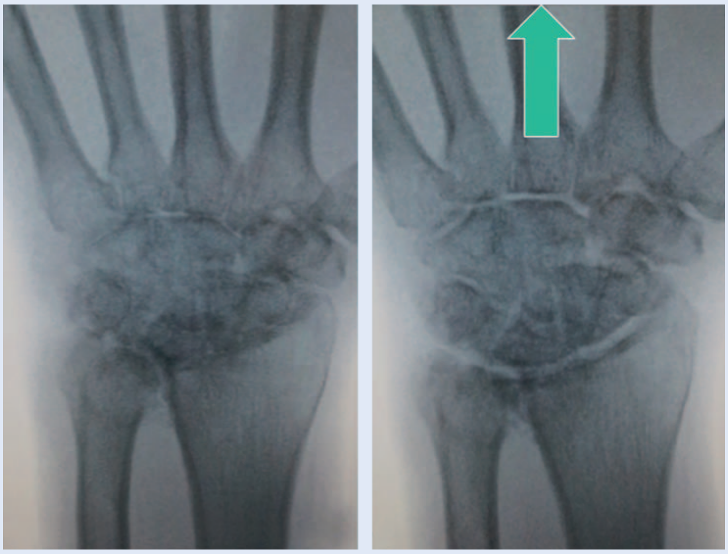

Figure 6. Feasibility for arthroscopic synovectomy can be predicted by performing traction test under fluoroscopic guide preoperatively to assess the joint distractibility.

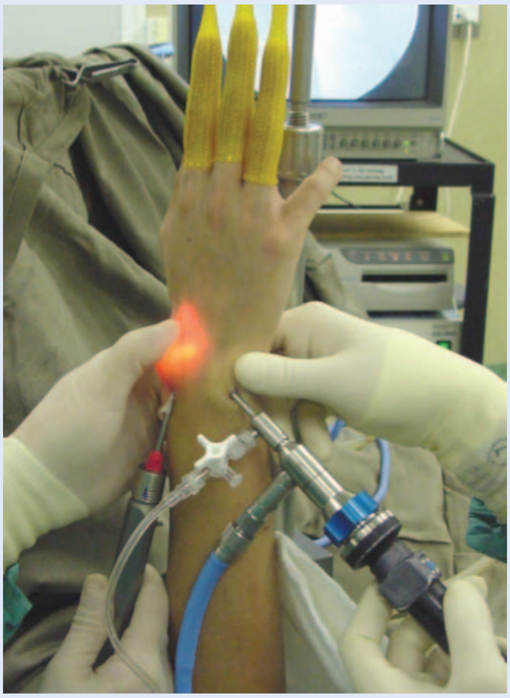

Figure 7. Manual compression technique: direct digital compression applied to the ganglion against the ending of the shaver after the capsular reflection on the scapholunate ligament was located arthroscopically.

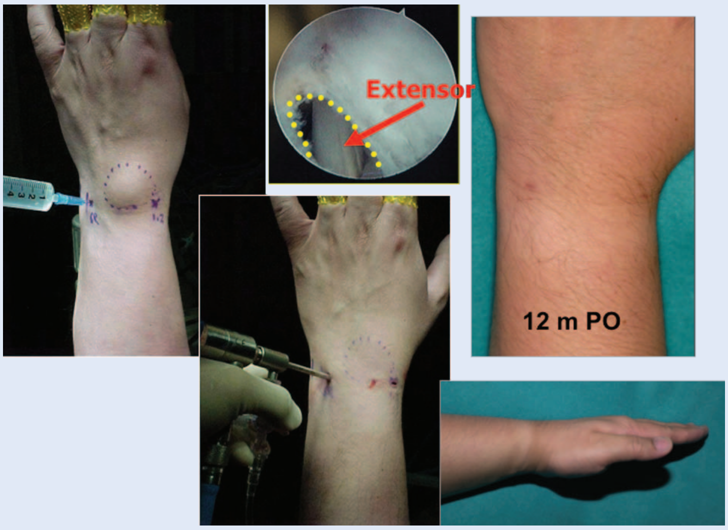

Figure 8. A 4 cm dorsal wrist ganglion arising from the scapholunate ligament-capsular junction decompressed by arthroscopic means. Noted the finger extensor outside the dorsal capsular defect as created by ganglionectomy. There was no recurrence after 12 months and the scars at the 1/2 and 6R portals are inconspicuous.

Figure 9. A 3 cm ganglion over the dorso-ulnar aspect of the wrist arising from the lunotriquetral joint treated successfully by arthroscopic means

successful in 19 patients (90.5 %)[24]. Two cases were converted to open. Definite stalk of ganglion was seen only in 4 patients.

The average operation time for direct vision technique was 46 minutes (range 18-68 minutes) while that for manual compression technique was 13.8 minutes (range 9-20 minutes). At an average follow up of 25 months, there were 5 recurrences (26 %). All recurrences were smaller than the original ganglion size and no patient requested further intervention. Surgical scar was inconspicuous (Figure 8). No major complication was detected. Thirteen (68 %) patients were satisfied with the procedure. Patients benefited from surgery with regards to minimal surgical scar, absence of wound complication and tourniquet discomfort, stitch-less operation and early mobilization. Gallego and Mathoulin reported the result of 114 patients with mean follow up of 42.3 months. The origin of the ganglion was more commonly related to the mid-carpal join in 74.6 %. There was significant improvement in the range of motion and grip power ($p < 0.005$). Recurrence was noted in 14 patients (12.3 %)[25]. Recently we described 2 cases of ulno-dorsal wrist ganglia arising from the lunotriquetral joint that were treated successfully by arthroscopic means in our center with the same principle[26] (Figure 9). There has been no report for arthroscopic treatment of volar wrist ganglion until we first described the technique and arthroscopic pathoanatomy of a typical volar ganglion arising from the radio-carpal joint in 2003[27]. In this technique, the 1/2 portal is used for viewing while the shaver is introduced through the 3/4 portal, the so called "1234" technique. The stalk of the ganglion is located at the interval between the palmar ligaments. Shaving of the interval and volar capsular tissue abolishes the one-way valve and allows drainage of the ganglion (Figures 10, 11). The defect will be replaced by natural fibrosis in 3-6 weeks of time, during which there should also be natural involution of the cyst. Because of continued communication with the wrist joint in the interim period, joint fluid may accumulate in the cyst wall before fibrosis can heal the capsular defect. Thus it is not surprising to observe "pseudo-recurrence" between first and third weeks after the surgery in some patients. Therefore all patients undertaking this surgery should be forewarned and explained about such phenomenon and advised to continue intermittent self-massage and local pressure to the ganglion site for at least 3 weeks after the surgery. The technique reduces the risk of iatrogenic injury to radial artery associated with open resection so long as the cyst wall is not violated by the shaver during the

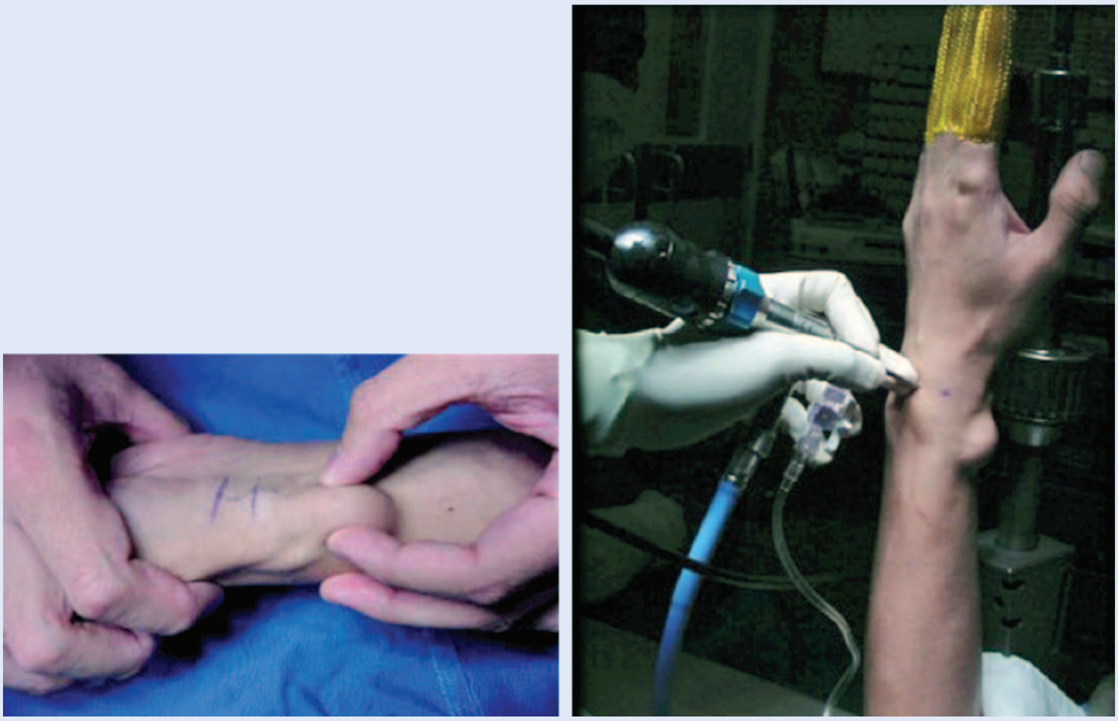

Figure 10. A 4 cm volar wrist ganglion arising from the radio-carpal joint of the left wrist treated with arthroscopic ganglionectomy

Figure 11. Gush of gelatinous fluid egresses from the joint after the ganglion is decompressed at the volar capsular stalk area. The surgical scars are minute and inconspicuous.

ganglionectomy procedure. Technically it is also much easier and straightforward than performing a dorsal ganglionectomy. Intra-operatively, the stalk can be identified by one of the following ways:

1. By manually pressing the volar ganglion externally, the involved ligament interval will bulge in arthroscopically with or without spontaneous drainage of mucinous fluid from the ganglion into the joint (Video 6).

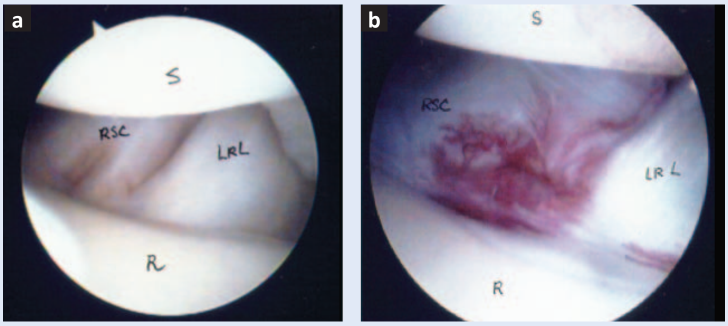

Figure 12. Sign of stalk of volar ganglion from the radiocarpal joint: a) normal interval between radioscaphocapitate ligament and long radiolunate ligament; b) abnormal synovitis at the ligament interval in patient with volar wrist ganglion.

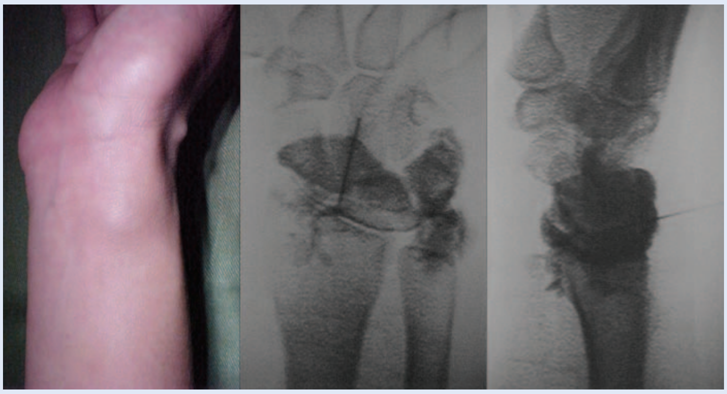

Figure 13. Intra-op wrist arthrogram to demonstrate the communication of the ganglion cyst with the wrist joint through the stalk.

Figure 14. A patient with a large recurrent volar ganglion treated with arthroscopic ganglionectomy. No recurrence was noted after 2 years of follow up.

2. The presence of abnormal synovitis at the ligament interval (Figure 12).
3. Intra-op wrist arthrogram to demonstrate the communication of the ganglion cyst with the wrist joint (Figure 13).

We have reviewed the long-term result of 21 volar wrist ganglia arising from the radio-carpal joint operated between August 1997 and April 2005[28]. The average size of the ganglion was 2 cm (range 1-4 cm). 75 % of ganglia arose from the interval between radioscaphocapitate and long radiolunate ligament, and 25 % from the interval between long radiolunate and short radiolunate ligament. Sixteen of the 21 ganglia could be excised by arthroscopic technique. The average follow up was 56 months (range 9-101 months). There were 2 recurrences. One was treated with repeated arthroscopic excision and the other by open excision (Figure 14) (Video 7). There was no impairment of wrist motion and function in all patients. No neurovascular complication was encountered.

Removal of loose body

Arthroscopy is considered as the best maneuver in removing an intraarticular chondral or osteochondral loose body that causes symptoms of locking or clicking. The causes can be due to osteoarthritis, intra-articular fracture, cartilage nutrition disorders, and infection. Frequently the loose body is radiolucent but can be detected with aid of CT scan or MRI. Mosquito graspers, straight and curved, are invaluable in retrieving loose body form within the joint (Figure 15). A hypodermic needle can be used to maneuver or skewer the loose body. Particular attention should be paid to potential recesses of the joint including the pre-styloid recess, recess between the radial styloid and palmar radiocarpal ligament, ulnar facet of the triquetral-hamate joint as well as the STT joint region. The author had an experience of removing an unsuspected loose osteo-chondral fragment from the DRUJ in a female patient presented with locking of the forearm rotation after trivial ulnar styloid fracture.

Capsular release

Verhellen and Bain described the use of combined volar and dorsal portals in performing ar-

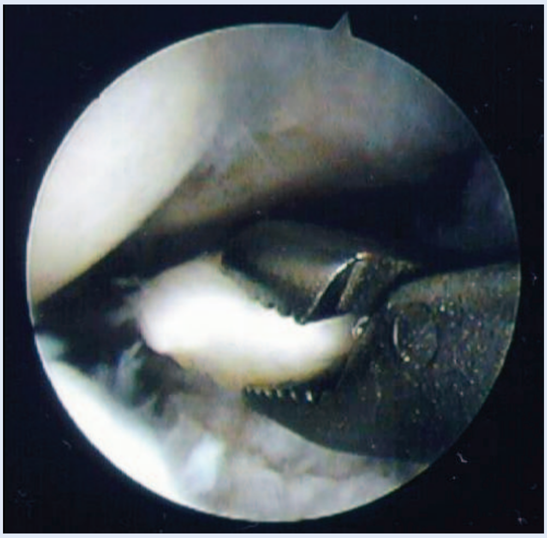

Figure 15. Removal of a cartilagenous loose body at the radiocarpal joint using a mosquito grasper

throscopic release in two cases of severe post-traumatic capsular fibrosis and stiff wrist[29]. All volar capsular ligaments except the ulno-carpal ligament complex and the volar radioulnar ligament were divided completely with a shaver, RF probe or using an arthroscopic knife, followed by gentle manipulation under anaesthesia (Video 8-11). The relationship of the major neurovascular structures to the volar capsule had been studied. The average distance from the radiocarpal joint capsule to the median nerve was 6.9 mm, 6.7 mm to the ulnar nerve and 5.2 mm to the radial artery[29]. Release could also be performed for the dorsal capsular ligament. However extreme caution needed to be exercised to avoid injury to the closely related extensor tendons. Arthroscopic knife and RF probe were contraindicated. Bain advocated the use of a nylon tape to be placed through the 3/4 and 4/5 portals and "railroading" it between the dorsal capsule and the extensor tendons[30]. The main difficulty in arthroscopic arthrolysis lies on the initial entry of the scope and instrument into an already contracted joint space. The trick is to perform progressive dilatation of the joint space using trocar of different sizes before the final introduction of the arthroscope. Also a small sized arthroscope of 1.9 mm facilitates the procedure. The joint usually becomes more spacious and visible after initial debridement of the intra-articular fibrosis. Luchetti et al reported the result on 28 patients with post-distal radius fracture arthrofibrosis at an average follow up of 28 months[31]. Radiocarpal, midcarpal and DRUJ porats were used. Wrist flexion/extension increased from an average of 84° to 99° and mean pronosupination increased from 144° to 159°.

Osteotomy

Major indications for osseous resectionplasty include radial styloidectomy for rheumatoid [32] and post-traumatic arthritis secondary to scaphoid non-union or carpal instability and Wafer procedure for ulnar impaction syndrome. Arthroscopic radial styloidectomy has the advantage of a better visualization and therefore preservation of the radio-scapho-capitate ligament, which is an important stabilizing structure of wrist. With the arthroscope inserted from the 4/5 portal and directed toward the dorsal aspect of the radial styloid, a 2.9 mm burr can be introduced from the 1/2 portal to burr on the arthritic articular surface of the styloid region (Video 12). Caution should be exercised to prevent over-burring of the rest of scaphoid fossa. The origins of the radioscaphocapitate and long radiolunate ligament on the distal radius mark the ulnar extent of the resection. Burring is continued at the radial border until a defect of even thickness of 5 mm is obtained. Volar aspect of the radial styloid can be spared as it is the important origin of the radio-scapho-capitate ligament and impingement symptom seldom arises from this area. (Video 13) Adequacy of radial styloidectomy can be confirmed by intra-operative fluoroscopy and by on-table manipulation of the wrist to ensure no impingement of the scaphoid with the distal radius (Figure 16). Nakamura et al recommended a styloidectomy of no more than 3-4 mm as increased radial translation with ulnar and palmar carpal displacement had been demonstrated after 6-mm and 10-mm radial styloidcetomy[33].

Wafer procedure is an established treatment for ulnar impaction syndrome. The prerequisite for an arthroscopic procedure is a completely perforated TFCC and is generally feasible only for degenerative TFCC tear of Palmer stage 2C or above. Procedure gone through the DDRUJ portal has been de-

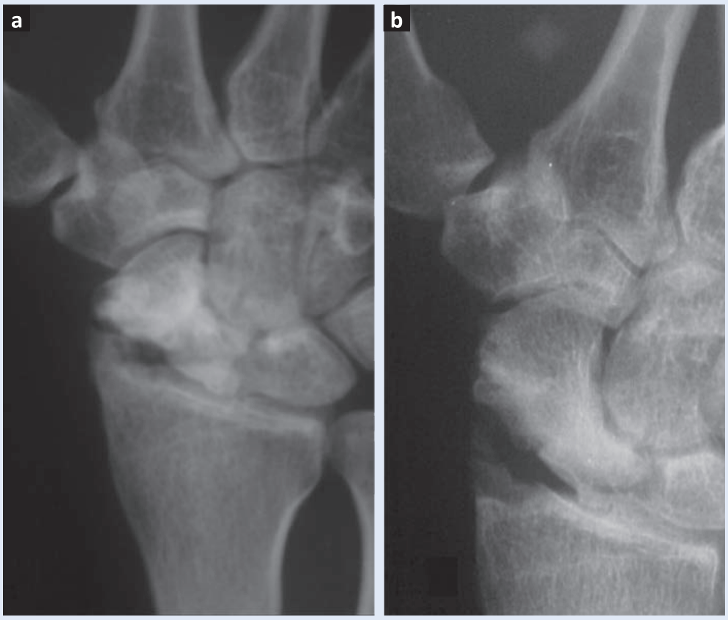

Figure 16. Stage 1 SNAC wrist treated with arthroscopic radial styloidectomy: a) before surgery; b) after radial styloidectomy. Note the extent of bone resection is smaller than conventional open technique, as the volar rim of the styloid area can be spared to preserve the origin of the radioscaphocapitate ligament.

scribed but is technically demanding[34]. With the arthroscope inserted from 3/4 portal, burring of the ulnar head can be performed with a 2.9 mm arthroscopic burr that is being introduced to the joint from 4/5 portal, after the initial debridement of TFCC to the peripheral stable rim and associated synovitis at the ulnocarpal joint as well as the radioulnar joint. Burring of the ulnar head should be done in fairly even manner at a horizontal plane taking care of this 270° of circumference. This can be achieved by gradually rotate the forearm from pronation to supination position while burring the ulnar head, with the aim to create ulnar minus variance of 2 mm (Video 14). Biomechanical study has shown that excision of 3 mm of subcondylar bone decreased the force transmitted across the ulnar head by 50 %[15]. Intra-operative fluoroscopy may be necessary as it can be quite difficult to accurately assess the amount of ulnar head excised by arthroscopic view alone (Figure 17). Additional portals in distal radioulnar joint can be employed to facilitate the resection process. Bernstein and Nagle retrospectively reviewed the result of combined arthroscopic TFCC debridement and arthroscopic Wafer distal ulna resection in 11 patients versus arthroscopic TFCC debridement and ulnar shortening osteotomy in 16 patients with ulnocarpal abutment syndrome[35]. Good to excellent result was obtained in 9/11 and 11/16 patients respectively. They concluded that the combined arthroscopic TFCC debridement and arthroscopic Wafer distal ulna resection provides similar pain relief and restoration of function compared to ulnar shortening but with fewer complications.

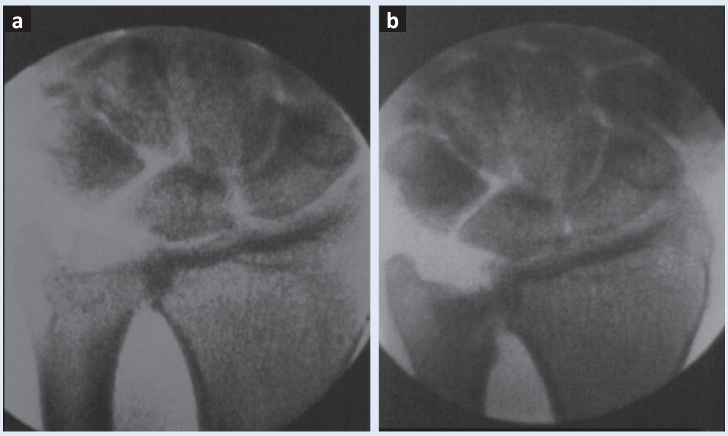

Figure 17. Arthroscopic Wafer procedure for ulnocarpal impaction syndrome: a) before surgery; b) after Wafer procedure. Note the radial 2/3 of the ulnar head was resected at 270 degree of circumference to create 2 mm of ulnar minus variance. The foveal part is spared so as to preserve the insertion of the radioulnar ligaments.

Other indications include ulnar head resection (Darrah procedure), match ulnar hemi-resection arthroplasty and scaphoidectomy for symptomatic radio-scaphoid joint arthritis in low demand aged patients. Randall Culp et al. reported their first experience of arthroscopic proximal row carpectomy in 7 patients in 1997 and achieved satisfactory pain relief and functional gain[36]. A recent study in 2011 by Weiss ND et al with the technique on 17 patients reported good outcome [37]. The average operation time was 70 minutes and range of motion exercise was initiated 2 days postoperatively. No case needed to be converted to open. At final follow up of average 24 months, mean flexion-extension arc and grip power were 80 % and 81 % of the unaffected side respectively (Figures 18, 19) (Video 15).

Ligament repair

TFCC is subjected to considerable axial loading and shear stresses[38,39] and is predisposed to injury. In 1989, Palmer was able to demonstrate and classify tears about the TFCC[40]. This paved way to modern diagnosis and management of ulnar-sided wrist pain. Thiru-Pathi[41] and Bednar[42] showed that the outer 10-40 % of the articular disc was well perfused and suggested a healing potential of these injured areas upon repair. In line with this belief, there has been considerable effort to preserve and repair peripheral TFCC lesions. Hermansdorfer and Kleinman in 1991[43] showed good results with open repair of the TFCC with 8 of 11 patients returning to normal activities. Cooney et al reported 26 good-excellent results in 33 wrists using open repairs[44]. The advent of wrist arthroscopy has given the surgeons the chance to duplicate, if not surpassing the results of open repairs[45-49]. Most studies reported results on repair of Palmar 1B tear and less commonly on type 1C and 1D tear. Repair of type 1d tear is considered controversial[50,51]. Estrella and Ho noted a new type of dorsal tear of TFCC amendable for repair[52].

Numerous methods of arthroscopic repair had been proposed and could be broadly classified into inside-out and outside-in approach. Instrument employed ranged from simple hypodermic needle[53], epidural Tuohy needle, meniscal needle to zone-specific repair kit[46,54]. The prevalence of knot pain and potential injury to dorsal cutaneous branch of ulnar nerve in these methods prompted the emergence of all-inside and knotless repair technique in the last 5 years, employing innovative devices such as FasT-Fix[55] and ultrasound energized suture welding system[56]. Further refinement of injury pattern clearly identified the entity of foveal detachment of the TFCC which could lead to DRUJ instability. Atzei proposed a comprehensive classification and management guideline for TFCC tear, denoting the possibility of a distal, proximal or complete tear of the ulnar insertion of TFCC[57]. Enthusiasm on foveal re-insertion of TFCC flourished with various methods being proposed involving open or arthroscopic transosseous repair with suture or bone anchor[58-61]. On the outcome of surgery, most studies in the literature reporting good-excellent results were cases series of level IV evidence. The only level III study on a retrospective comparison between open and arthroscopic repair in 75 patients over 10 years by Anderson et al (2008)[62] demonstrated no statistical difference

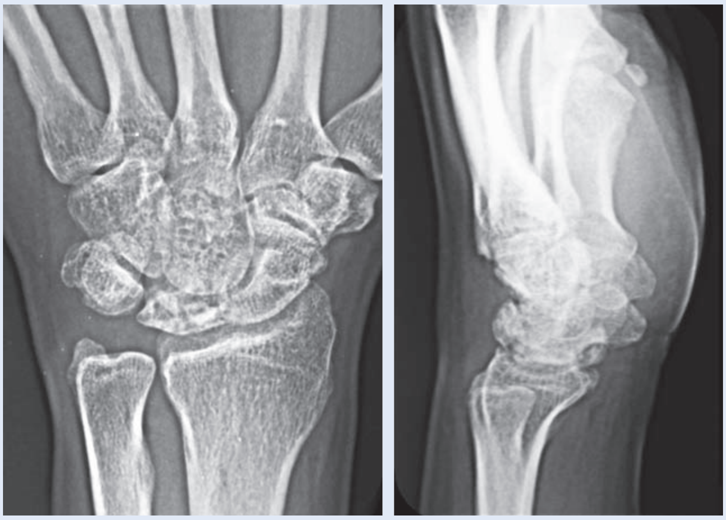

Figure 18. Lichtman stage 3B Kienbock disease with significant carpal collapse. Articular surface at proximal capitate and lunate fossa remains intact.

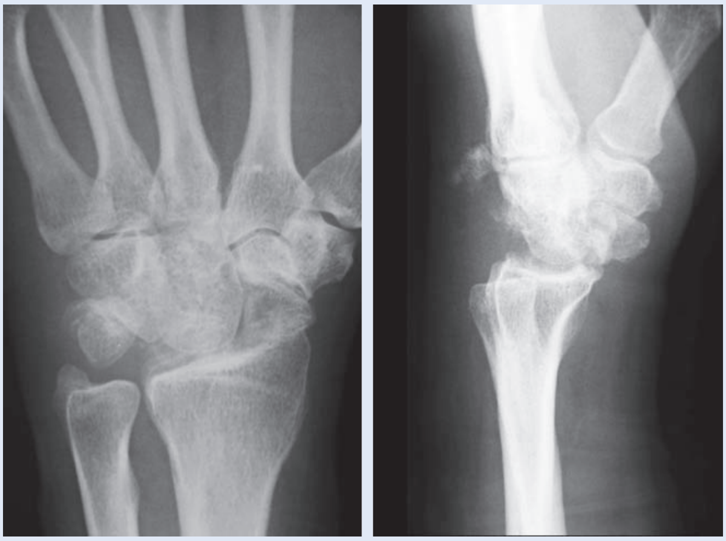

Figure 19. Arthroscopic proximal row carpectomy performed. Note that the distal scaphoid is not resected as it does not have contact with radius. The radial column of the hand can also be rendered more stable.

in clinical outcome, though there was tendency of increased postoperative superficial ulnar nerve pain and re-operation rate in the open group. Updated there was no study comparing results of different arthroscopic repair techniques.

Because of no clear superiority of one method over the others, the author has been using inside-out arthroscopic technique employing either epidural needle or zone-specific TFCC repair kit since 1997 for all types of symptomatic peripheral TFCC tears. Advantages included simplic-

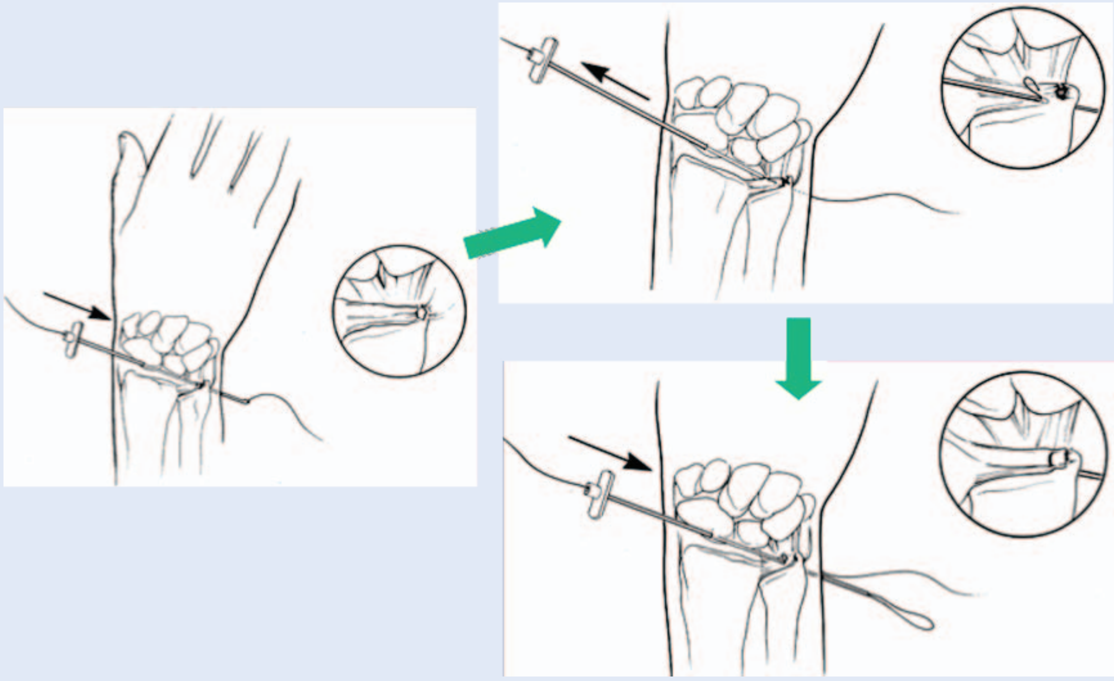

Figure 20. Poehling's epidural needle technique in repairing 1B TFCC tear

ity of administration, more precise intra-articular control of the repair site, ability to apply multiple sutures and adaptability of suture pattern to suit different types of tear, generally vertical mattress for capsular tear and horizontal mattress for proximal and foveal tear.

In all TFCC repairing procedure, it is important to debride the rim of the tear down to healthy vascular tissue to promote healing and encourage fibrovascular ingrowth. The principle is to appose the torn peripheral rim of the TFCC towards the capsular tissue or the fovea so as to secure healing. Performing arthroscopy without the use of tourniquet permits accurate assessment of vascularity of the torn site and ensures better chance for healing. The epidural needle technique is particularly useful for managing 1B type of TFCC tear (Figure 20). A 19G epidural needle is introduced from the 1/2 portal and the curved tip is guided through to reach the ulnar side of the TFCC approaching the tear site. The needle is then passed through the detached area of the TFCC, and brought through a small longitudinal incision volar to the ECU tendon at the ulnar snuffbox. A 2-0 PDS suture is then threaded through the needle, exited at the ulnar incision and stabilized outside the skin as the needle is retracted back into the ulno-carpal joint. The needle, with threaded suture, is then moved distally for 5-8 mm to puncture through the ulnocarpal joint capsule adjacent to the first pass of the suture, thus once again being brought out through the skin. As the beveled end of the needle is not sharp, it protects the suture from being damaged during the second pass procedure. The looped end of the suture is held outside the skin while the needle was withdrawn from the radial side. Thus a vertical mattress loop is formed to grasp onto the torn edge of the TFCC to the capsule. Similar steps are repeated 2-3 times adjacent to the original suture site. The stitches are finally tightened and knotted outside the capsule. Extreme care has to be exercised during the knotting process to ensure that the suture is not tying onto a dorsal branch of ulnar nerve or the extensor tendons. Araujo reported satisfactory results in 70 % of the 17 patients with type 1B tear at 16-24 months post-operatively with this technique[54]. For foveal tear, the epidural needle technique can be modified to anchor the torn part to the foveal region with the peri-foveal repair technique. The ulnar part of the TFCC can be lifted off the fovea using a hook probe, the so-called hook sign[63] (Video 16). A shaver or burr can be inserted from the 6R portal to debride the foveal region of the ulna head down to bleeding bone. The approach and the first suture pass through the TFCC is same as described above. The second pass of the needle with the threaded suture is through the TFCC again 3-5 mm dorsal or palmar to the first pass of the suture, thus forming a horizontal mattress loop grasping onto the TFCC tear site (Video 17-19). The direction of needle pass should be as proximal as possible, so that when the suture is pulled, the TFCC will be approximated to the fovea. The procedure is repeated 2-3 times to secure the repair. This method enables multiple sutures for the foveal tear, an advantage over the transosseous technique where usually no more than 1-2 loops of stitch can be applied.

Dorsal tear is a common injury pattern involving the connection of the TFCC to the dorsal capsule between the sigmoid notch and ECU subsheath region. The author favors the use of the TFCC repair kit as designed by Terry Whipple (Figure 21). The kit consists of a curved cannulated suture passer and a loop suture retriever. After the dorsal nature of the tear is identified, a transverse incision is made as a transverse extension of the 4/5 portal. The extensor retinaculum is split and EDM tendon is retracted, exposing the dorsal capsule. The curved cannulated suture passer is then inserted through the capsule on the under-surface of the detached part of the TFCC under arthroscopic guidance. The

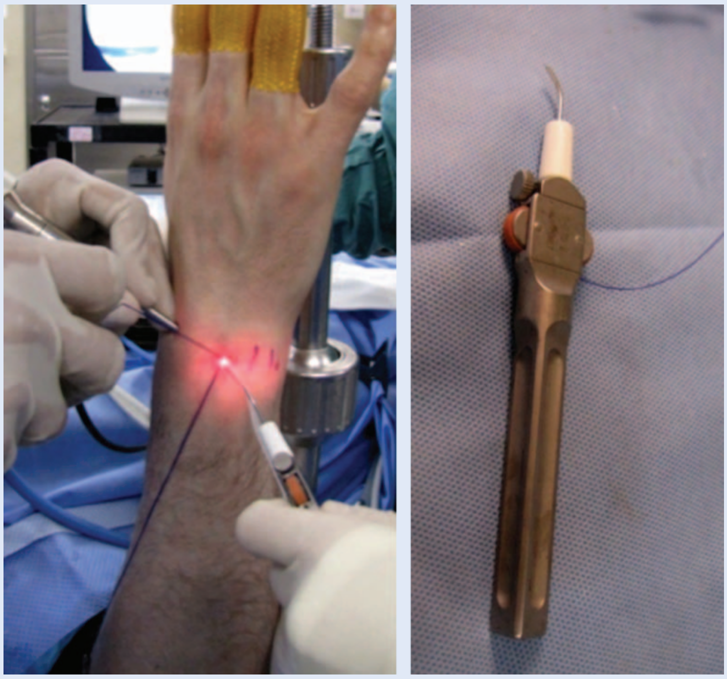

Figure 21. TFCC repair kit as designed by Terry Whipple in repairing dorsal tear of TFCC

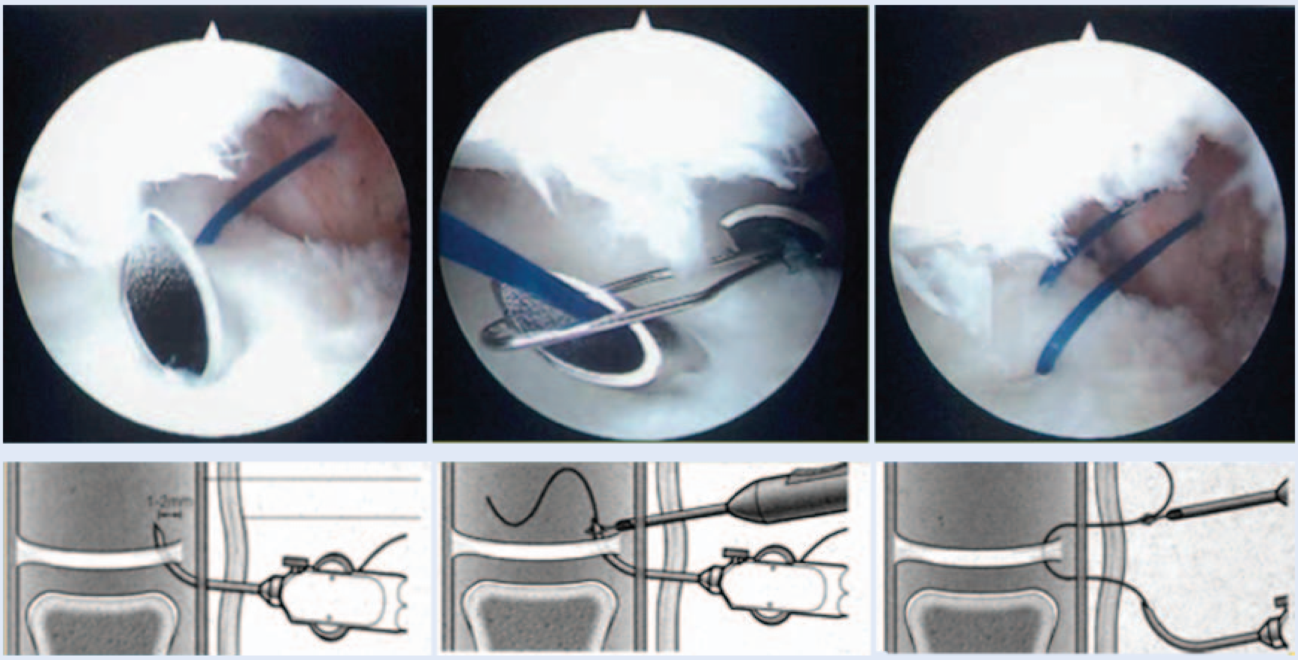

Figure 22. The torn TFCC is reattached to the dorsal capsule with 2'0 PDS using the TFCC repair kit to form a suture loop across the tear site

loop suture retriever is then passed through the capsule above the TFCC and the loop is put encircling the end of the passer. A 2-0 PDS suture is then passed through the hook by spinning the wheel on the passer. The suture retriever is then pulled back out of the joint, bringing the end of the suture with it, and leaving a suture loop grasping the peripheral edge onto the dorsal capsule (Figure 22) (Video 20). After passing 2-3 loops each separated by at least 2 mm, the sutures can be tied at the position of the forearm when the tear is best reduced. Corso reported 93 % satisfactory rate in 44 patients in a multicentre trial at an average of 37 months follow-up using this technique[46].

From Jan 1997 to December 2002, 35 TFCC repair procedures have been carried in our institution[52]. Over instability of the distal radio-ulnar joint was noted in 5 cases. The average duration of symptom was 8.8 months (range 1 week to 37 months). Both methods described by Whipple and Phoeling had been employed depending on the type of TFCC injury. At an average follow up period of 39.4 months (ranging 4-82 months), 26 patients (74.3 %) achieved excellent to good result according to modified Mayo wrist score. Average range of motion compared to opposite unaffected side was: extension 88.9 %; flexion 85.4 %; pronation 95.2 % and supination 95.7 %. Grip strength improved from 57.7 % to 84.1 % of the opposite hand. There was significant reduction of exertion pain and improvement in wrist function score. No correlation of primary outcome was note with respect to age, gender, hand dominance, work compensation, delay of surgery and type of TFCC tear.

Arthroscopic-assisted reduction and internal fixation (ARIF)

Wrist arthroscopy is now recognized as an invaluable adjunct in assessing joint configuration and assisting of reduction in intra-articular fracture around the wrist and various carpal instability conditions. Indications include intra-articular distal radius fracture[64], scaphoid fracture[65], scapholunate dissociation[66, 67], lunotriquetral instability[68] and in selected cases of perilunate fracture dislocation[69]. In most of the conditions, fluoroscopy is still mandatory for adequate reduction and fixation. In addition, arthroscopy can also be used for treatment of those associated soft tissue injury at the same setting, which ranges from 40-75 % in distal radius fracture[64] and up to 50 % in scaphoid fracture. (Ho PC. Acute ligamentous injury in scaphoid fracture. Presented in the International Wrist Investigators Workshop, American Society for Surgery of the Hand, Boston, 1999).

In distal radius fracture, the best indication for arthroscopic intervention is intra-articular fracture with comminution and displacement. The goal of articular reduction is within 2 mm of step or gap[70]. Depressed intra-articular fragments are notoriously difficult to be accessed and assessed by percutaneous mean. Arthroscopy has been shown to be superior to intraoperative fluoroscopy and plain radiograph in assessing joint surface reduction[71]. Patients with arthroscopically assisted reduction of intraarticular distal radius fractures have demonstrated superior clinical outcomes, better range of motion, and improved radiologic variables in term of displacement and angulation, when compared to conventional reduction method with fluoroscopy alone[72,73]. The displaced fragments can be tackled, elevated and reduced under direct vision using a probe or a fine bone tam through arthroscopic portals. Both dorsal and volar portals can be employed, particularly when volar plating is contemplated. The fragments can also be elevated with an osteotome or a bone spike introduced from the metaphyseal region while the articular reduction is observed and controlled arthroscopically. The reduced fracture is then fixed with subchondral screws or pins. Dry arthroscopy has gained popularity in recent years particularly in fracture reduction and fixation for more ease in fracture manipulation and less risk of fluid extravasation causing compartment syndrome[74]. Arthroscopy has also the benefit of diagnosing and treating unrecognized concomitant soft tissue and cartilage injury.

Percutaneous screw fixation is gaining popularity in managing acute scaphoid fracture. Most series report high union rate and functional outcome. We adopted the policy of percutaneous fixation for acute scaphoid fracture since 1991[75-

[77]. Arthroscopy is a good adjunct to this minimal invasive approach in managing the more difficult situations, such as in displaced fracture, fracture comminution and delay presentation, and thus obviating the need for open reduction in many situations. It has minimal disturbance to the vascularity and the soft tissue envelope, and thus favors fracture union. We perform reduction and percutaneous fixation through the volar approach in most cases, even in proximal third fracture. Volar approach does not only demonstrate a high union rate and low complication rate in many series, it gives a safe and easy access to screw entry, maintains and corrects fracture deformity with wrist in extension, does not violate the load bearing proximal scaphoid cartilage, has minimal hardware problems, and does not bear risk to the tendons and dorsal wrist structures, which had been reported in dorsal approach surgeries[78]. When reduction of the displaced scaphoid fractures is not satisfactory, arthroscopic assisted reduction can be performed with midcarpal joint arthroscopy, viewing at MCU portal, and working at MCR portal (Figure 23). Reduction is achieved by manipulating the guide pin in the distal scaphoid. Another larger-diameter K-wire is sometimes necessary if the guide pin is not strong enough to work as a joystick. A 2.7 mm trocar is inserted through the MCR portal to press on the fragment to reduce any stepping or rotational malalignment seen. Then the guide pin is advanced forward across the fracture while another K-wire is inserted to further stabilize the fracture. Drilling and tapping can then be performed along the guide pin fluoroscopically. Cannulated screw insertion and fracture compression is visualized arthroscopically. Fracture comminution with bone defect or cystic resoprtion of the fracture site as seen in delay presentation cases can be managed with arthroscopic bone graft or bone substitute filling of the bone defect on top of the percutaneous fixation (Figure 24-27) (Video 21). Chu PJ and Shih JT reported a series of 15 patients with fibrous union or nonunion of a

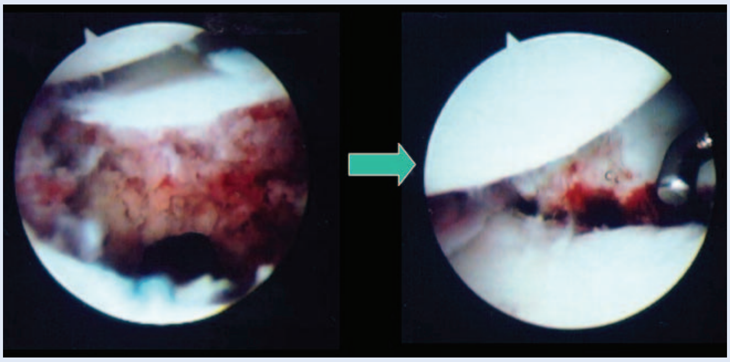

Figure 23. Assessment of reduction of scaphoid fracture at mid-carpal joint

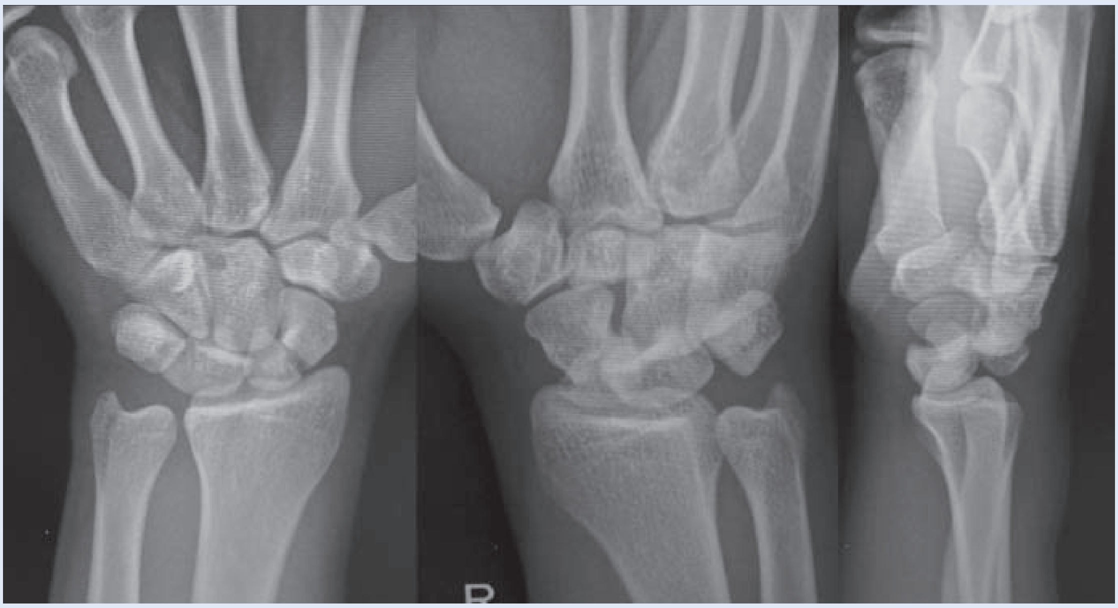

Figure 24. Trans-scaphoid perilunate fracture dislocation with displaced comminuted fracture of scaphoid

Figure 25. Arthroscopic assisted reduction of scaphoid fracture with arthroscopic insertion of bone substitutes to replenish the bone defect at fracture comminution site.

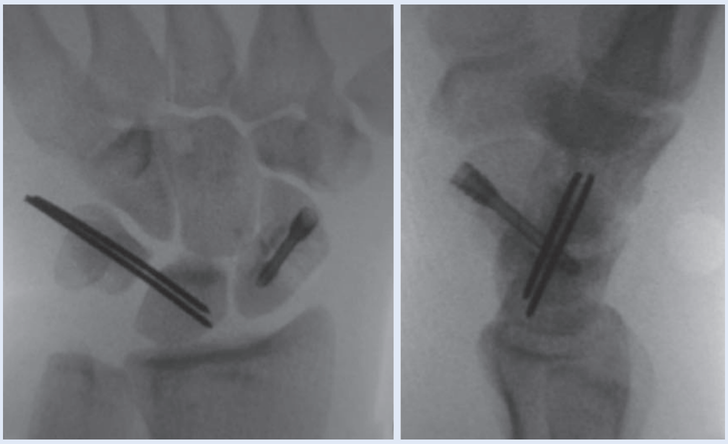

Figure 26. Post-operative X-ray showing good reduction of the perilunate dislocation, scaphoid fracture and filling of bone defect with bone substitutes.

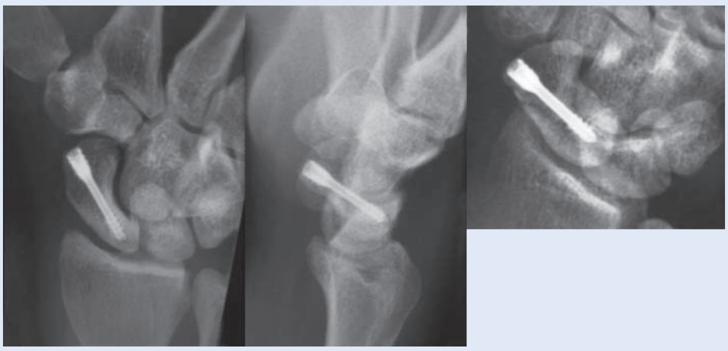

Figure 27. X-ray at 15 months post-operation showing good healing with no complication

scaphoid fracture of Schmitt stage I or II and of average duration of 6.5 months with minimal sclerosis or resoprtion at the nonunion site. They treated the fractures with arthroscopically assisted percutaneous internal fixation combined with the use of injectable bone substitute inserted to the nonunion site through the midcarpal joint and was successful in 14 patients in obtaining radiological and clinical union at a mean of 15.4 weeks. Mayo Modified Wrist Score was excellent in 10 and good in 4[79].

Chondroplasty

Cartilage lesions are commonly seen in degenerative and post-traumatic conditions of the wrist[36]. It has been found to be far more common than expected and contributes as important differential diagnosis in chronic wrist pain. They may be manifested as chondromalacia change or frank osteo-chondral defect (Video 22). Other imaging modalities are notoriously poor in diagnostic accuracy compared to wrist arthroscopy[80]. Prognosis depends on the size of the lesion as well as underlying cause for the lesions.

Whipple showed that chondral defect smaller than 5 mm responds well to arthroscopic treatment[81]. Lesions with secondary underlying cause such as instability or fracture has lower symptomatic relief rate. Conventional treatment consists of abrasion or drill chondroplasty. The aim is to excise damaged cartilage and unstable flaps or debris, to render the rim of the chondral defect stable and to encourage fibrocartilage formation to cover the exposed subchondral bone. Typically motorized shaver or burr is employed. Fine K-wire of 0.9 mm or 1.1 mm diameter is used to drill multiple times through the subchondral bone over the base of the defect to encourage the emigration of mesenchymal cell for the formation of fibrocartilage (Video 23). During the insertion of K-wire, iatrogenic injury to extra-capsular structures can be minimized by threading the K-wire with metallic sheath of a 14G angiocathether. There were reports on laser and thermal chondroplasty with promising early results for grade II and III chondromalacic changes[22]. However, caution should be taken for grade IV lesion as cauterization of cancellous bone may retard fibrous tissue ingrowth.

Bone grafting

The entire intra-articular location of scaphoid nonunion allows an arthroscopic approach for both evaluation and therapeutic intervention with maximal preservation of blood supply and ligamentous architecture and hence favours union and functional restoration. In 1998, Ho et al first reported on the technique of arthroscopic bone grafting in repairing osseous defects in 11 cases including scaphoid non-union, acute comminuted scaphoid fracture, bone cyst and triscaphe fusion (Ho PC. Presented in 7th Congress of International Federation of Societies for Surgery of the Hand, Vancouver, Canada, 1998). The author achieved union in all cases at an average of 3.4 months. Potential benefits included: minimal disturbance to complex ligamentous structures, maximal preservation of vascularity of carpal bones, global assessment of wrist joint allowed before surgical intervention, minimal pain and scar, operation without need for tourniquet, stitchless operation, speedy rehabilitation.

For scaphoid nonunion, evaluation started at the radiocarpal joint arthroscopy to check for any SNAC wrist changes and concomitant ligament lesions. Stage 1 SNAC wrist could be managed by arthroscopic radial styloidectomy. The standard repair procedure was conducted at the mid-carpal joint. MCU was usually selected as the viewing portal and the MCR portal is the best portal to take down the fibrosis around the nonunion in the proximal and waist portion. In distal third nonunion, STT portal is frequently required getting access to the nonunion site. Frequently, the portals could be interchanged to allow better visualization of the distal and proximal fragment of the scaphoid separately. The nonunion site was identified with a probe. Fibrous tissue interposed was radically debrided from the defect with aid of angled curette, punch and shaver. Sclerotic bone ends should then be resected using high-speed burr until healthy cancellous bone was encountered. Tourniquet was not inflated so that vascularity of both fragments could be appreciated critically. Curettage could be stopped when punctate bleeding was seen clearly from the cancellous bone surface (Video 24). Lack of bleeding from the proximal scaphoid segment indicated a less favorable prognosis. After adequate debridement and curettage, the two fragments of the non-union site should now be more mobile to facilitate subsequent reduction. DISI deformity could be corrected by closed Linscheid maneuver under fluoroscopic guidance (Figure 28). In the presence of an intact scapholunate ligament, correction of dorsiflexion deformity of proximal scaphoid could be done by passive flexion of wrist joint to realign the dorsally tilt lunate with the radius (i.e. to restore the normal radio-lunate

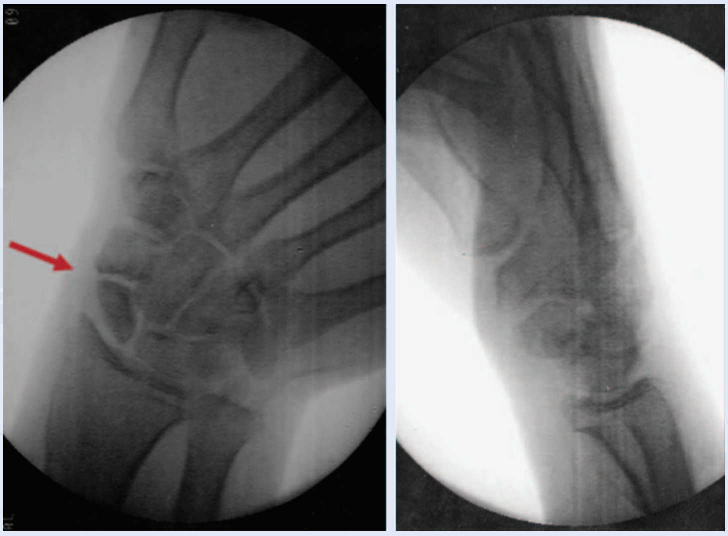

Figure 28. Chronic scaphoid nonunion with significant humpback deformity with DISI alignment

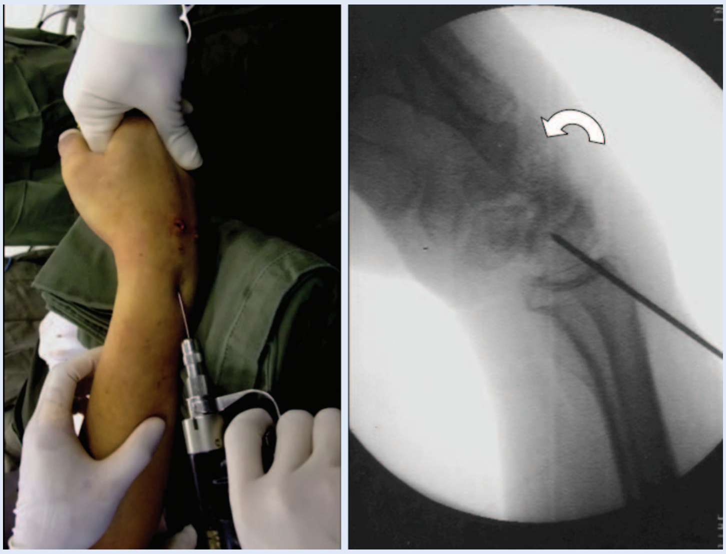

Figure 29. Linscheid maneuver to realign the dorsally tilt lunate with radius so as to achieve a normal RL angle. The RL interval is transfixed with a 1.6 mm K-wire percutaneously.

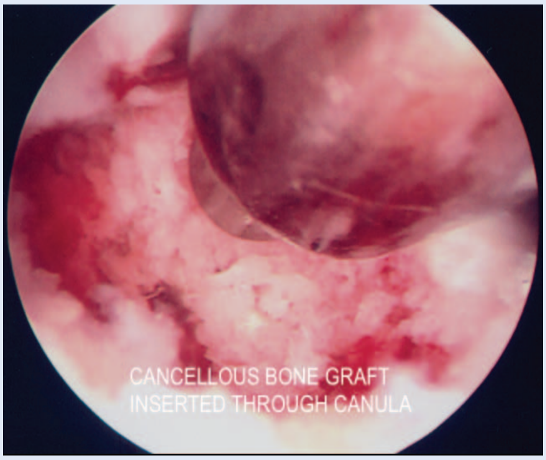

Figure 30. Cancellous bone graft harvested from the iliac crest delivered to the nonunion site via a 4.5 mm arthroscopic cannula

angle). The radiolunate joint was then temporarily transfixed with a percutaneous 1.6 mm K-wire inserted from dorsal distal radius through a mini-incision (Figure 29). In this regard, the proximal scaphoid should then be well aligned with the distal radius. Traction and manipulation by gentle passive ulnar deviation, hypersupination and extension of the wrist was carried out to re-align the distal fragment with the proximal one and to restore the length of the scaphoid (Video 25). The fracture was then transfixed with a single K-wire inserted percutaneously at the scaphoid tubercle. Cancellous chip graft harvested from the iliac crest was delivered and densely packed into the fracture site through a 4.5 mm arthroscopic cannula (Figure 30). We considered bone graft from distal radius inadequate. Fibrin glue was injected at the end to stabilize the bone graft and to protect the articular surface. Fixation was completed either by inserting 2 additional K-wires (69 cases) or with a cannulated screw (30 cases) (Figures 31, 32). Wounds were apposed with steri-strips. Early active mobilization was initiated two weeks after the procedure. The buried K-wires were removed under local anaesthesia when union was evidenced (Figure 33-37) (Video 26).

Wong and Ho reported the result of arthroscopic bone grafting in 69 patients of symptomatic

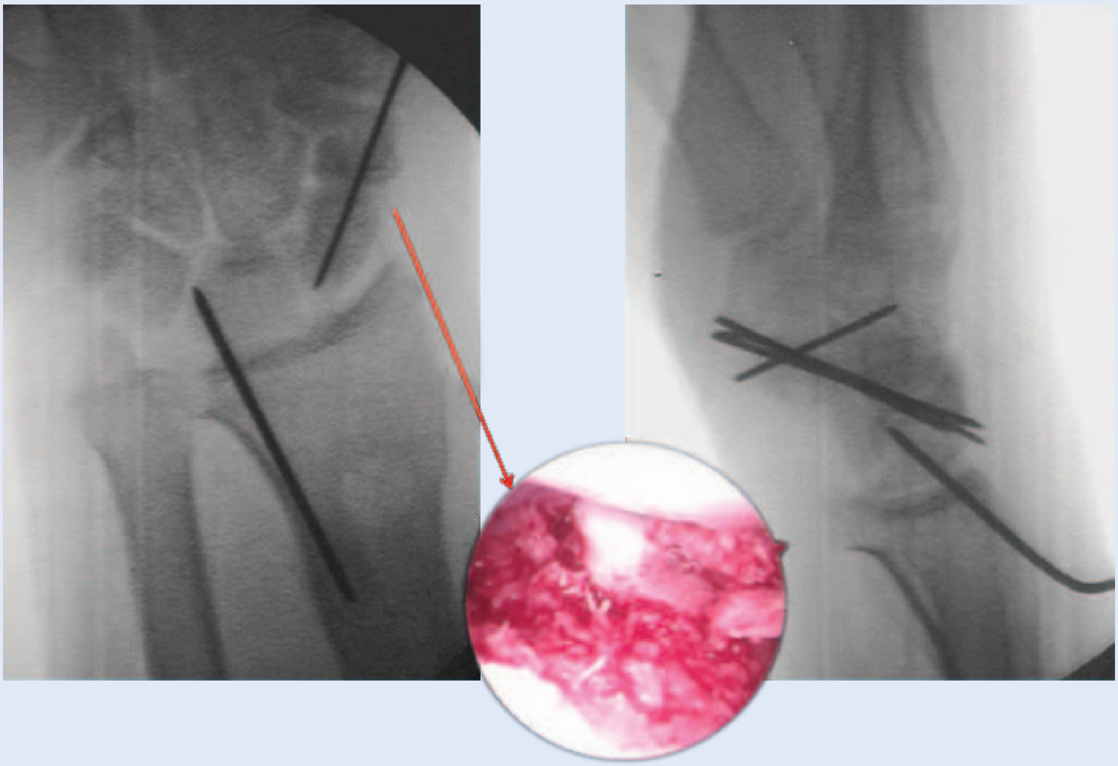

Figure 31. Restoration of the normal length and angle of the scaphoid after closed reduction, and the bone defect is densely packed with cancellous bone graft. Multiple K-wire fixation is performed to stabilize the nonunion and to maintain normal carpal alignment.

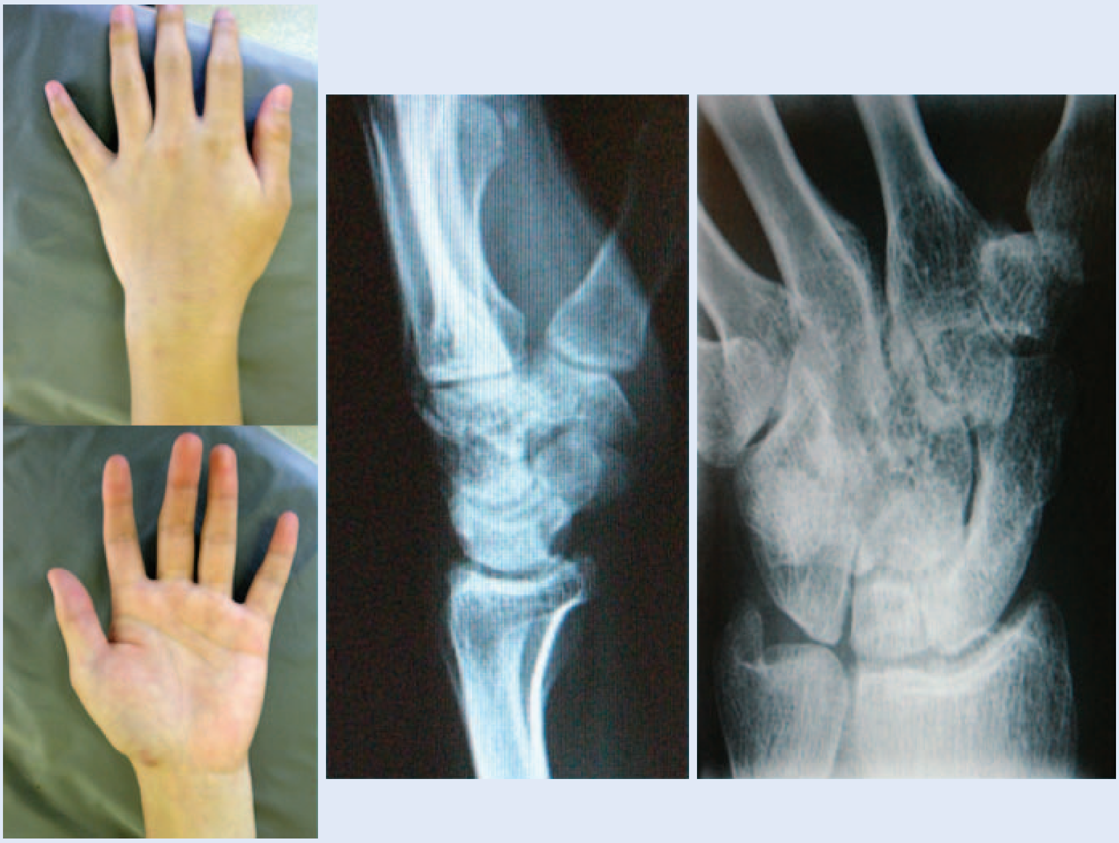

Figure 32. X-ray and clinical photo 3.5 years post- operation showing minimal scarring, solid fracture union and complete correction of DISI deformity

scaphoid nonunion and achieved an overall union rate was 91.2 % (62/68)[82]. Lately the author reviewed a large group of patients, including 82 established non-union and 17 delayed union cases being operated between April 1997 and October 2013. (Ho PC, presented at 2014 Annual Meeting of American Association for Hand Surgery, Jan 2014, Kauai, Hawaii, USA) There were 90 male including 2 bilateral cases and 7 female, with an average age of 27.9 (ranged 14-58). The median duration of symptom was 11 months (ranged 1-480 months). There were 13 distal third, 49 mid-third and 37 proximal third fractures. Thirty cases had DISI deformity. The average follow up was 31.9 months (range 5-164 months). Overall primary union rate was 90.8 % (89/99). The average radiological union time was 12 weeks (range 6-80 weeks). While good bleeding from proximal scaphoid fragment predicted union in 56 out of 56 cases (100 %), unsatisfactory bleeding still permitted union in 33 out of 42 cases (78.6 %) Complications were few. There was no pain in majority of the patients. There

Figure 33. Six months old scaphoid nonunion at waist

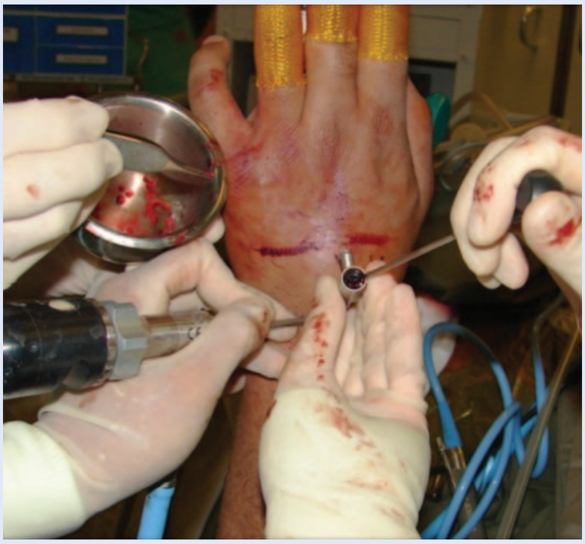

Figure 34. Arthroscopic insertion of cancellous bone graft chips harvested from iliac crest via arthroscopic cannula

Figure 35. Small incisions for arthroscopic intervention and percutaneous fixation using volar approach

Figure 36. Post-operative X-ray showing stable screw fixation of the fracture and good filling of bone defect with cancellous bone.

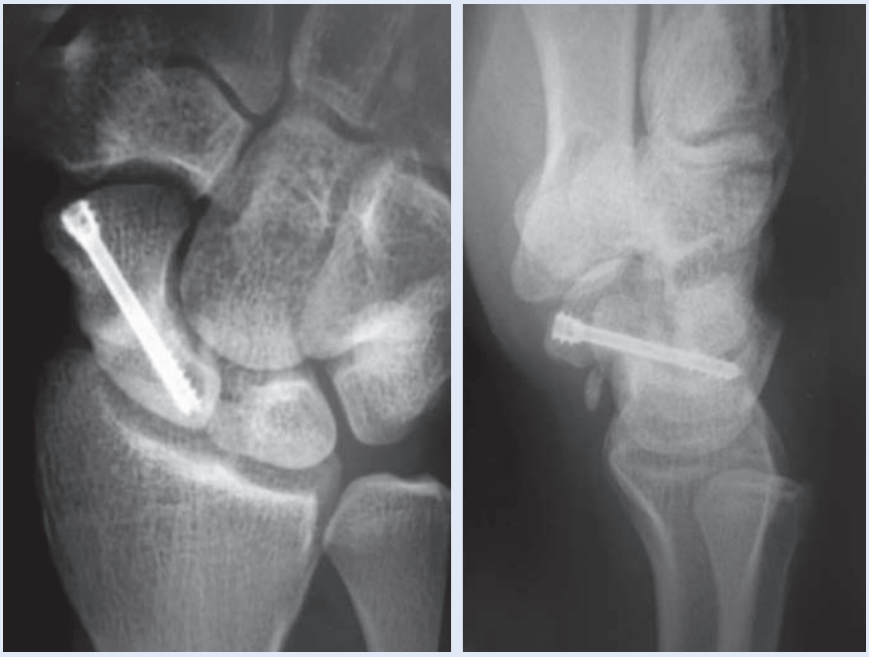

Figure 37. X-ray at 18 months post-operation showed solid union and good carpal alignment.

was significant improvement in ADL performance score, ADL pain score, exertion pain and grip power ($p < 0.05$). The average scapho-lunate angle is 62.3° and AP intra-scaphoid angle is 34.5°. Lee and Woo reviewed the clinical results of 20 patients with scaphoid nonunions treated with arthroscopically assisted bone grafting and percutaneous K-wires fixation from November 2008 to July 2012. Time from injury to treatment was 74 months (range, 3-480 months) in average. All nonunions healed successfully. The average radiologic union time was 9.7 weeks (range, 7-14 weeks). The average modified Mayo wrist score increased from 62.5 preoperatively to 85.7 at the last follow-up[83].

We conclude that with minimal surgical insult to the blood supply of the carpal bones and their ligamentous connections, arthroscopic bone graft provides a more favourable biological environment for the nonunion to get repaired with a quicker pacing of rehabilitation. High union rate is uniform at 90.8 % and clinical outcome is satisfactory. Avascular necrosis is not a contraindication as a union rate of 78.6 % can be expected and compares favorably to other techniques. DISI and humpback deformity can be corrected and tackled adequately.

Partial wrist fusion

Partial wrist fusion is a widely accepted concept and technique in salvaging a failing wrist with preservation of motion and function, with adequate pain control. Conventionally the open surgical approach may induce excessive stiffness, infringe vascularity, impair bony union and prolong rehabilitation. In 2008, we first reported the experience and result of arthroscopic partial wrist fusion in 12 patients between November 1997 and May 2008 with an average follow up of 70 months[84]. Arthroscopic approach provides unimpeded articular view of the wrist and hence offers excellent ground for various forms of partial wrist fusion. Arthroscopic assessment ensures a more accurate staging of the arthritis and facilitates clinical decision making on the most appropriate choice of fusion. Combining with strong percutaneous fixation technique, arthroscopic partial wrist fusion can potentially generate a better functional outcome by preserving the maximal motion pertained with each type of partial wrist fusion. Post-operative pain cab be reduced which favors rehabilitation. There is also cosmetic benefit with the minimal surgical scar. From Nov 1997 to Oct 2011, arthroscopic partial wrist fusion was performed in 23 patients of an average age of 42 years old (range 18-68 years old). These include STT fusion in 3, scaphoidectomy plus four corners fusion in 5, scaphoidectomy plus capitolunate fusion in 4, lunatectomy plus scaphocapitate fusion in 3, radioscapholunate fusion in 4, radiolunate fusion in 2 and luno-triquetral fusion in 2. Through the radiocarpal or midcarpal joint, the corresponding articular surfaces were denuded of cartilage using arthroscopic burr and curette. 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 (Figure 38). This phenomenon can be easily observed if a tourniquet is not used during this process. Carpal bones involved in the fusion process are then transfixed with K-wires percutaneously after the alignment being corrected under fluoroscopic control. If dead space is present, autogenous cancellous bone graft or artificial bone substitute can be inserted and impacted to the fusion site to fill up the void through a cannula under the direct arthroscopic view. The final fixation is achieved with multiple K-wires or cannulated screws. Early mobilization is encouraged.

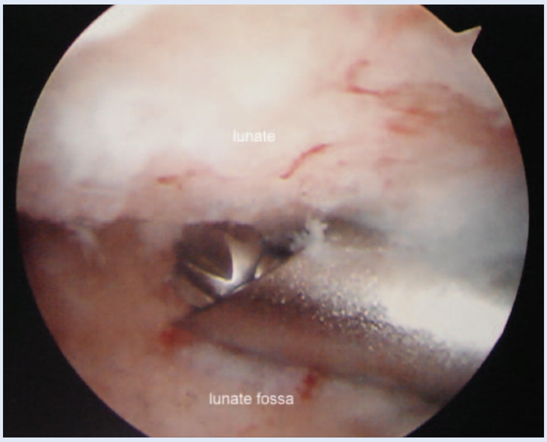

Figure 38. Arthroscopic burring of the articular surfaces pending for fusion. Noted the punctated bleeding from the subchondral plate which marks the end point of burring process.

Arthroscopic treatment has changed the philosophy in managing some of the common post-traumatic disorders. In stage II or III SLAC or SNAC wrist condition, the author now prefers capitolunate (CL) fusion and scaphoidectomy than four-corner fusion. CL fusion 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 demonstrated a high union and satisfaction rate with an arthroscopic assisted CL fusion, accountable by the minimal invasive method and the rigid percutaneous fixation[85]. The more conservative bone resection also eliminates the potential drawback of triquetral hamate impingement.

Arthroscopic scaphoidectomy is performed at the mid-carpal joint using high-speed burr of caliber from 2.9 mm to 4.5 mm. Alternatively a small osteotome can also be used to break the bone into piece-meal fashion 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 cutaenous nerve. The distal tubercle of the scaphoid can be left in-situ so as the preserve the scapho-trapezial ligament, as long as it does not cause impingement with distal radius. The articular surface between the capitate and the lunate is then carefully denuded of cartilage with 2.9 mm burr, while those of the triquetrum and hamate should be carefully protected and preserved. If there is significant DISI deformity of the lunate and radial subluxation of the capitate off the lunate margin, effort should be made to maximize the joint contact between capitate and lunate. The lunate should be first reduced and fixed to the radius temporarily. Two mini stab wounds are being made over the distal dorsal surface of the capitate at the junction with the base of third metacarpal. Under an image intensifier, two pins were inserted and driven across the capitate towards lunate, while 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 (Figure 39-43). In CL fusion, the articular congruency achieved between the capitate and lunate is typically good. There is no need for added bone graft or substitute. Conversion of the K-wires fixation with cannulated compression screws is then followed.

Surgical complications in our series were few and minor, including pin tract infection, skin burn and delay union. Radiological union of the fusion site was obtained in 19 cases, stable asymptomatic fibrous union in 3 cases and definite nonunion requiring revision in 1 case. At an average follow-up of 59.9 months (range 11-112 months), the symptom was resolved or improved and the functional motion was obtained in all cases. The surgical scars were almost invisible and the aesthetic outcome was excellent.

In short, arthroscopic partial wrist fusion is a viable option for patients suffered from post-traumatic or non-progressive wrist arthritis who would like to preserve useful wrist motion with good aesthetic outcome. Union rate is high and complication uncommon.

Figure 39. With the lunate temporarily transfixed to the distal radius with a 1.6 mm K-wire, the capitate is manually reduced to the lunate by passive ulnar translation of the wrist so that it sits as much as possible on the distal lunate articular surface.

Figure 40. Two mini stab wounds are being made over the distal dorsal surface of the capitate at the junction with the base of third metacarpal. Under an image intensifier, two pins were inserted and driven across the capitate towards lunate for later cannulated screw insertion.

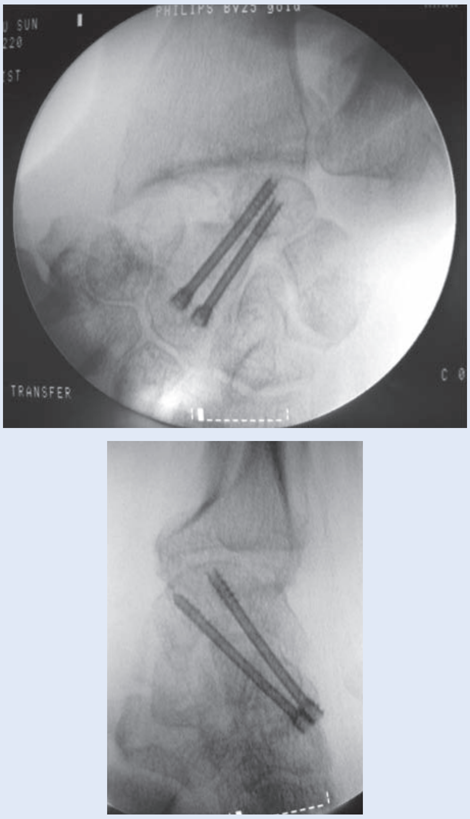

Figure 41. CL interval transfixed with two cannulated compression screws. No bone graft or substitute is needed because of the highly congruent articular surfaces.

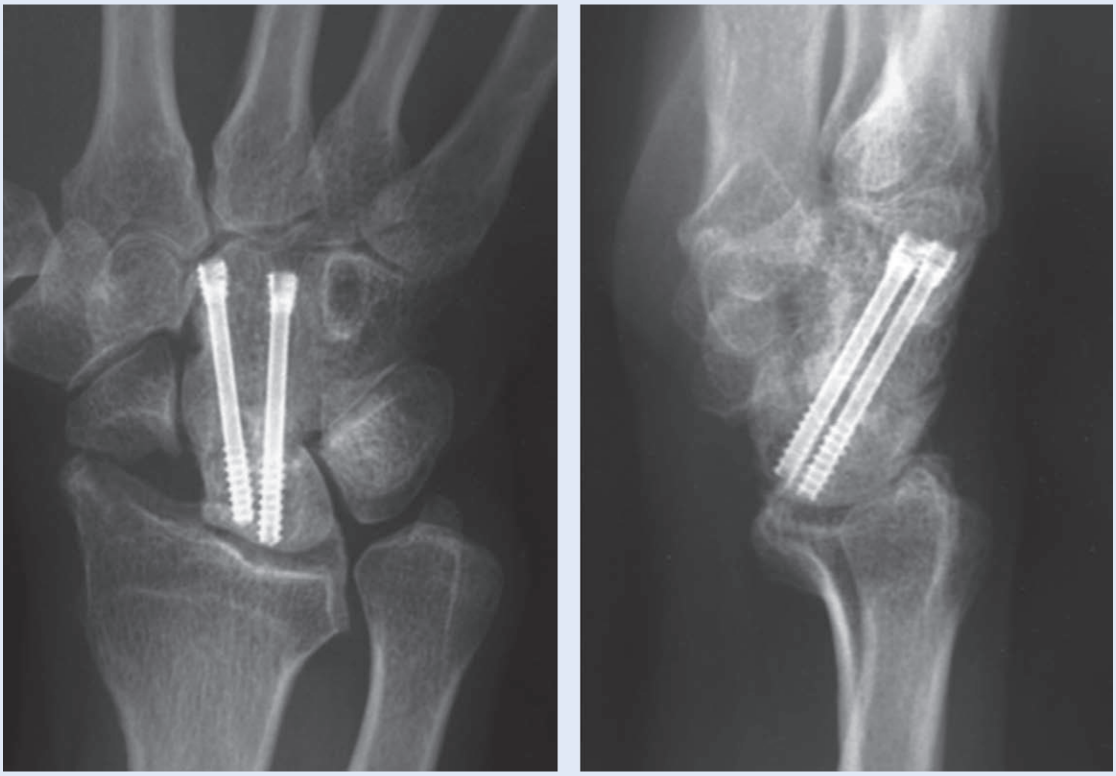

Figure 42. Post-operative X-ray showing solid union across CL fusion site

Figure 43. Minimal surgical scar and satisfactory clinical function

TFCC reconstruction with tendon graft

Until recently, there has been great controversy toward the best surgical reconstruction for painful DRUJ instability caused by disruption of TFCC. It was now recognized that the most important stabilizers of the DRUJ were the palmar and dorsal radio-ulnar marginal ligaments which exhibited their tautness during the various phase of prono-supination. Damage to either or both of these ligaments generated pain and instability during forearm rotational movement. Extensive biomechanical study had been performed by Adams et al and they proposed the anatomical reconstruction of the distal radio-ulnar ligaments as the ultimate solution for this difficult condition[86,87]. They reported good result of open reconstruction using palmaris longus tendon graft in 12 patients with post-traumatic DRUJ instability at 1 to 4 year's follow up evaluation[88]. We have been successful in performing this operation entirely under arthroscopic control since 2000[89].

Operation is performed under general or regional anaesthesia with the aid of image intensifier to locate isometric point for tendon tunnel drilling. The surgical approach and the anatomical structures at risk are illustrated in Figure 44. Radiocarpal joint arthroscopy is conducted to evaluate and debride TFCC lesion and associated synovitis. Dorsal skin incision extending from the 4/5 portal is made to retract extensor tendon. The volar skin incision is made for harvesting palmaris longus (PL) tendon graft, retracting flexor tendons and protecting ulnar neurovascular bundle. Drill hole of 2.4 mm using a cannulated drill is then made dorsal to volar over margin of sigmoid notch just distal to the distal border of the pronator quadratus under an image intensifier, simulating the radial origin of radioulnar ligaments (Figure 45). Separate incision is made at subcutaneous border of ulna ulnar and a drill hole of 2.9-3.2 mm created at fovea of ulnar head, the isometric insertion point of TFCC (Figure 46). Caution has to be taken to avoid iatrogenic fracture of the ulnar styloid. Position can be verified both arthroscopically and fluoroscopically (Video 27). The PL graft is passed through the bone tunnel at the sigmoid notch from dorsal to volar (Figure 47). Both limbs of the PL graft are then delivered to joint through arthroscopic portals and retrieved outside ulna through ulnar tunnel (Figure 48) (Video 28). Graft is then tightened and tied around another trans-osseous tunnel over the ulnar shaft with forearm in neutral position (Figure 49) (Video 29). Full range of pronosupination can be obtained without jeopardizing DRUJ stability. A sugar-tong cast is given for 3 weeks with the forearm in neutral position before changing to functional brace for mobilization. Early mid-range forearm rotation under supervision is started from the 4th week onward postoperatively.

Fifteen patients (7 males and 8 females) with mean age of 37 (range 17-49) received the operation between Nov 2000 and October 2009[90]. The median duration of symptom was 16 months (ranged 4-240 months). Indications included: traumatic peripheral TFCC tear with irreparable defect (4), ulnar styloid non-union with overt DRUJ instability (2), chronic DRUJ instability (8) and rheumatoid arthritis (1). The mean follow-up period was 85.5 months (range 32-38 months). No intraoperative complication was noted. Twelve patients reported satisfactory results and returned to their pre-injury job. Forearm rotation range increased from 76.6 to 92.1 % of the un-injured contralateral side. Grip power improved from 56.1 to 76.9 % of the un-injured contralateral hands. No evidence of DRUJ arthritis was noticed during latest follow-up (Figure 50). Two patients developed transient neurapraxia of the ulnar nerve and 3 cases complained of hypersensitive ulnar scar but not requiring surgery. The 3 unsatisfactory cases included 2 late re-rupture of volar limb of graft after second trauma episodes and one unexplained psychosomatic symptom with dystonia.

We conclude that arthroscopic anatomical reconstruction of TFCC using tendon graft is technically feasible and is a preferred treatment option in symptomatic peripheral destabilizing TFCC lesions not amendable for repair either due to its chronicity or presence of sizable defect. The method preserves better prono-supination motion of the forearm compared to open surgery.

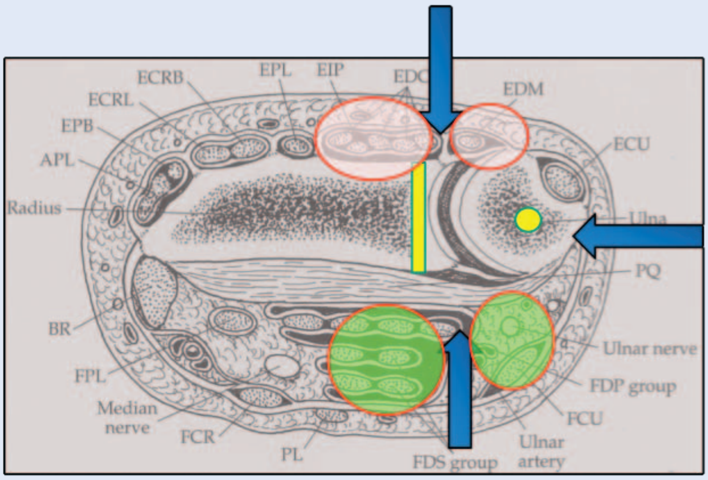

Figure 44. Diagram illustrating the surgical approach and the vital anatomical structures at risk

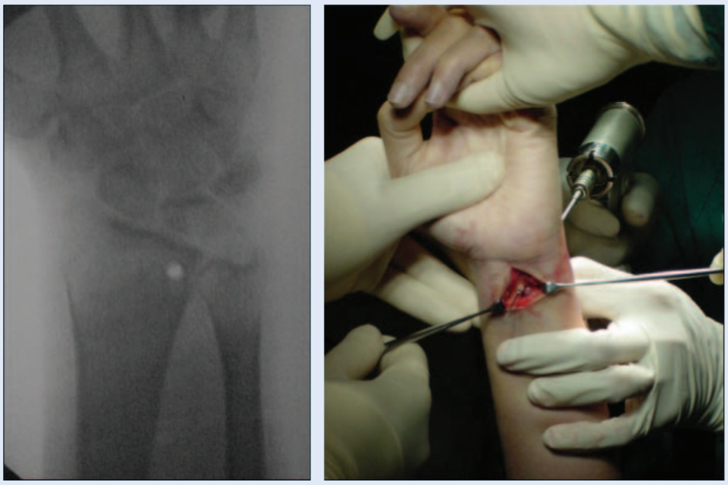

Figure 45. Sigmoid notch bone tunnel creation. Drill hole should be 2.5 mm or below.

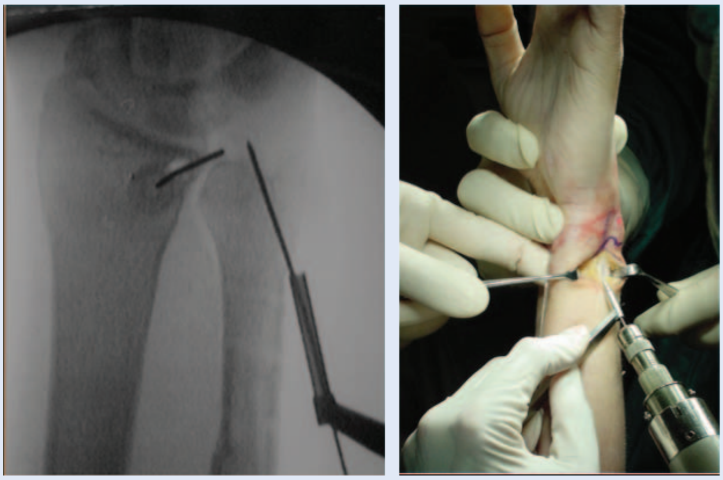

Figure 46. Ulnar head bone tunnel aiming at fovea using freehand technique

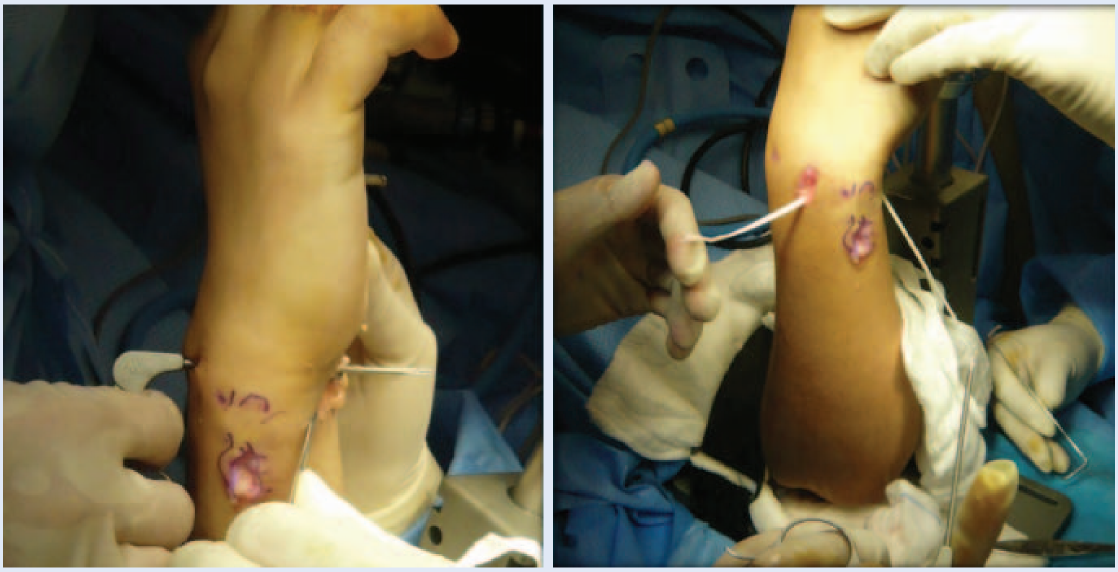

Figure 47. Mosquito grasper used to deliver the tendon graft across the wrist through the sigmoid notch tunnel

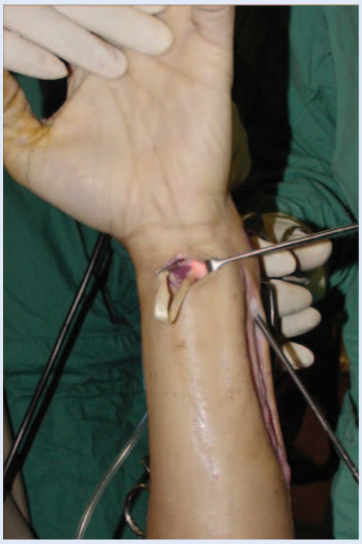

Figure 48. Tendon graft inside the wrist being grasped by a 2 mm mosquito grasper inserted into the joint through the ulnar head tunnel, to be delivered outside the ulna.

Figure 49. Both limbs of the tendon graft delivered outside the ulna. One limb is being passed through a separate transverse osseous tunnel proximal to the ulna head tunnel, to be tied with the other limb in shoe-lace fashion with maximal tension.

Combined dorsal and volar scapholunate ligament reconstruction with tendog graft

Both dorsal and volar portion of the scapholunate interosseous ligaments are the major stabilizers of the scapholunate joint. Most conventional methods to restore scapholunate stability do not address the volar constraints and frequently fail to reduce the SL gapping[91]. Wrist arthroscopy allows complete evaluation of the SL interval, accompanying ligament status and associated SLAC wrist changes. It enables simultaneous reconstruction of the dorsal and palmar scapholunate ligaments anatomically with the use of palmaris longus tendon as tendon graft in a box-like structure without violating major blood supply and soft tissue envelope[92] (Figure 51).

With the assistance of arthroscopy and intraoperative imaging guide, a combined limited dorsal and volar incision can expose the dorsal and palmar scapholunate interval without violating the wrist joint capsule (Figure 52). Bone tunnels of 2.4 mm can be made by cannulated drill under image control on the proximal scaphoid and lunate (Figure 53). Correction and control of the DISI deformity can be attained through placing the drill holes at different levels, typically from dorso-proximal to volar-distal over the lunate and from dorso-distal to volar-proximal over the scaphoid to counter-rotate the deformity (Figures 54, 55). Palmaris longus tendon graft is then delivered through the wrist capsule and the bone tunnels to reduce and connect the two bones in a box-like fashion (Figure 56). Once joint diastasis is reduced and DISI malrotation corrected, the tendon graft can be knotted and sutured under maximal tension on the dorsal surface of scapholunate joint extracapsularly in shoe-lacing manner (Figure 57). The scapholunate or scaphocapitate joint is then transfixed with K-wires for temporary protection of the reconstruction for 6-8 weeks (Figure 58). Additional bony anchors and sutures can be used to augment the reconstruction dorsally (Video 30).

From Oct 2002 to June 2012, the treatment method was applied in 17 patients of chronic SL instability of average duration of 9.5 months (range 1.5-18 months). There were 15 male and 2 female of average age 42 (range 26-60). There were 3 Geissler grade 3 and 14 grade 4 instability cases. The average pre-op SL interval was 4.9 mm (range 3-9 mm). DISI deformity was present in 13 patients and the average SL angle was 85° (range 52-102°). Six patients were identified to have stage 1 SLAC wrist change radiologically.

The average follow up was 48.3 months (range 11-132 months). Thirteen were able to return to their pre-injury job level, 4 had some restriction at work. Eleven patients had no wrist pain at all time and 6 had some pain on either maximum exertion or at the extreme of motion. The average total pain score was 1.7/20 in performing the 10 ADL tasks, compared with the preoperative score of 8.3/20. Visual analogue scale of pain at daily maximum exertion averaged 1.8/10 (preoperative 6.2/10). The average extension range improved for 13 %, flexion range 16 %, radial deviation 13 % and ulnar deviation 27 %.

Post-operative average total wrist performance score was 37.8/40, with improvement of 35 %. Mean grip strength was 32.8 kg, which was 120 % of the pre-operative status, and was 84 % of the contralateral side. Radiographs showed the average SL interval of 2.9 mm (range 1.6-5.5 mm). Recurrence of DISI deformity was noted in 4 patients without symptom. Ischaemic change of proximal scaphoid was noted in one case without symptom or progression. There was no major

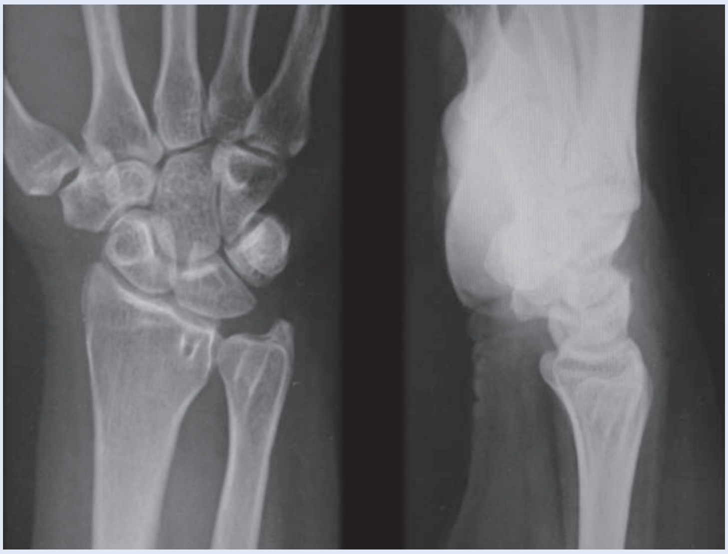

Figure 50. X-ray of the 1st case taken 11 years 8 months post-operation showing the bony tunnels with sclerotic margin and no arthritic change

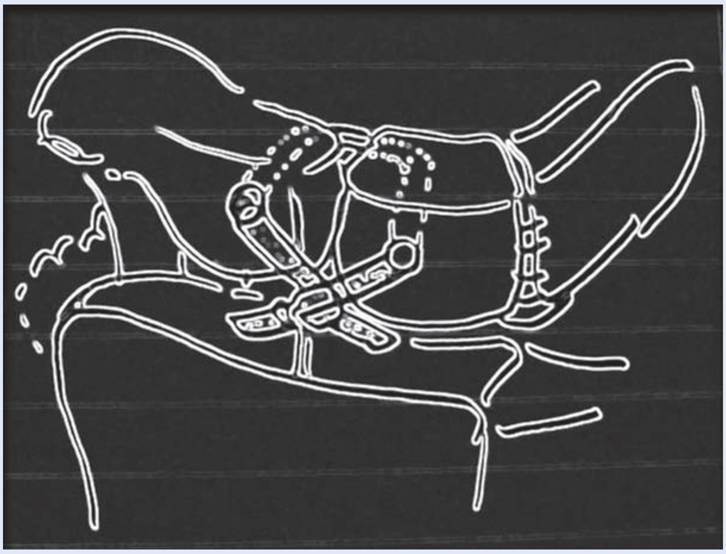

Figure 51. Simultaneous reconstruction of the dorsal and palmar scapholunate ligaments anatomically with the use of palmaris longus tendon as tendon graft in a box-like structure

complication. The patients with stage 1 SLAC wrist showed no progression of arthritis. All patients were satisfied with the procedure and treatment outcome.

Our method of reconstructing both the dorsal and volar SL ligament, in a minimally invasive way, is a logical and effective technique to improve the SL stability. The potential risk of ischemic necrosis of the carpal bone is minimized attributed to the preservation of blood supply, the small size of the bone tunnels created and

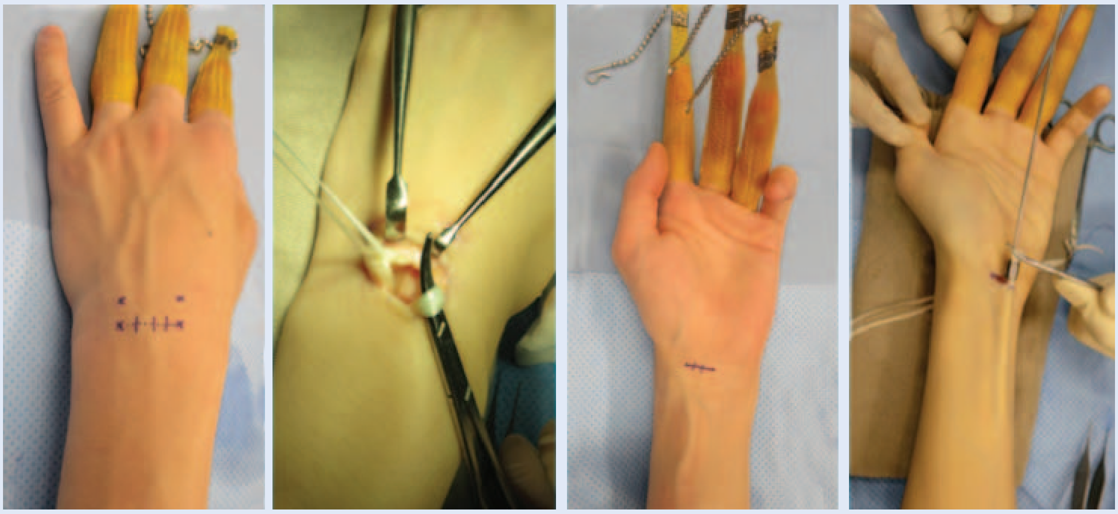

Figure 52. A combined limited dorsal and volar incision can expose the dorsal and palmar scapholunate interval without violating the wrist joint capsule. Over the dorsal wound, the extensor tendons are retracted exposing the dorsal wrist capsule. Through the volar incision, the PL graft can be harvested with the use of a tendon stripper.

Figure 53. DISI deformity of lunate is reduced by Linscheid maneuver, radiolunate joint is transfixed with a 1.6 mm K-wire in corrected alignment, another K-wire is position to prepare the lunate tunnel from dorsal to volar direction.

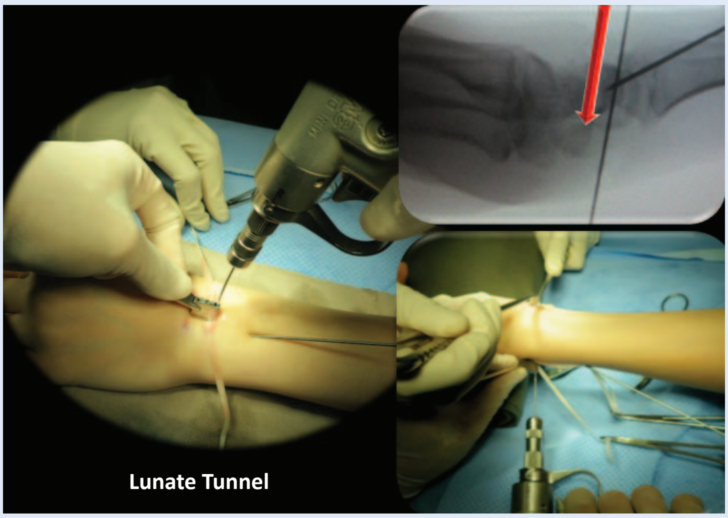

Figure 54. Preparation of the lunate tunnel with K-wire inserted through the dorsal capsule typically from dorso-proximal to volar-distal direction

the inclusion of the capsule at the reconstruction site. Our intermediate term result demonstrates the ability to improve patient's symptoms, improve the strength, the range of motion and retard the progression to arthritis. Scapholunate pinning carried the risk of damaging the tendon graft during the passage and is not recommended.

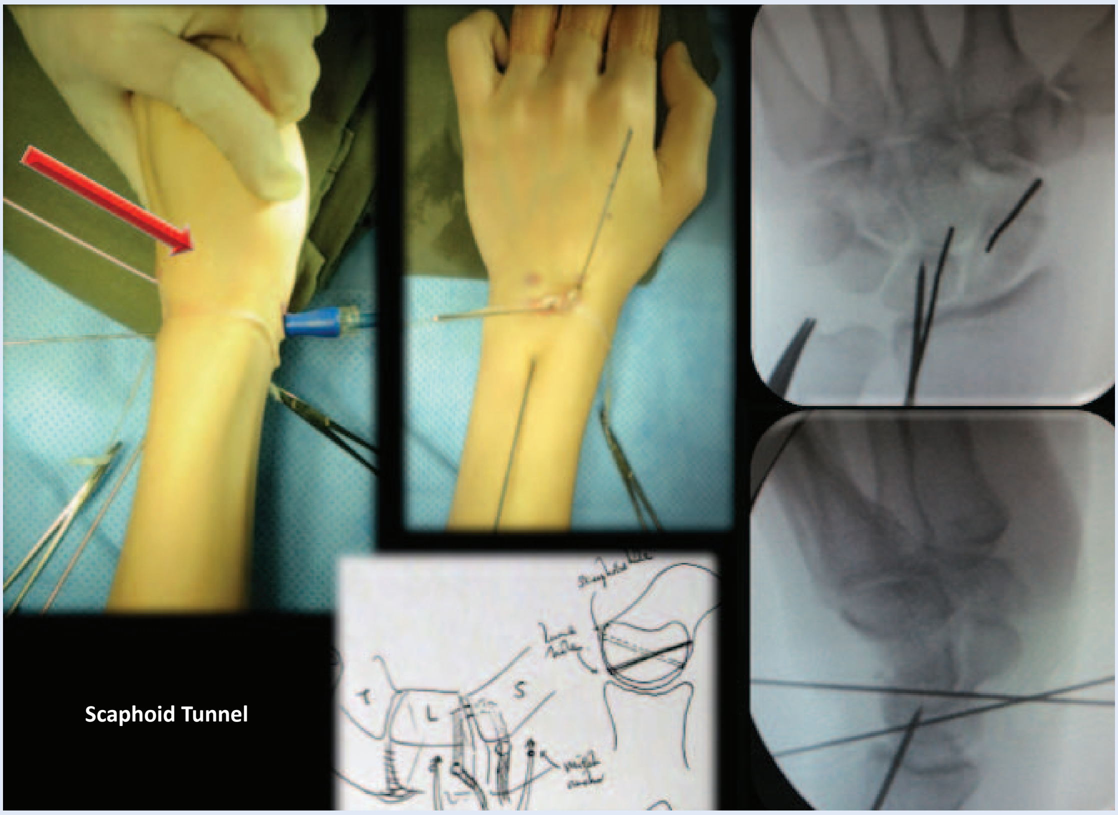

Figure 55. Preparation of the scaphoid tunnel with K-wire inserted through the dorsal capsule typically from dorso-distal to volar-proximal direction

Figure 56. Palmaris longus tendon graft is delivered through the wrist capsule and the bone tunnels to reduce and connect the two bones in a box-like fashion

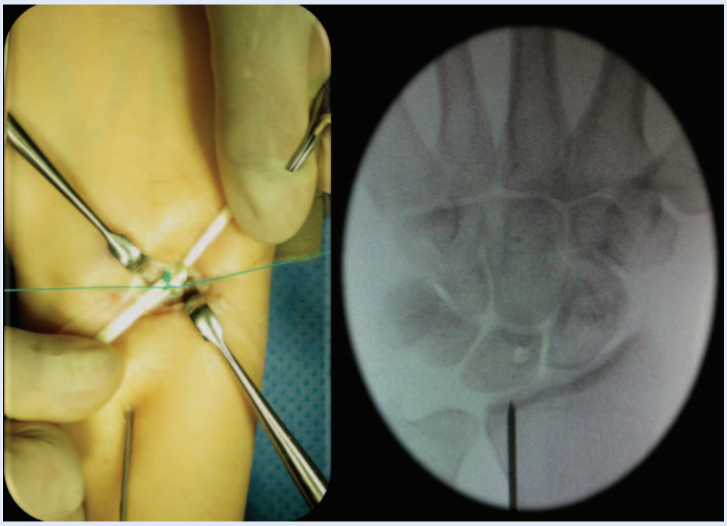

Figure 57. Tendon graft knotted and sutured under maximal tension on the dorsal surface of scapholunate joint extra-capsularly in shoe-lacing manner. Note the reduction of the SL interval and the correction of DISI deformity on X-ray.

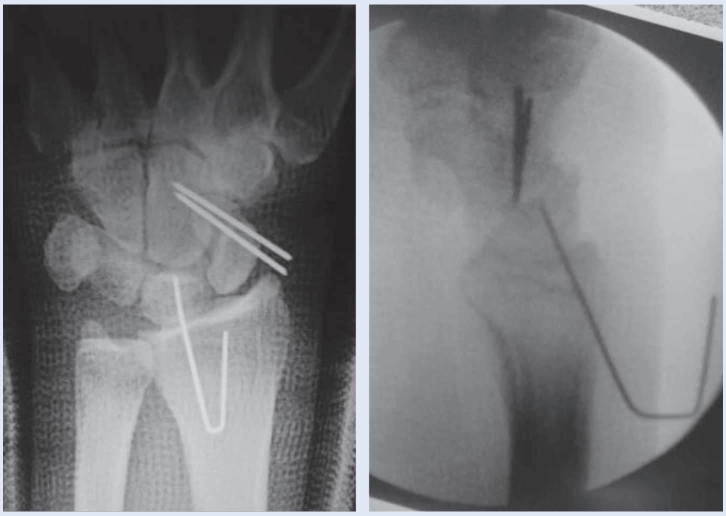

Figure 58. The radiolunate joint and the scaphocapitate joint are transfixed with 1.1 mm K-wires to protect the ligament repair

Osteochondral grafting

Focal chondral lesion is a common cause of chronic wrist pain. While smaller lesion responds well to drill chondroplasty, the best treatment for more sizable lesion remains unknown. We developed a technique of arthroscopic transplantation of osteochondral autograft from the knee joint to the distal radius with satisfactory clinical result.

Between Dec 2006 and Dec 2010, we had operated on 4 patients who were diagnosed to have post-traumatic localized osteochondral lesion over the dorsal lunate fossa of the distal radius[93]. There were 3 male and 1 female patients of average age 31 (range 24-41). They all presented with chronic central dorsal wrist pain and loss of motion after injury episode. The average duration of symptom was 28.3 months (range 11-71 months). All patients had pre-op imaging including CT scan and/or MRI. The definite diagnoses were confirmed by arthroscopy. The size of the lesions varied from 6 mm to 10 mm.

The transfer operation was performed under general anaesthesia. Synovitis over dorsal lunate fossa was debrided with 2.0 mm shaver to uncover the underlying osteochondral lesion. We employed the Osteoarticular Transfer System (OATS; Arthrex, Naples, FL) for the harvest and transfer process. A 6 mm recipient harvester was inserted into the joint through 3/4 portal (Figure 59). With the wrist flexed passively, the trephine was driven into the osteochondral defect for 10-12 mm and a cylindrical plug of bone containing the osteochondral defect was removed (Figure 60).

Figure 59. Insertion of the trephine through the 3/4 portal, the arthroscope is placed at 4/5 portal to control the positioning of the trephine. Note the wrist is flexed to accommodate the 6 mm trephine.

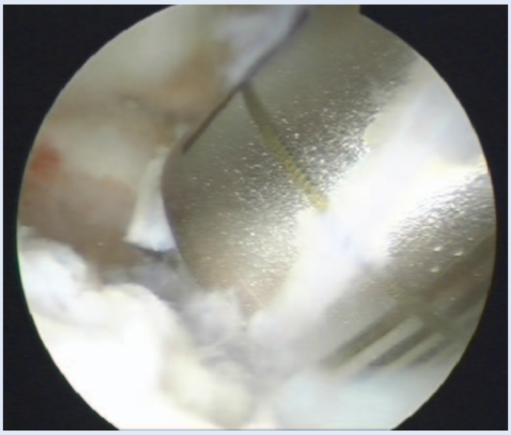

Figure 60. Arthroscopic view of the trephine at the osteochondral lesion

The donor site was the knee of the non-dominant leg. Through a small incision, a 6 mm donor harvester was inserted to the sulcus terminalis of the lateral femoral condyle to a depth slightly longer than that in the wrist (Figure 61).

A short transparent plastic delivery tube containing the osteochondral plug was then inserted into the defect through the 3/4 portal gently with the aid of a rotating dial (Figure 62). A plastic tam could be used to press-fit the plug. Mis-match at

Figure 61. Harvesting of osteochondral graft from the knee through a small incision

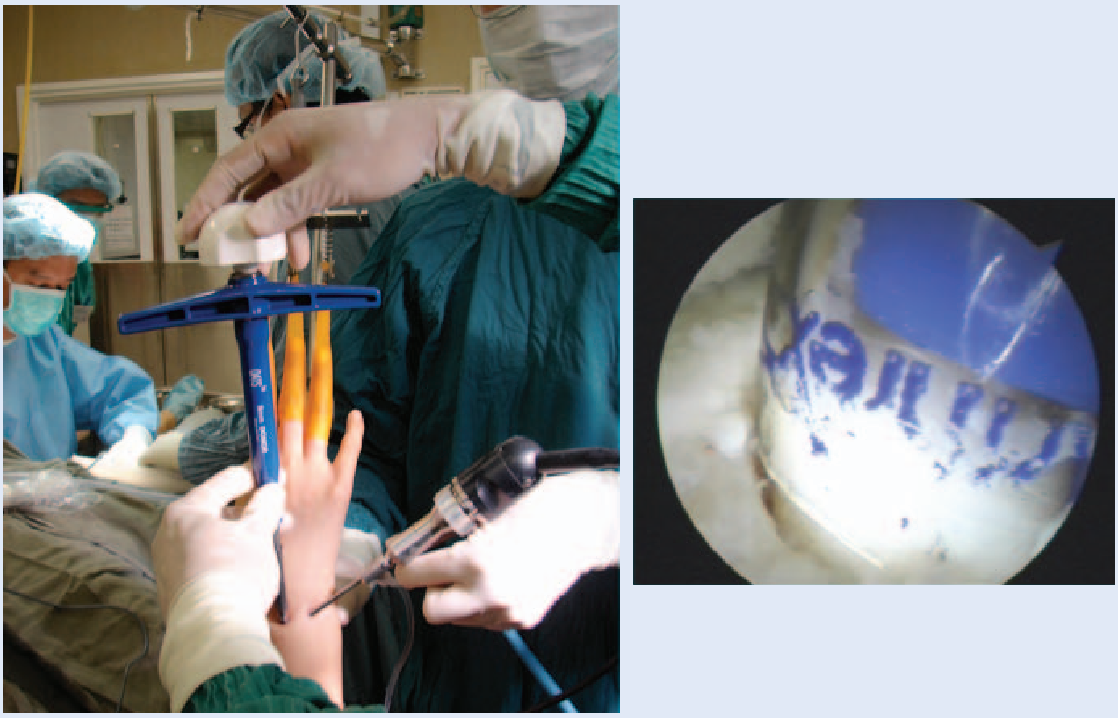

Figure 62. Transplant of the osteochondral graft into the wrist joint. The delivery of the graft can be precisely observed and controlled through a transparent plastic sheath.

the junction was trimmed with an arthroscopic knife (Figure 63). The graft was generally very stable and no internal fixation was required. A wrist splint was prescribed for 2-4 weeks and the patient was instructed to perform gentle active wrist motion from day 3. Load bearing of the wrist was discouraged for the first 6 weeks (Video 31).

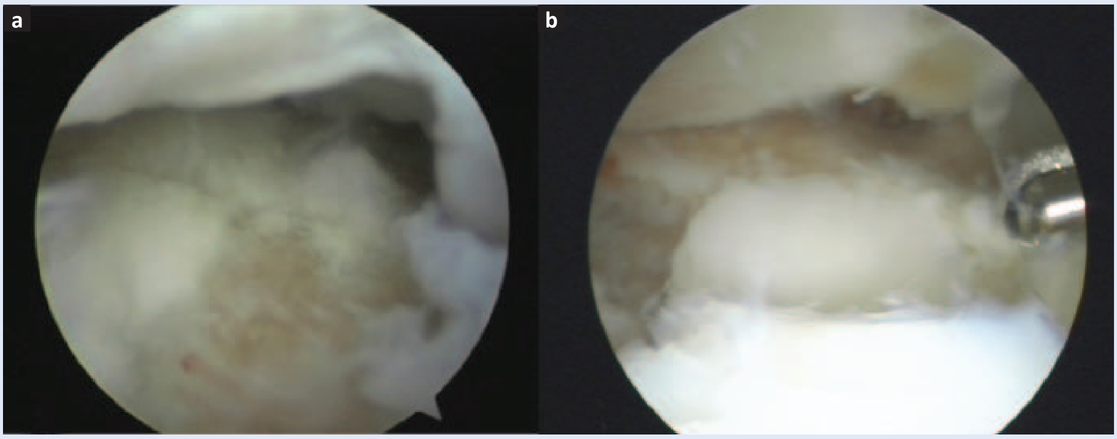

Figure 63. a) Osteochondral lesion at the lunate fossa; b) Osteochondral graft replacing the lesion

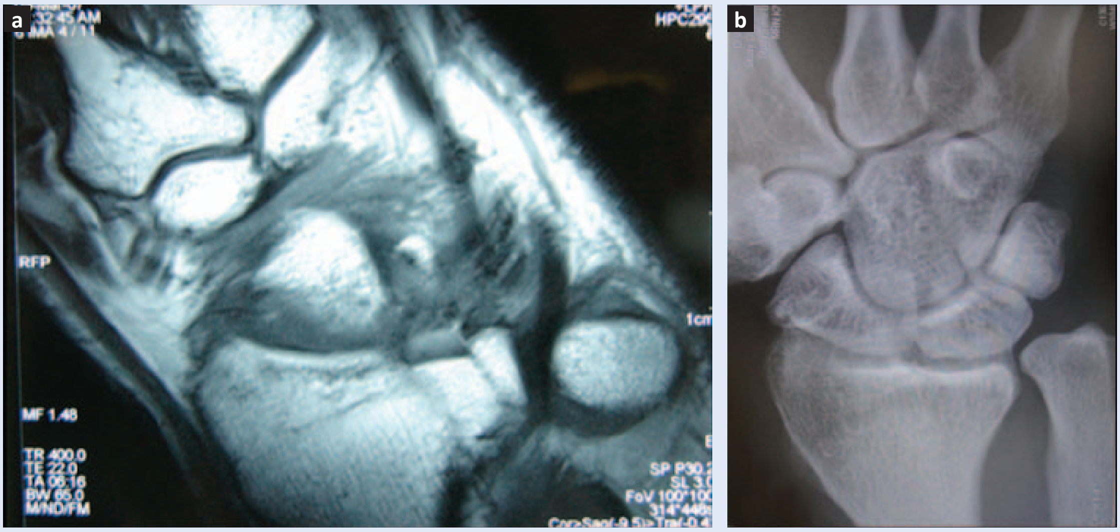

Figure 64. a) Follow up MRI at 4 months showed the incorporation of the graft at the lunate fossa; b) X-ray taken at 89 months post-operation showed no arthritic change

Figure 65. Patient showed excellent clinical outcome at 89 months of follow up

In all cases, the osteochondral grafts were shown by CAT scan or MRI to have complete incorporation to the host bone by 3-4 months post-operation (Figure 64). Second look arthroscopy at 6-9 months post-operation in 3 patients confirmed preservation of normal cartilage at the grafted area. There was a small rim of junction defect of 1-2 mm between the graft and the host cartilage. Biopsy of the grafted area in one patient confirmed hyaline cartilage. In one patient, a third look arthroscopy at 29 months post-operation showed complete coverage of the junction defect by hyaline cartilage.

At the final follow up of average 52.3 months (range 24-83 months), all patients showed improvement in the wrist performance score (pre-op 27.5, post-op 39.0 out of a 40 points scale) and pain score (pre-op 9.5, post-op 0.5 out of a 20 points scale). Grip strength improved from 62.6 % to 98.2 % of the contra-lateral side. Motion improved from 115.5° to 131.3°. They were all satisfied with the procedures (Figure 65). Surgical scars were inconspicuous. X-ray, CT scan and/or MRI showed good graft incorporation, no loss of joint space or other sign of degeneration. There was no complication.

In conclusion, wrist arthroscopy is the gold standard for diagnosis to determine the precise nature, location and extent of an osteochondral lesion. Osteochondral autograft transfer is an effective treatment to restore the normal hyaline cartilage and the articular environment. Our new arthroscopic approach enables autograft transfer without violating the soft tissue envelope and hence favours graft healing and rehabilitation. Due to limitation by the current instrumentation, the size of the osteochondral plug is restricted to 6mm. In the future, more patients can be benefitted if the instrument can be down-sized so that multiple grafting is made possible.

FUTURE POTENTIAL

Forty years ago when people started to argue whether meniscal surgery of the knee could be done arthroscopically, today the term “open meniscetomy” will probably only appear in the dictionary. The minimally invasive arthroscopic surgery is also the ideal and preferred mode of treatment if the result can be proven to be equal or superior to open technique. With a relatively short history of development only since 1986, the wrist arthroscopy is inherited with a tremendous potential for future development. In fact we saw from the literature over the past 15 years that attempts had been made to perform most of the conventional open surgery of the wrist arthroscopically with variable success. While diagnostic arthroscopy had firmly established its standard, most of the innovative therapeutic trials, however, consisted of few clinical subjects, lacked controlled randomized prospective study and devoid of long term evaluation. Probably only the test of time and carefully planned clinical study can clear skepticism and consolidate their therapeutic roles in various wrist disorders. With the development of PSLA technique to allow wrist arthroscopy to be performed under local anaesthetic setting, the risk associated with arthroscopy has markedly diminished and the acceptance of the surgery both by the patients and the surgeons can be escalated. One can foresee a much wider clinical application in the future and wrist arthroscopy as an office diagnostic procedure becomes a real possibility. Future development will probably only be limited by the imagination and bioskill of the surgeons. Nevertheless, more controlled randomized prospective studies need to be conducted in the future to establish the true value of each arthroscopic treatment modality.

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