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Wrist: Current Diagnosis and Treatment of Scaphoid Fractures and Injuries of the Scapholunate Ligament

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Schlüsselwörter: Handgelenk – Kahnbeinfraktur – skapholunäre Bandverletzung – Handgelenksarthroskopie.

Summary: Background: Fractures of the scaphoid and injuries to the scapholunate ligament are mostly seen as causes of the acute and chronic painful wrist. Strict guidelines are necessary to precisely detect these lesions in the acute stage and to provide adequate treatment. A computed tomography bone scan parallel to the long axis of the scaphoid is best for demonstrating fractures and any associated deformities. Scapholunate ligament injuries are best staged by standard plane radiographs including stress views and by arthroscopy of the wrist.
Methods: To avoid lengthy plaster immobilization and to lower the risk of nonunion, displaced and comminuted scaphoid fractures of the wrist as well as all proximal pole fractures should be internally fixed. Headless screws such as the Herbert screw, now available in a cannulated shape, allow the minimally invasive stabilization of the majority of these fractures with a high success rate under early mobilization. Undisplaced fractures can be treated conservatively with a below-elbow cast; alternatively, they can be stabilized percutaneously without the need for immobilization in a cast. Early diagnosis of scapholunate ligament injuries is most important, as anatomical healing of the injured ligaments can be expected only with primary treatment including correct realignment of the scaphoid and lunate followed by immobilization in a cast for about 8 weeks. In cases of chronic lesions, ligament reconstruction or even partial wrist fusion can be performed. In order to assess the different procedures, precise classification and staging with regard to a dynamic or static pattern are needed.
Results: Early rigid fixation of scaphoid fractures promotes a union rate of up to 100 % with rapid functional recovery. Primary repair of scapholunate ligament injuries provides the best clinical outcome. Ligament reconstruction or partial wrist fusion can help to prevent rapid secondary arthrotic changes in the wrist and leads to significant pain relief, albeit with restriction of mobility and grip strength.
Conclusions: Standardized diagnosis and treatment of scaphoid fractures and scapholunate ligament injuries improve clinical outcome and significantly reduce post-traumatic arthrotic changes in the wrist.

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Handgelenk: Aktuelle Diagnostik und Therapie der Kahnbeinfraktur und der skapholunären Bandverletzung

Zusammenfassung: Grundlagen: Kahnbeinfrakturen und Rupturen des skapholunären Bandes stellen die häufigsten Handwurzelverletzungen dar und kommen nicht selten wegen übersehener Diagnose oder inadäquater Primärtherapie verspätet in ärztliche Behandlung. Zur Vermeidung von Spätfolgen ist eine exakte primäre Diagnosestellung notwendig. Ergänzend zu den Standard-Röntgenaufnahmen ermöglicht die CT in der Längsachse des Kahnbeins eine sichere Diagnose und morphologische Beurteilung der Fraktur des Kahnbeins. Zur Beurteilung der skapholunären Bandverletzung sind Standard-Röntgenaufnahmen mit ergänzenden Projektionen unter Streß und die Arthroskopie des Handgelenkes erforderlich.
Methodik: Verschobene oder klaffende Frakturen des Kahnbeins im mittleren Drittel sollten ebenso wie alle Frakturen des proximalen Drittels operativ stabilisiert werden, da sie bis zur Heilung eine lange Gipsimmobilisation erfordern und das Risiko für das Entstehen einer Pseudarthrose erhöht ist. Verbesserte Osteosynthesematerialien in Form kanülierter Schrauben, die intraossär plaziert werden, erlauben die minimalinvasive Versorgung der Mehrheit der im mittleren Drittel lokalisierten Frakturen bei gleichzeitiger Frühmobilisation. Proximale Polfrakturen werden von einem dorsalen Zugang mit Mini-Herbertschraube versorgt. Die Primärtherapie der skapholunären Bandverletzung erfordert eine korrekte Reposition des Kahnbeins und Lunatums mit anschließender Gipsimmobilisation, um eine anatomische Heilung zu ermöglichen. Im chronischen Stadium, ohne reparables Bandmaterial, können Bandrekonstruktionen der intrinsischen und extrinsischen Ligamente oder Teilarthrodesen der Handwurzel, den Karpus stabilisieren und sekundärarthrotische Veränderungen vermeiden oder zumindest hinauszögern.
Ergebnisse: Die operative Stabilisierung der Kahnbeinfraktur läßt bei minimalinvasiver Technik ohne Gipsimmobilisation eine Heilungsrate zwischen 96 % und 100 % erwarten. Die Primärtherapie der skapholunären Bandverletzung liefert die besten klinischen Resultate mit nur geringen Einschränkungen. Sekundäre Bandrekonstruktionen führen zu einer Einschränkung der Beweglichkeit zwischen 20 % und 50 % und Kraftminderung von 10 % bis 40 %.
Schlußfolgerungen: Standardisierte Diagnose und adäquate Therapie verbessern die Ergebnisse nach Frakturen des Kahnbeins und Verletzungen des skapholunären Bands. Hierdurch können posttraumatische Spätschäden mit Arthrose des Handgelenkes verhindert werden.

Introduction

In the evaluation of wrist pain, the hand surgeon has to look at a multitude of differential diagnoses when identifying the cause of the symptoms. By far, the main sources of pathology of the wrist are represented by injuries to the scaphoid and the surrounding ligaments. Despite all advances, complications of scaphoid fractures, such as nonunion and in late stages carpal collapse, remain a common and disabling problem (16). The same is true for injuries of the scapholunate ligament, whose importance has been clearly defined but whose diagnosis in the acute stage is often missed. To improve this situation, new strategies of diagnosis and treatment have been developed based on a better understanding of wrist biomechanics and pathoanatomy. First of all, a high awareness of these injuries by means of precise clinical examination is necessary (6, 7). The accurate application of diagnostic tools such as computed tomography (CT), magnetic resonance imaging (MRI) and arthroscopy of the wrist can provide precise diagnosis in the acute as well as in the chronic stage. As a consequence, we are seeing a more aggressive treatment of scaphoid fractures by internal fixation, mostly

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performed minimally invasively, and more frequent detection of acute scapholunate ligament injuries followed by initial adequate treatment.

Fractures of the scaphoid

Diagnosis

The problem of detecting fractures of the scaphoid by conventional radiographs has been well known for a long time, and additional special projections are regarded as a matter of course. However, in our experience, the majority of patients presenting with nonunion of the scaphoid were seen initially by a doctor but the diagnosis was missed or conservative treatment failed. To diminish these complications, clear guidelines and precise knowledge about additional diagnostic tools such as CT scan and MRI are mandatory, as clinical symptoms are often minimal and a high index of suspicion is necessary.

In cases of radial-sided wrist pain, which should routinely be checked following wrist trauma by palpation and stress manoeuvres under ulnar and radial movement, further diagnostics are needed. High-quality radiographs should include, as a minimum, posteroanterior (PA) and lateral views with the wrist in neutral alignment, a PA view in full ulnar deviation (scaphoid view), and an oblique view in 45-degree pronation. If a fracture is suspected but cannot be demonstrated on these initial radiographs, a CT bone scan should be ordered in the early stage (8). Sagittal sections taken at 0.5- or 1-mm intervals that run parallel to the long axis of the scaphoid are best for demonstrating fractures and any associated deformities (Fig. 1). This technique requires the patient to lie prone in the scanner with his/her arm extended above the head. Precise positioning is essential. Reconstructions of axial CT scans of the wrist should not be used as an alternative as they are of poor quality due to limited spatial resolution in scan direction and motion artefacts. MRI is occasionally used to assess the vascularity of the proximal pole; however, this is more frequently used in cases of nonunion. MRI does not clearly show bony details and displacement of the fracture because of the limited image matrix. Furthermore, bone marrow oedema, which is depicted by MRI with great sensitivity, might be due to either a bone contusion (so-called 'bone bruise') requiring no treatment, or a fracture requiring treatment (18).

Treatment

Tradition has it that the majority of scaphoid fractures will heal uneventfully if adequately immobilized in plaster. This remains by far the most common method of treatment today (21). The problem with this approach to management is that treatment is often prolonged for many months, particularly if primary healing is not achieved, and the fact is that nonunion of the scaphoid remains a common and disabling problem (23). Nowadays, few patients can afford such a prolonged period of disability. As with other fractures, there is increasing pressure for immediate and definitive treatment in this mostly young patient group, which would enable a rapid return of normal function.

According to Herbert's classification (Table 1), all displaced fractures of the wrist (B1, B2, and B4) should be regarded as unstable and treated by internal fixation (11). Type A2 undisplaced fractures might be treated conservatively in a short arm cast; alternatively, they might be operated whenever treatment in a cast is not appropriate, e.g. in the case of a professional athlete or anyone else whose financial pressures dictate an early return to work, which would not be possible with a plaster (25). Similarly, the management of patients with coexisting or multiple injuries is greatly simplified if the scaphoid fracture is internally fixed and plaster can be avoided. In contrast to fractures of the wrist, which can be classified as stable or unstable according to the amount of displacement and the direction of the fracture line, all proximal pole fractures should be regarded as unstable, whether or not they are displaced (14). The reason for this is the precarious vascularity of the small proximal pole fragment, resulting in poor healing potential.

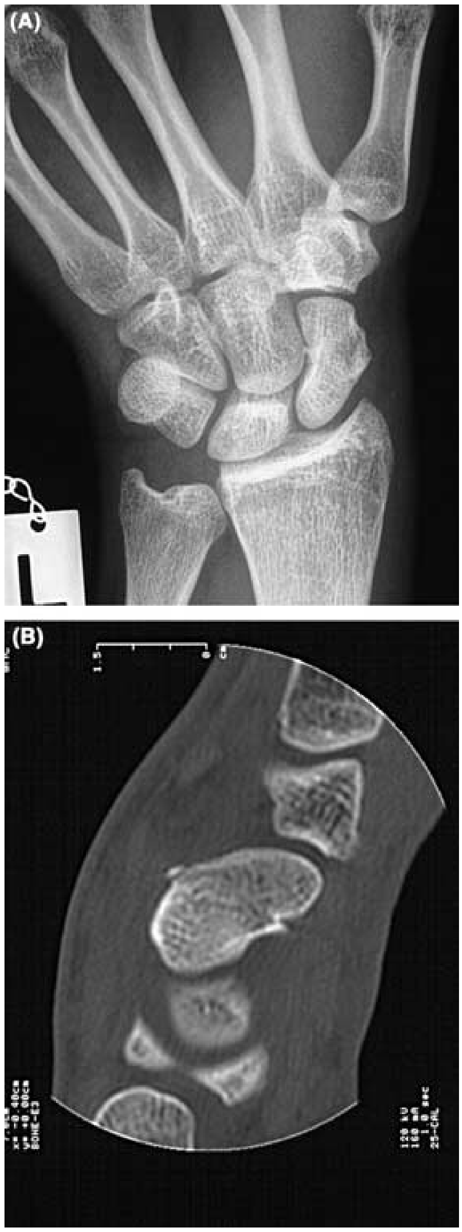

Fig. 1. (A) Initial radiograph (posteroanterior in ulnar deviation) demonstrating slight deformity at the ulnar cortex, consistent with recent trauma, although the fracture itself cannot be seen. (B) A CT scan is used to confirm the diagnosis; the fracture line is now clear and can be seen to involve both cortices, with the potential for displacement.

Table 1. Classification of scaphoid fractures according to Herbert and CT scan.

Type A	Stable acute fractures
A1	Fracture of the tubercle
A2	Undisplaced wrist fracture
Type B	Unstable acute fractures
B1	Oblique fractures
B2	Displaced wrist fractures
B3	Proximal pole fractures
B4	Trans-scaphoid perilunate fracture dislocation

Fig. 2. High and low compression type of the HBS (headless bone screw) system cannulated for a 1.0-mm guide wire. The high compression screw is preferably used to treat nonunion of the scaphoid.

Material

The size, shape and intra-articular position of the scaphoid bone dictate the use of small, accurately positioned implants, capable of providing sufficiently secure fixation to allow early joint mobilization. In this respect, headless bone screws are particularly suitable, since they can be entirely buried beneath the articular surface and do not need to be removed later. The smaller the implant, the easier it is to insert and the less likely it is to cause damage. There is no longer any place for the use of standard bone screws in the treatment of scaphoid fractures. Recent improvements in the quality and availability of intraoperative X-rays have led to the growing popularity of percutaneous methods of scaphoid fixation because of the obvious advantages these have over the more traditional open approach. At the same time, a new generation of cannulated headless screws has been developed, as accurate positioning of the screw within the scaphoid is greatly facilitated by the use of a guide wire, inserted under X-ray control (12). The latest development, the HBS (headless bone screw), represents a cannulated screw for a 1-mm guide wire based on the original Herbert screw design (Fig. 2).

Methods

Palmar approach – percutaneous

The great advantage of this technique is that no palmar ligaments are damaged and no immobilization in plaster is routinely necessary. Indications are all fractures of the wrist that are undisplaced or can be reduced by closed manipulation. The continuous availability of X-ray control is an important prerequisite for the procedure. We prefer the image intensifier to be permanently positioned opposite the surgeon, with the assistant at the head of the table. A short incision is carried out and the scaphotrapezotrapezoidal (STT) joint identified. The drill guide is positioned firmly on the distal pole of the scaphoid towards its radial side, and the 1-mm guide wire is inserted through the sleeve. The correct entry point should be checked with the C-arm. Then, aiming the guide towards the proximal pole of the scaphoid (approximately 45 degrees dorsally and 45 degrees unfairly in relation to the neutral plane), the guide wire is slowly inserted under X-ray control. The optimum position should be along the mid-axis of the scaphoid in both planes, and as closely perpendicular to the fracture as possible. The guide wire should enter, but not penetrate, the firm subchondral bone at the apex of the proximal pole. The intraosseous position in all planes must be checked by continuously moving the wrist from pronation into supination. After measuring the length, fixation of the guide wire into the radius is preferred to avoid loosening when drilling. Finally, the appropriate screw is selected and placed over the guide wire. The threads are well buried beneath the surface of the tubercle. The final position – and stability of fixation – is controlled by screening the wrist on the image intensifier (Fig. 3).

Postoperative treatment includes elastic bandage for 2 weeks. This normally provides adequate support for the wrist during the

Fig. 3. (A) Guide wire being inserted through a small incision over the tubercle of the scaphoid. (B) Intraoperative screening of the central position of the guide wire. (C) Posteroanterior radiograph shows satisfactory fixation. (D) At 8 weeks, CT confirms sound healing of the fracture.

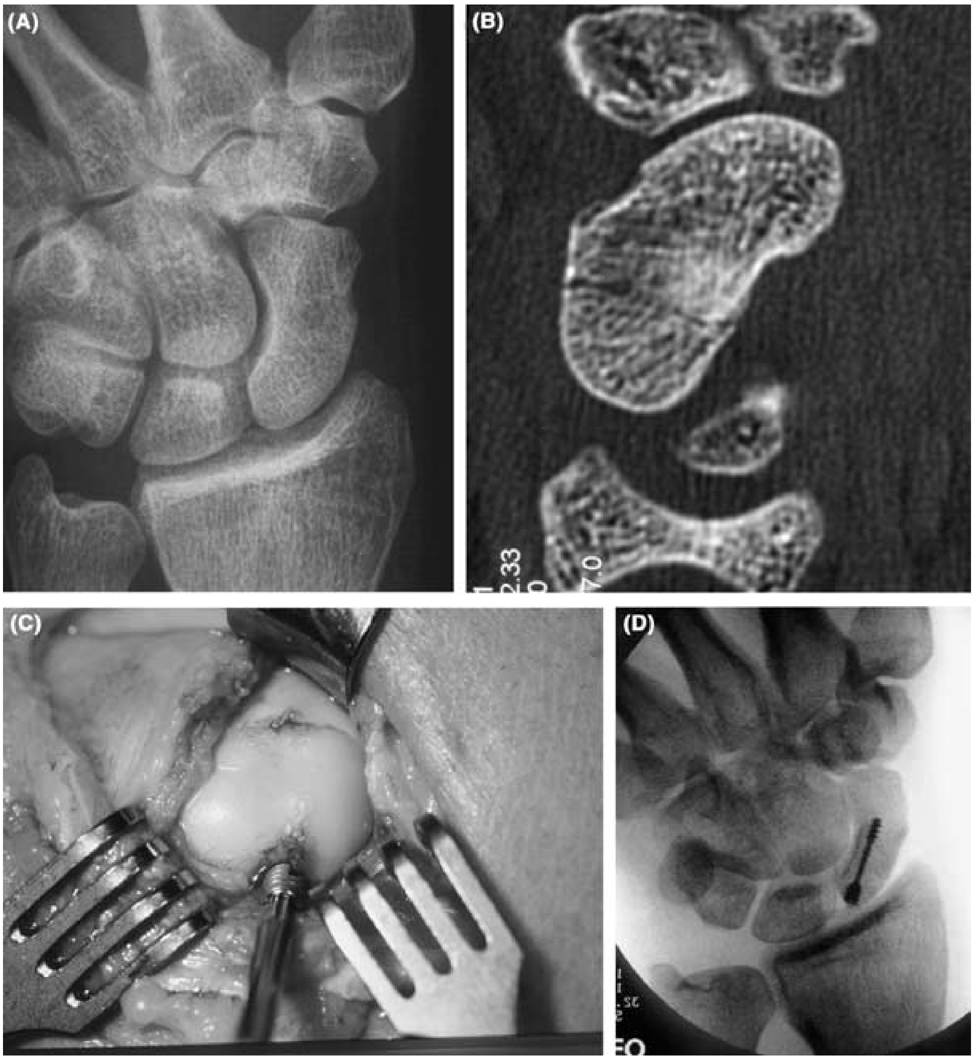

Fig. 4. (A) Suspected fracture of the scaphoid. (B) Proximal pole fracture detected on CT scan. (C) Intraoperative view of the dorsal approach with a mini Herbert screw inserted through the proximal pole. (D) Posteroanterior view demonstrating the screw buried beneath the cartilage.

period of wound healing while at the same time allowing sufficient movement to prevent adhesions and joint stiffness. Heavy manual work and contact sports are to be avoided during the first 6 weeks. The fracture should heal within 6 to 10 weeks. The percutaneous approach is not suitable for any fracture that cannot be reduced by closed manipulation or that needs bone graft to restore stability or length. Under these conditions, reduction by open approach is necessary and internal fixation is performed using the same technique described above. When using the open approach, initially 2 weeks in a short arm cast is recommended for healing of soft-tissue structures.

Dorsal approach

For fractures at the proximal third of the scaphoid, internal fixation is best carried out through a dorsal approach, using an intraosseous fixation device appropriate to the small size of the proximal fragment (14, 26). The dorsal approach provides limited access with partial opening to the second and third extensor compartments and the wrist capsule over the scapholunate joint. It does not further compromise the blood supply to the proximal fragment, and it allows clear visualization of the fracture and exact placement of the screw. There is no real advantage over percutaneous insertion, as no ligaments are incised with the open technique and the risk of incorrect positioning of the screw increases with the closed technique. If realignment must hold, a K-wire of 1.0 mm is inserted. Then, by using the special handholder, the drill is inserted to a length that crosses the fracture side to at least the same distance as that proximally. The mini Herbert screw can be easily inserted under direct vision into the small proximal fragment using a freehand technique. The small size of this screw minimizes the risk of additionally disturbing the small proximal fragment and allows the screw to be buried beneath the subchondral cartilage (Fig. 4).

The wrist is immobilized postoperatively for 2 weeks in a below-elbow cast, and heavy manual activity is restricted during the first 6 weeks. Once radiographs demonstrate fracture union, full activities may be resumed. This treatment regime has a high success rate in our hands, even for proximal pole fractures that present up to 4 months following injury.

Results

Recently, we published a series of 32 patients who were treated according to the aforementioned criteria (18). The majority showed unstable patterns – B1 (1), B2 (22) and B3 (5) – and only four demonstrated a stable situation according to the A2 type. Half of them were fixed minimally invasively, 11 through a palmar open approach, and five through a dorsal open approach. All fractures united. Meanwhile, in another series of 68 minimally invasive procedures, we observed two nonunions: One patient had a technical failure with incorrect positioning of the screw, where the proximal fragment was only partially fixed; the other patient had a severe second wrist trauma 3 weeks following surgery.

Injuries of the scapholunate ligament

With better understanding of wrist anatomy and biomechanics, the injury of the scapholunate interosseous ligament (SLIL) has become more evident as an important cause of the painful wrist. Dissociation between the scaphoid and lunate results in a palmar flexion attitude of the scaphoid and concomitant extension of the lunate, described as the DISI (dorsal intercalated segment instability) pattern (22). Currently, static and dynamic instability are differentiated as the result of complete rupture of the SLIL (33). *Watson* and *Ballet* (29) have clearly demonstrated that the long-term history of untreated lesions leads to progressive, severe and disabling arthrosis, ending as the scapholunate collapse pattern (SLAC wrist). For this reason, treatment of SLIL injuries warrants early surgical intervention. A wide range of procedures have been advocated for the management of this injury, including ligament repair, tendon weaves, ligament reconstruction, different types of capsulodesis and limited intercarpal arthrodesis. Finally, the latest developments represent bone–ligament–bone reconstruction combined with capsulodesis (4, 33). The main principle of all these procedures is to prevent the abnormal movement of the scaphoid, resulting in impingement on the radius with secondary arthrotic changes. By far, the most important factor determining

Fig. 5. Standard radiographs to detect scapholunate ligament injuries. (A) Posteroanterior, (B) lateral, (C) ulnar-deviated views. (D) Clenched fist with load reveals dynamic pattern of scapholunate dissociation.

the success of treating SLIL injuries lies in the accurate evaluation and staging of the injury.

Diagnosis

Early diagnosis is the key factor, as initially adequately treated injuries can heal without any long-term disability. If a SLIL lesion is suspected at clinical examination, which should routinely include the scaphoid shift manoeuvre (Watson stress test (31)), PA and lateral radiographs as well as stress views (clenched fist, ulnar deviated position) with and without load are routinely needed (Fig. 5). Based on these radiographs, it is possible to differentiate a dynamic pattern, where an increasing scapholunate gap can be noticed only under stress view, from a static pattern demonstrating a widened scapholunate angle over 70 degrees by rotary subluxation of the scaphoid and DISI position of the lunate. Cineradiography can provide further information, especially in chronic lesions. One should always keep in mind that SLIL injuries can occur in combination with fractures of the radius particularly when the articular surface is involved. Under these conditions, when stress views cannot be obtained, as well in cases of normal radiographs but severe clinical symptoms, arthroscopy of the wrist joint is mandatory (Fig. 6). MRI has improved in cases of complete rupture of the SLIL, with a success rate of up to 90 %, but it may be regarded as an alternative only in the hands of an experienced radiologist and using a high-resolution MRI technique.

By using arthroscopy, the attending surgeon not only can identify the SLIL as the cause of symptoms, but also can accurately stage the injury, either as an acute lesion where the ligament can be directly repaired, or as a chronic lesion where

Fig. 6. Arthroscopic view of rupture of the scapholunate ligament with a view of the head of the capitate from the radiocarpal joint.

there is no adequate ligament remaining for repair (34). When treating chronic lesions, the absence of degenerative changes in articular cartilage should routinely be confirmed by both radiographic and arthroscopic examinations, because early degenerative changes can be missed on routine radiographs and are a contraindication for SLIL reconstruction. This will allow proper selection among the various surgical procedures of a technique that provides the patient with the best relief of symptoms and also leads to the best functional outcome.

Treatment

Acute injuries

If an acute lesion is diagnosed within the first days after injury, the key factor for healing of the injured structures is realignment of the scaphoid and lunate, followed by immobilization for about 8 weeks in a short arm cast. Under these conditions, lesions of the intrinsic and extrinsic carpal ligaments can heal anatomically. In cases of static pattern, open reduction and internal fixation by K-wires is needed, whereas in dynamic patterns percutaneous fixation can be performed. Partial lesions usually cause no instability and are best treated by immobilization for about 4 weeks. It is well documented that early diagnosis and treatment of SLIL injuries provides the best functional outcome, and, as a consequence, early arthroscopy should be carried out if there is any doubt (10).

Subacute injuries

The subacute stage can be defined as a time period (arbitrarily between 3 and 12 weeks after injury). However, with regard to the intraoperative findings, it should rather be defined as a time-independent stage that still shows adequate ligament available for direct repair. As ligaments quickly lose their ability to repair themselves, the treatment of these stages, whether dynamic or static, should be expanded to include direct ligament suture of the SLIL by transosseous repair using pull-out sutures or bony anchors (Fig. 7). Additionally, a capsulodesis should be performed using the technique described below. With this technique, *Lavernia* et al. (20) found significant pain relief, improved grip strength and X-ray appearance, with only a slight change in range of motion (ROM) due to a loss of palmar flexion, which averaged 11.5 degrees.

Chronic injuries

For chronic lesions where no adequate SLIL is available for direct repair, it becomes far more difficult to decide what might be the best treatment. The reason for this is the fact that the clinical results reported in the literature are usually related to one special procedure and do not deal with the different patterns of SLIL injuries, e.g. dynamic, static, acute, subacute or chronic.

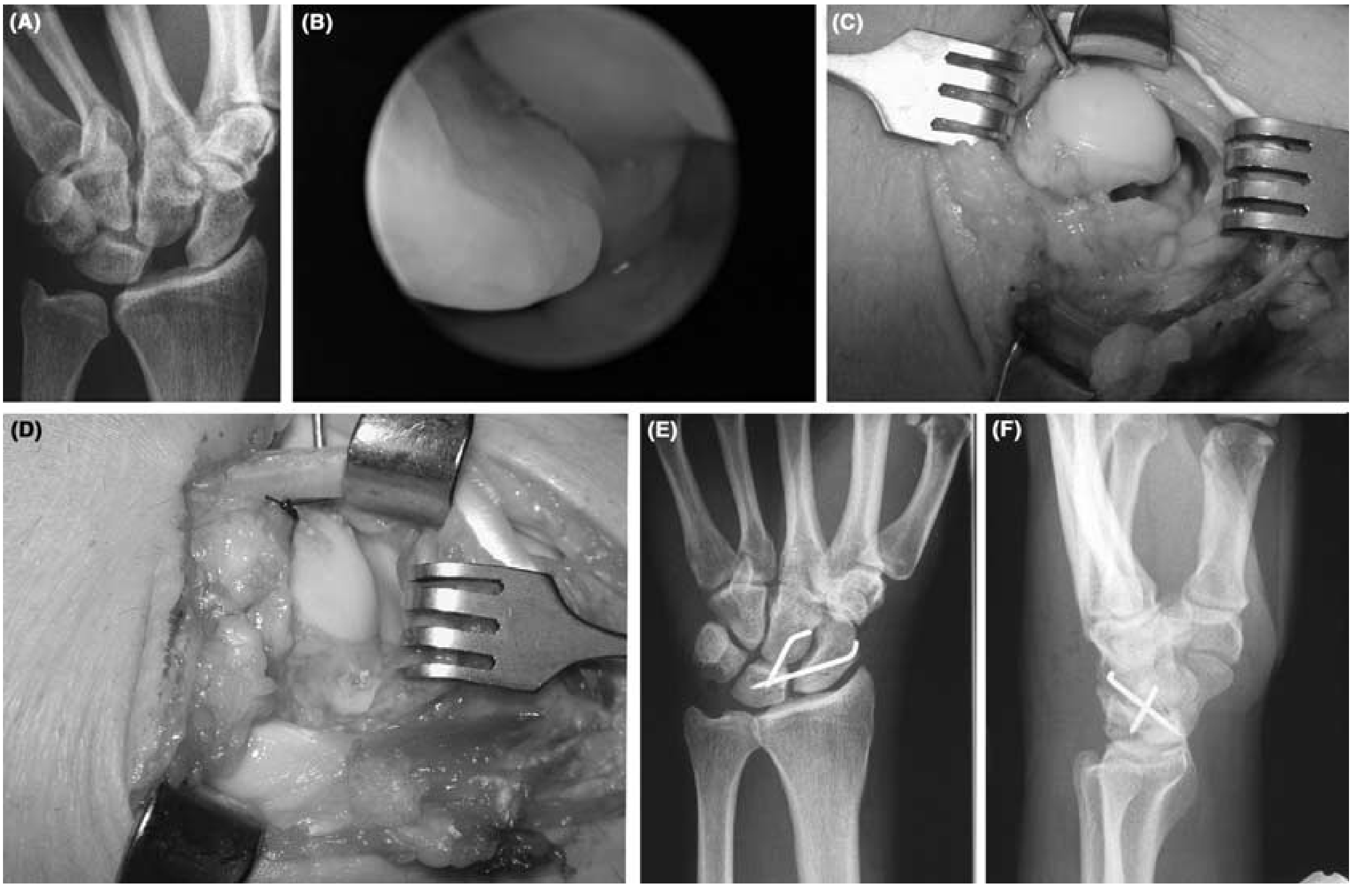

Fig. 7. (A) Static pattern of scapholunate ligament rupture 8 weeks after the initial injury (subacute) showing a significant scapholunate gap. (B) Arthroscopic view of the avulsed scapholunate ligament. (C) Intraoperative view of the ligament torn off at the scaphoid. (D) Reattachment by transosseous suture. (E) K-wire fixation; note the realignment of the scaphoid and lunate. (F) Lateral view of reduced scapholunate angle.

Fig. 8. Static pattern of chronic scapholunate dissociation with rotary subluxation of the scaphoid. Note the ring sign of the shortened scaphoid.

It is important to take into consideration that those SLIL injuries are in general the result of a lesion of the SLIL itself and of the extrinsic carpal ligaments. The extent of extrinsic damage determines whether a dynamic or a static pattern is found. For this reason, repair or reconstruction of chronic SLIL injuries should include intrinsic and extrinsic reconstruction. As a result, formerly recommended single SLIL reconstructions using tendon weaves have been abandoned because of inconsistent and disappointing clinical results.

For extrinsic ligament repair, the dorsal capsulodesis is mostly used. The basic goal of this procedure is to create a proximally based check-rein mechanism to prevent the acute flexion of the scaphoid and thus eliminate the rotary subluxation (Fig. 8). First described by *Blatt*, a dorsal capsular flap is developed and, with the scaphoid, is maintained in its reduced position by K-wire fixation; this flap is fixed to a fresh bony bed at the distal pole under tension by a volar pull-out suture (1). We recently reported the clinical results of a modified type, which involved mobilizing a strip of the dorsal intercarpal ligament left attached to the scaphoid distally and sutured to the lunate and radius under tension dorsally (3). This procedure, as stand-alone treatment for dynamic lesions, leads to consistent clinical results with significant pain relief and improved grip strength. Mobility of the wrist joint is reduced in palmar flexion to about 70 % that of the contralateral side.

Static lesions are more difficult to treat and should include a reconstruction of the SLIL itself. Bone–ligament–bone autograft in combination with dorsal capsulodesis seems to produce better clinical results. This technique was first described by *Weiss* using autograft from the dorsum of the radius with part of the retinaculum for SLIL reconstruction (33). Meanwhile, *Cuenod* et al. (5) showed that the trapezoid-to-second metacarpal ligament proved to be significantly stronger. Reduction has to be maintained by temporary K-wire fixation for at least 8 weeks. *Brunelli* and *Brunelli* (2) described a different manner of reconstruction.

Pointing out the importance of the STT ligaments for stabilization of the scaphoid, they used a slip of the flexor carpi radialis (FCR) tendon, which is passed through a tunnel created in the distal pole of the scaphoid and pulled dorsally to reduce the subluxed scaphoid. The slip is then sutured to the dorsal edge of the radius. This surgical technique should reduce the scaphoid to its normal position, correct the dissociation between scaphoid and

Fig. 9. (A) Post-traumatic carpal collapse (SLAC wrist) with arthrosis of the radiocarpal and midcarpal joints, DISI position of the lunate. (B) Treatment by midcarpal fusion; note the restored lunate.

lunate, and maintain the correction by reconstruction of a strong STT ligament. The first clinical reports are promising for dynamic as well as for static patterns in the chronic stage.

All soft-tissue procedures claim better postoperative wrist ROM than is often afforded by intercarpal fusion. However, those patients with fixed static deformity by capsular contracture, where significant forces are required for reduction, are preferably treated by bony stabilization with an intercarpal fusion. STT fusion has been proven in several reports to be a clinical procedure where wrist mobility is reduced between 20 % and 50 % compared with the contralateral side (30, 32). Alternatively, SC (scaphoid–capitate) fusion might be used (24).

SLAC wrist

In cases of arthrotic changes with carpal collapse (SLAC wrist), salvage procedures are needed (15). We regard four-corner fusion as the preferred treatment. In contrast to proximal row carpectomy, it can be used when radiocarpal and midcarpal joints are compromised (17). The success of this procedure is strongly related to complete excision of the scaphoid and realignment of the carpus by restoring the lunate from its DISI position (Fig. 9). Clinical results demonstrate significant pain relief, improved grip strength and preserved mobility of about 60 degrees ROM in extension/flexion. Nowadays, wrist fusion is only needed in rare cases (19).

Discussion

Conservative treatment of scaphoid fractures still represents a common concept. The reported high success rate in the literature in conjunction with the difficult operative technique seems to confirm this strategy. However, the long time period of cast immobilization and the rate of failed conservative treatment have slowly changed this point of view. Additionally, missed diagnosis by incorrect radiographs plays a major role, especially for those patients who are finally diagnosed in late stages of scaphoid nonunion as carpal collapse (SNAC wrist). Herbert's classification of scaphoid fractures provides the rational basis for a treatment concept according to fracture type. A CT bone scan in the long axis of the scaphoid is the best method of differentiating between stable (nondisplaced) and unstable (displaced or comminuted) fractures, which is difficult to do from plane radiographs owing to the particular three-dimensional anatomy of the scaphoid. To avoid lengthy plaster immobilization and to diminish the risk of nonunion, unstable fractures should be fixed operatively. Headless screws such as the Herbert screw, now available in a cannulated shape, allow the minimally invasive stabilization of the majority of scaphoid fractures of the wrist (27, 28). Severely displaced fractures need the classical open palmar approach. All proximal pole fractures, whether displaced or not, should be treated by open reduction and internal fixation via a dorsal approach. There is no longer any place for conservative treatment of these fractures, because it is associated with a lengthy period of plaster immobilization and an unacceptably high risk of nonunion. The published results confirm the strategy of internal fixation for acute unstable scaphoid fractures. *Inoue* and *Shionoya* (13) and *Haddad* and *Goddard* (9) reported union rates of up to 100 % without cast immobilization, which closely resembles our findings. With special respect to the demands of professional athletes, *Rettig* and *Kollias* (25) reported a rapid return to sports after internal fixation of unstable fractures.

Injuries of the scapholunate ligament should be met with a high degree of suspicion. Arthroscopy should be performed if there is any doubt. This is particularly important as true healing can only be expected in cases of early diagnosis and adequate treatment by anatomical reduction and lengthy immobilization for about 8 weeks. The treatment of chronic injuries is more controversial, as real reconstruction of the scapholunate ligament is not possible owing to the special anatomical configuration. A major point is to regard the scapholunate ligament rupture as a combination of the SLIL itself and parts of the extrinsic ligaments. For this reason, a stand-alone procedure at the SLIL usually fails in chronic stages. With a combination of bone–ligament–bone autograft and dorsal capsulodesis, a soft-tissue procedure is available with promising results. However, long-term experience proving the prevention or significant delay of degenerative arthrotic changes needs to be awaited; to date, the repairs and capsuloplasties that claim success are all dorsal and do not include effective repair of the volar part of the SLIL. Alternatively, reconstruction of the STT ligaments as proposed by *Brunelli* and *Brunelli* might be used. The ideal procedure of ligament reconstruction in the chronic stage does not yet exist.

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