Diplomarbeit

Evaluation of scaphoid fractures after treatment with angular stable plate osteosynthesis

Results after treatment of scaphoid fractures using
"Medartis® 1.5 TriLock scaphoid plate"

eingereicht von

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Graz, am 4. Mai 2021 *Balthasar Johannes Langegger eh.*

Danksagung

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Glossary and abbreviations

CCS	Cannulated Compression Screw
CL angle	Capitolunate angle
CT	Computed tomogram/Computed tomography
DASH	Disabilities of the Arm, Shoulder and Hand
DISI	Dorsal Intercalated Segment Instability
F	Female
FCR	Flexor Carpi Radialis
H/L ratio	Height to Length ratio
HCS	Headless Compression Screw
HD	Humpback Deformity
ICD-10	International Statistical Classification of Diseases and Related Health Conditions
IMI	Institute for Medical Informatics, Statistics and Documentation
LKH	Landeskrankenhaus – State Hospital
M	Male
M/F	Male or Female
MEX	Metal Removal
MHQ	Michigan Hand Questionaire
Mini-HCS	Mini Headless Compression Screw
MR	Matti Russe
n	Sample size
NRS	Numeric Rating Scale
NVBG	Non Vascularized Bone Graft
openMEDOCS	Styrian Medical-Nursing Documentation and Communication Network
PA	Pseudarthrosis
PACS	Picture Archiving and Communication System
Patient-ID	Patient Identification number
PCS	Pain Catastrophizing Scale
POA	Postoperative Arthritis
PRWE	Patient-Rated Wrist Evaluation
RedCap®	Research Electronic Data Capture

RF	Recent Fracture
ROM	Range of Motion
RR	Red/Red zone
RW	Red/White zone
SD	Standard Deviation
SNAC	Scaphoid Nonunion Advanced Collapse
SNU	Scaphoid Nonunion
SOP	Standard Operating Procedure
Study-ID	Study Identification number
VBG	Vascularized Bone Graft
WW	White/White zone

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Zusammenfassung

Einleitung: Neben der konservativen Behandlung stehen dem HandchirurgInnen bei rezenten Kahnbeinfrakturen mehrere chirurgische Optionen zur Verfügung, wie z. B. eine Headless compression screw (HCS) oder eine Plattenosteosynthese, jeweils mit oder ohne zusätzliche Knochentransplantation. Kahnbein-Pseudarthrosen (Nonunion, die mindestens 6 Monate nach der Verletzung bestehen bleibt) erfordern eine chirurgische Behandlung. Seit 2016 steht an der Universitätsklinik für Orthopädie und Traumatologie in Graz die "medartis® 1,5 TriLockS-caphoid-Platte" für die Versorgung von Kahnbeinfrakturen zur Verfügung. Daher haben wir in dieser Studie das radiologische und funktionelle Outcome sowie standardisierte PatientInnen-Selbsteinschätzungs-Scores für alle PatientInnen mit Kahnbeinfrakturen nach operativer Osteosynthese seit März 2014 ausgewertet.

Material und Methoden: Die Studie umfasste 13 chirurgisch behandelte PatientInnen mit Kahnbeinfrakturen zwischen März 2014 und März 2019, 11 Männer und 2 Frauen mit einem Durchschnittsalter von 39 Jahren (22-66 Jahre). Davon waren 7 rezente Frakturen und 6 Pseudarthrosen. Alle rezenten Frakturen wurden durch HCS stabilisiert, eine mit zusätzlichem Knochentransplantat. 2 Pseudarthrosen wurden durch HCS und Knochentransplantation stabilisiert. Die restlichen 4 Pseudarthrosen wurden mit 4 Platten und Knochentransplantation behandelt.

Bei allen 13 PatientInnen wurde ein CT-Scan des Handgelenks angefertigt und radiologisch nachgeprüft, ob eine Humpback-Deformität, eine Union der Frakturteile, eine postoperative Arthrose, eine DISI-Deformität (dorsal intercalated segment instability) und ein SNAC-wrist (scaphoid nonunion advanced collapse) vorlagen. Die funktionellen Ergebnisse umfassten den Bewegungsumfang (ROM), die Griffstärke, den Schmerz nach der numerischen Ratingskala (NRS) und den Mayo- und Krimmer-Score. Für die Selbstbeurteilung der PatientInnen erhoben wir verschiedene standardisierte Scores wie die Pain-Catastrophizing-Scale (PCS), den DASH-Score (Disabilities of the Arm, Shoulder and Hand), den PRWE-Score (Patient-Rated Wrist Evaluation) und den MHQ (Michigan Hand Questionaire).

Ergebnisse: Alle Frakturen wiesen auf den letzten CT-Scans Teile vereinigter Frakturfragmente auf. Die mittlere Union lag bei 75% (46-100%), bei einer mittleren Nachbeobachtungszeit von 375 (47-1314 Tagen) Tagen. 8 können als vereinigt (75-100%), 3 als teilweise vereinigt (50-75%) und zwei als nur zaghaft vereinigt (≤50%) eingestuft werden. Die funktionellen Scores, z.B. der Krimmer-Score mit durchschnittlich 79 Punkten (40-100 Punkte) zeigten gute Ergebnisse. Der mittlere Dash-Score war mit 9 Punkten (0-27 Punkte) ausgezeichnet.

Schlussfolgerungen: Die Behandlung von rezenten Kahnbeinfrakturen und Kahnbeinpseudarthrosen an der Universitätsklinik Graz hat in diesem 5-Jahres-Zeitraum zu guten bis mäßigen Ergebnissen geführt. Für eine aussagekräftige Auswertung müsste jedoch eine prospektive Studie mit mehr PatientInnen und einheitlichen Follow-Up-Intervallen geplant werden.

Schlüsselwörter: Kahnbein, Scaphoid, Headless Compression Screw, Platte, Nonunion, Pseudarthrose, medartis®

Abstract

Introduction: Next to conservative treatment hand surgeons have several surgical options for recent scaphoid fractures such as a Headless Compression Screw (HCS) or plate osteosynthesis, each with or without additional bone grafting. Scaphoid pseudarthroses (nonunion persisting for at least 6 months after injury) require surgical treatment. Since 2016 the “medartis® 1.5 TriLockScaphoid Plate" has been available for the treatment of scaphoid fractures at the Department of Orthopedics and Traumatology at the University Hospital Graz. Therefore, in this study, we evaluated radiological and functional outcome and standardized patient self-assessment scores for all patients with scaphoid fractures after surgical osteosynthesis since March 2014.

Materials and methods: The study included 13 surgically treated patients with scaphoid fractures between March 2014 and March 2019, 11 men and 2 women of mean age 39 years (22-66 years). Of these, 7 were recent fractures and 6 were pseudarthroses. All recent fractures were stabilized by HCS, one with additional bone grafting. 2 pseudarthroses were stabilized by HCS and bone grafting. The remaining 4 pseudarthroses were treated with plate osteosynthesis and bone grafting.

All 13 patients had a CT-scan of the wrist and were radiologically re-evaluated for humpback deformity, union of the fracture parts, postoperative osteoarthritis, dorsal intercalated segment instability (DISI) and scaphoid nonunion advanced collapse (SNAC). The functional outcome included the range of motion (ROM), the grip strength, the pain according to the numeric rating scale (NRS) and the Mayo and Krimmer scores. For the patients self-assessment we collected several standardized scores such as pain catastrophizing scale (PCS), disabilities of the arm, shoulder and hand (DASH), patient-rated wrist evaluation score (PRWE) and the Michigan hand questionaire (MHQ).

Results: All fractures had parts of united fracture fragments, mean union 75% (46-100%), on the final CT scans with a mean follow-up of 375 (47-1314 days) days. 8 can be classified as united (75-100%), 3 as partially united (50-75%) and two only as tenuously united (≤50%). The functional scores, e.g. the Krimmer score with mean 79 points (40-100 points) showed good results. The mean dash score was excellent with 9 points (0-27 points).

Conclusions: The treatment of recent scaphoid fractures and scaphoid pseudarthroses at the University Hospital of Graz has resulted in good to moderate outcomes over this 5-year period. However, for a meaningful evaluation, a prospective study with more patients and unified follow-up intervals would have to be planned.

Keywords: Scaphoid, Headless compression screw, Plate, Nonunion, Pseudarthrosis, medartis®

1 Introduction

At the Department of Orthopaedics and Traumatology at the University Hospital Graz, scaphoid fractures have been treated using the "medartis® 1.5 TriLock Scaphoid Plate" since 2016. It was interesting for the clinic whether this new surgical method leads to good results compared to the alternative osteosynthesis method using headless compression screw (HCS). Therefore, a retrospective case work-up with follow-up study was performed to control the results.

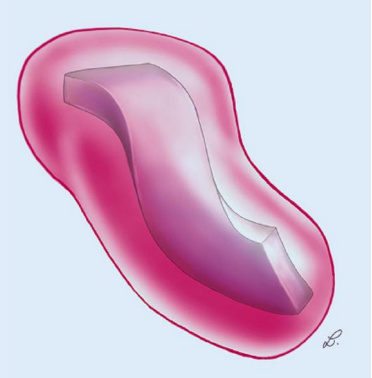
The results are important because scaphoid fractures can lead to non-union of the fracture, to pseudoarthrosis and thus to considerable limitations in the wrist. In general, there are still rather few clinical studies on "medartis® 1.5 TriLockScaphoid Plate" with low case numbers.

The major limitations of this study include the low number of cases and the non-standardized follow-up intervals because, unfortunately, the study was not planned prospectively.

In this thesis, the basics of the scaphoid (anatomical features and biomechanics) and scaphoid fractures (diagnostic and therapeutic procedures) are described as an introduction. This is followed by the clinical study with description of the materials and methods, presentation of the results and discussion of the results and their limitations.

1.1 Anatomical specifics of the scaphoid and complications

The scaphoid is a bone on the radial side of the proximal carpal row. It is slightly S-shaped twisted and curved and can be divided into 3 different sections - the proximal part, the middle part and the distal part (1).



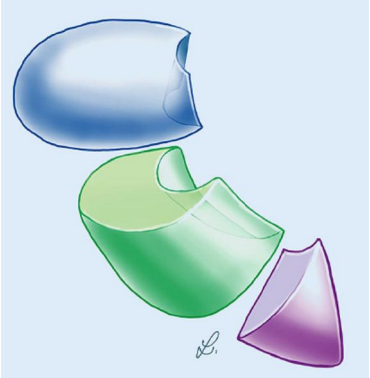


Figure 1 Scaphoid shape (1)

Figure 2 Scaphoid sections (1)

In the case of a fracture of the scaphoid, problems may occur as a result of some anatomical specifics. Due to the retrograde blood supply in the scaphoid from distal to proximal, fracture of the proximal fragment can lead to reduced perfusion of this fragment. Furthermore, the scaphoid is mostly covered by articular cartilage and only small areas are covered by periosteum. Thus, periosteal bone healing is absent when a fracture occurs (2).

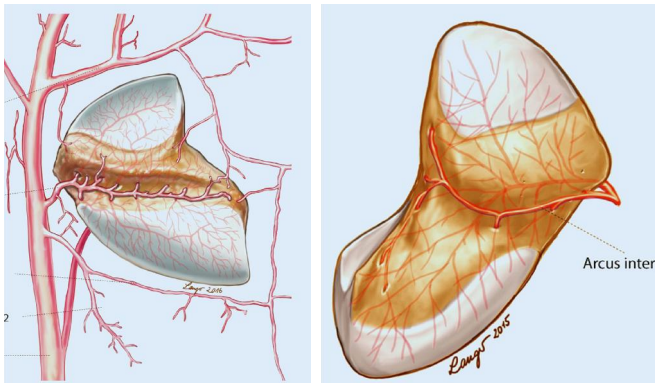


Figure 3 Retrograde blood supply in the scaphoid (1)

The shape of the scaphoid, which is curved in three planes, causes a rotating flexion-extension motion (See chapter 1.2 Biomechanics) of the scaphoid during wrist

movements. In fractures in the longitudinal axis of the forearm, especially fractures of the proximal pole, the fragments are exposed to a significant rotational load. In fractures in the middle part of the scaphoid, the distal fragment may flex in palmar direction and form a humpback deformity (See chapter 2.2.3.1 Humpback deformity) (2).

Because of these anatomical peculiarities, an unhealed scaphoid fracture and the development of pseudarthrosis can occur rapidly (2). A nonunited scaphoid fracture (pseudarthrosis) can lead to severe late complications such as SNAC-wrist (See chapter 2.2.3.5 Scaphoid nonunion advanced collapse (SNAC wrist)) (3).

1.2 Biomechanics

The scaphoid, lunate and triquetrum form a mechanical unit through their connections with interosseous ligaments. If this continuity is interrupted by a fracture, it leads to instability (4).

The scapoid itself, when moving the wrist from the neutral position to the flexion position, makes an average movement of 58° in flexion, but also 18° ulnar deviation and 10° pronation. During extension from neutral position it makes 50° of extention, 4° of radial deviation and 6° of supination. Thus, in the flexion-extension movement, the scaphoid rotates (1).

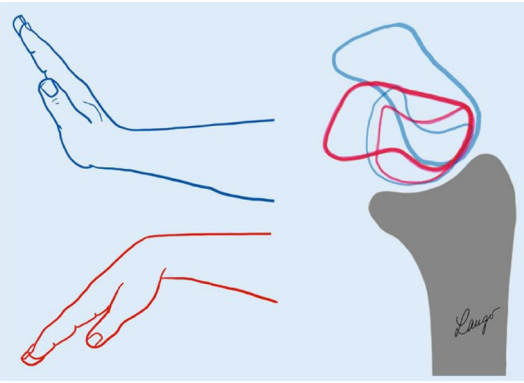


Figure 4 Scaphoid in extension and flexion (1)

In radial deviation, the movement is mainly in the mediocarpal joint. The scaphoid must deviate palmar for the trapezoid and trapezium. It thus makes only 5° of radial deviation, but a 13° palmarflection. Ulnar deviation results in an avarage 18° uprighting of the scaphoid (which is important in x-rays), an ulnar deviation of 16° and a pronation of 11° (1).

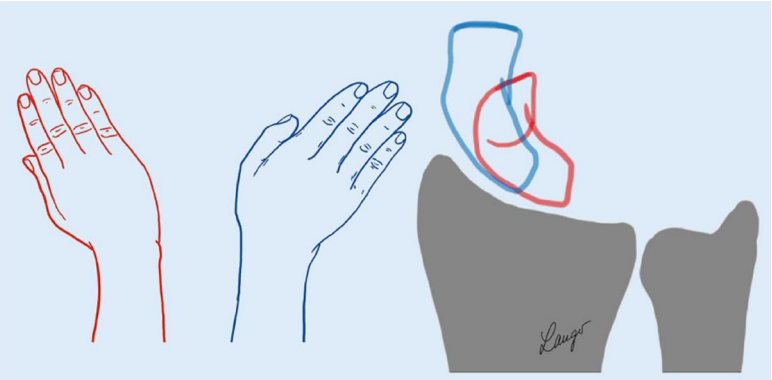


Figure 5 Scaphoid in radial and ulnar deviation Diagnostics (1)

1.2.1 Anamnesis

A differentiation must be made between recent fractures and pseudarthroses. Pseudarthrosis is defined as a nonunion that persists at least 6 months after injury (5).

Causes for delayed start of therapy or development of pseudarthrosis (6):

- Patients have misjudged the injury (no visit to the doctor, no diagnostics)
- the doctor did not recognize the fracture (diagnosis of distortion, insufficient immobilization)
- insufficient radiological diagnostics (not adequately treated)
- despite recognized fracture immobilization period too short (4-6 weeks)
- the detected fracture was unstable (despite instability no indication for surgery was given)

Therefore it is important: Correct assessment of the accident by the patient. And the medical doctor must do everything to exclude a fracture (6).

1.2.1.1 Accident pattern and pathomechanism

The most common mechanism for a scaphoid fracture is a fall onto the hyperextended hand. The distal scaphoid pole is fixed - by ligaments to the trapezium as well as by contact to the ground. The edge of the radius acts dorsally like a chisel and palmar the radioscaphoid ligaments pull the proximal pole to the dorsal direction (1).

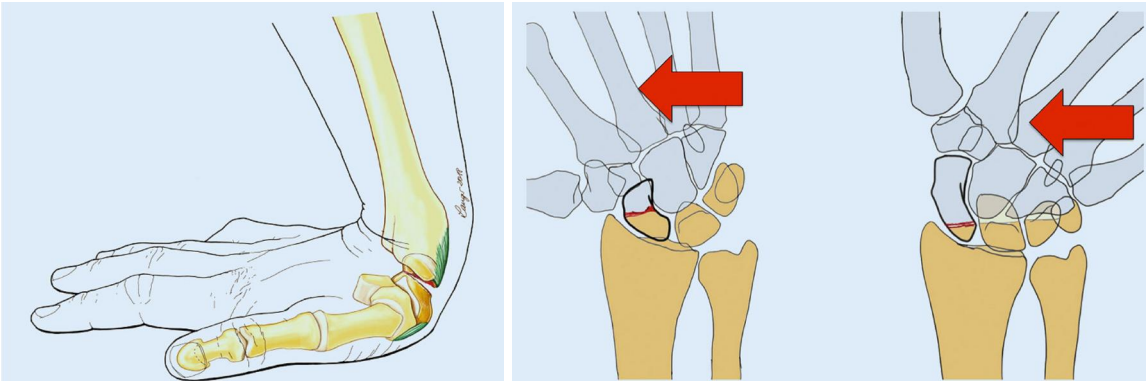


Figure 6 Accident pattern and pathomechanism (1)

Figure 7 Position of the wrist and fracture type (1)

Different fracture types occur depending on the force applied and the position of the wrist during the impact. The more radial deviation, the further distal the fracture line is. If the lateral forces predominate, transverse fractures are more likely to occur. Sagittal fractures can occur if axial forces are involved (1).

1.2.2 Clinical diagnostics

Pressure pain in the tabatière is the leading symptom of a scaphoid fracture. In addition, a compression pain can be found in the area of the 1st and 2nd finger. A primary symptom may be visible swelling or painful restriction of movement due to wrist effusion (3).

1.2.3 Radiological diagnostics

1.2.3.1 X-rays

In the dorsopalmar and lateral images of conventional radiographs, the scaphoid is often incompletely visible. Therefore, an additional image is taken in the "Stecher position": In fist closure and ulnar deviation, the scaphoid can be shown freely in its entire length. These three X-rays form the basis for initial diagnosis and follow-up examinations. CT is the gold standard for detecting a fracture and is superior to the classic scaphoid quartet series. It should be taken at an early stage following the 3 standard images (7).

1.2.3.2 Computed tomography

In case of diagnostic uncertainty (clinical suspicion but negative radiographs), for classification of a confirmed fracture (See chapter 1.3.2 Modified classification according to Herbert and Krimmer in CTs) and for therapy planning, a CT with a slice thickness of 1 mm, parallel to the longitudinal axis of the scaphoid should be obtained in addition (7).

According to the paper of Schmidle (8), a CT can also be used to classify scaphoid pseudarthroses (See chapter 1.3.3 Classification of scaphoid pseudarthroses in CTs), which has an influence on the choice of the bone graft used in surgery.

1.2.3.3 Magnetic resonance imaging

Magnetic resonance imaging is also suitable for fracture detection, but has some limitations compared with CT. Therefore, it should only be used for special questions (e.g.: additional ligament injuries, etc.) and it can only be interpreted correctly if the age of the trauma is known (7).

1.2.4 Differential diagnosis

As differential diagnoses, the distal radius fracture, wrist distortion, other carpal fractures, as well as capsule-ligament injuries of the intrinsic and extrinsic ligaments of the wrist must be considered (9).

1.3 Fracture classification

1.3.1 Fracture classification according to Herbert in X-rays

According to Herbert and Fisher (10), the fractures are classified into stable acute fractures (type A), unstable acute fractures (type B), delayed unions (type C) and pseudarthroses (type D) (11).

Fracture classification according to Herbert and Fischer	
Type A	**stable acute fractures**
A1	Fracture of tubercle
A2	Incomplete fracture trought waist
Type B	**Unstable acute fractures**
B1	Distal oblique fracture
B2	Complete fracture of waist
B3	Proximal pole fracture
B4	Trans-scaphoid-perilunate fracture
Type C	**Delayed union**
Type D	**Nonunion**
D1	Fribrous union
D2	Pseudarthrosis

Table 1 Fracture classification according to Herbert and Fischer (11)

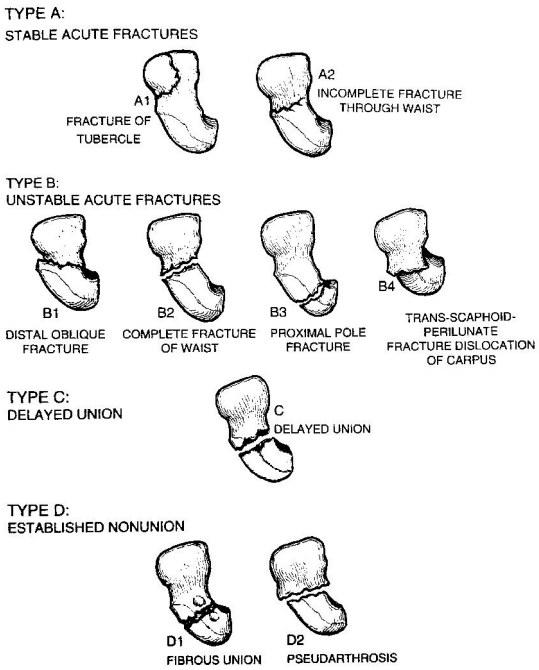


Figure 8 Fracture classification according to Herbert and Fischer (11)

1.3.2 Modified classification according to Herbert and Krimmer in CTs

For the classification of recent scaphoid fractures and for the development of a therapy concept, a CT should be performed, because localization, stability and dislocation can be assessed better. As in the Herbert and Fischer classification, a distinction is made between recent stable fractures and recent unstable fractures, since this affects the therapy. Stable fractures (type A) can be treated conservatively or surgically (type A2).Unstable fractures (type B) have to be stabilized surgically (7).

Fracture classification according to Krimmer, Schmitt and Herbert	
Type A	**Stable acute fractures**
A1	Fracture of tubercle
A2	Undislocated crack fractures with transverse course in the middle or distal third
Type B	**Unstable acute fractures**
B1	Oblique fractures
B2	Dislocated or gaping fractures
B3	Fractures of the proximal third
B4	Transscaphoid perilunate dislocation fracture

Table 2 Fracture classification according to Krimmer, Schmitt and Herbert (7)

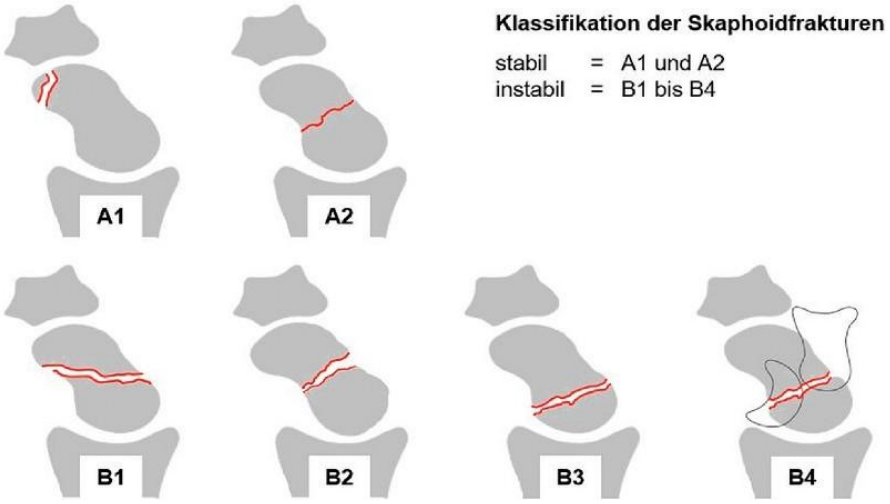


Figure 9 Fracture classification according to Krimmer, Schmitt and Herbert (12)

1.3.3 Classification of scaphoid pseudarthroses in CTs

In 2018, Schmidle (8) proposed a classification for scaphoid pseudarthroses on CTs. 4 types are differentiated according to trabecular structure, sclerosis and fragmentation of the proximal fragment. Depending on the location of the fracture line, further differentiation can be made into white/white zone (WW), red/white zone (RW) and red/red zone (RR). This classification should allow an evaluation of the bone healing capacity on CT and facilitate the selection of the appropriate bone graft. However, larger study populations are still needed.

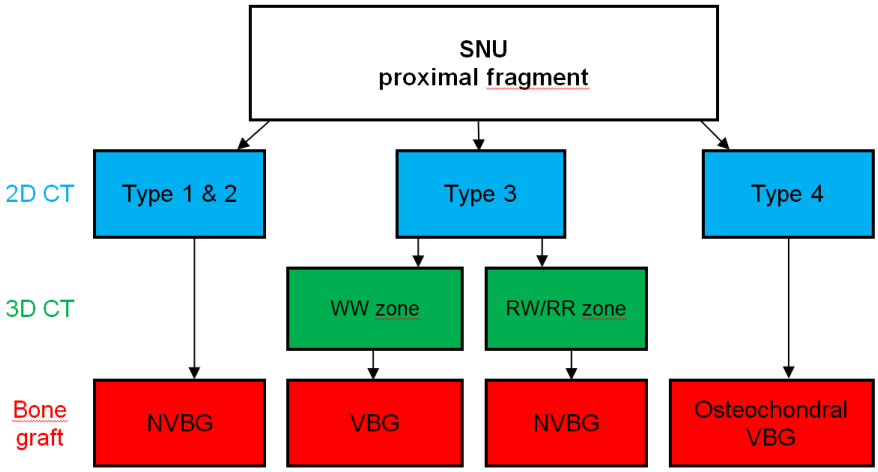


Figure 10 Treatment algorithm for bone graft selection (Own illustration acc. (8))
2D-CT SNU types (blue), 3D-CT fracture location (green), and recommended bone graft (red)

1.4 Treatment options

Depending on the fracture type, a scaphoid fracture can be treated surgically or non-surgically. According to the S3 guideline (2), a fracture classification and therapy decision should be made after a CT has been performed.

The classification should be based on the Herbert classification modified by Krimmer for CTs and should contribute to the therapy decision. Unstable fractures (B1, B2, B3, B4) should be treated surgically. Stable fractures (A1, A2) can be treated conservatively. Stable fractures of the middle third (A2) can be treated surgically to shorten the immobilization period (2). Pseudarthroses must be treated surgically, otherwise they result in posttraumatic osteoarthritis in 75-97% after 5 years and in 100% after 10 years (8).

1.4.1 Conservative treatment

Only stable fractures (A1, A2) are recommended for conservative therapy (9). Immobilize with a forearm cast including the basic joint of the thumb (See figure 11) for 6 weeks, followed by X-ray control. Depending on the radiological progress, immobilize for another 2-4 weeks. If uncertain, repeat CT scan and change treatment procedure if necessary (13). Stable fractures of the middle third (A2) can be treated surgically to shorten the immobilization period (2).

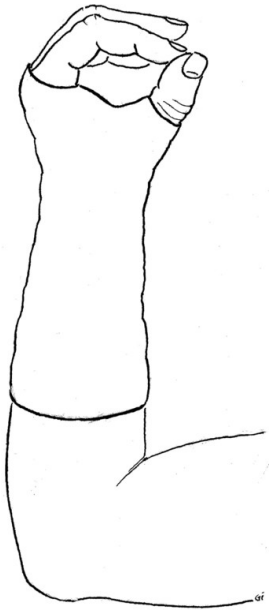


Figure 11 Forearm cast including the basic joint of the thumb (13)

1.4.2 Surgical treatment

There are different surgical techniques available, including screws and plates (See chapters 1.4.2.3 Headless Compression Screw (HCS) and 1.4.2.4 medartis® Tri-Lock 1.5 Scaphoid Plate) each with or without bone graft (See chapter 1.4.2.5 Autologous bone chip – Matti-Russe) (8).

1.4.2.1 Indication for surgery

Recent unstable fractures (B1, B2, B3, B4) should be treated and stable fractures of the middle third (A2) can be treated surgically (2). Pseudarthroses need to be treated surgically to prevent posttraumatic osteoarthrosis (8).

1.4.2.2 Aim of the surgical treatment

According to the paper of Slade (14), the aim of surgical treatment is to restore the anatomy, correct the deformity, provide stability, viability and vascularity. Achieving union, relieving the symptoms, improving the range of motion and preventing the progression of osteoarthrosis are mentioned in Paper Quadlbauer as further goals of surgical treatment (15).

1.4.2.3 Headless Compression Screw (HCS)

The first generation of the headless compression screw (HCS) was the Herbert screw. Compression of the fracture fragments can be achieved by 2 threads with different pitches and different widths (See figure 12). Since it is headless, it can be completely countersunk into the bone and so irritation can be avoided. Another advantage is the small size of the screw (10).

The first generation of the headless compression screw (HCS) was the Herbert screw. Now various forms of the Headless Compression Screw (HCS) are now available (See figure 13): Headless Compression Screw (HCS), Cannulated Compression Screw (CCS), and Mini Headless Compression Screw (Mini-HCS) (7).

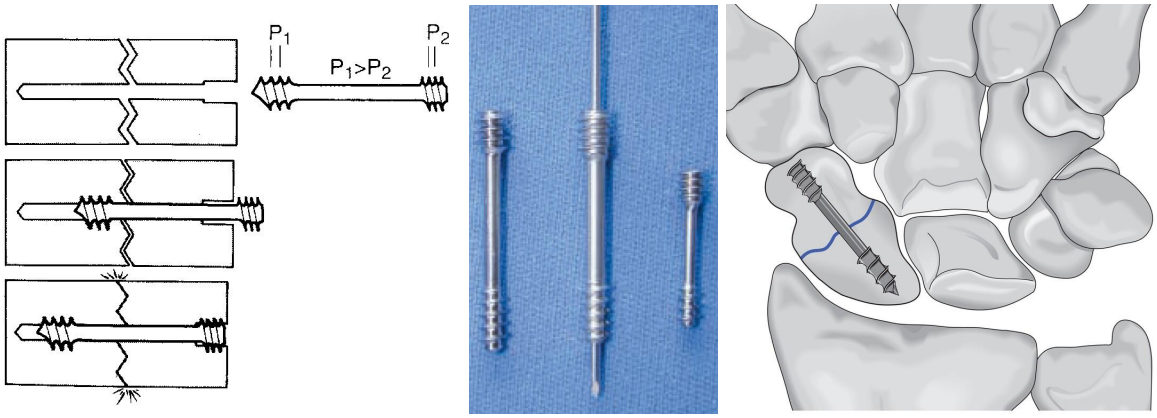


Figure 12 Compression principle of the HCS (11)

Figure 13 Compression screw types: HCS, CCS, Mini-HCS (7)

Figure 14 Position of the HCS in the scaphoid (3)

The approach is selected depending on the fracture localization. Fractures of the middle and distal thirds are treated either openly or minimally invasively from the palmar side. Osteosynthesis of fractures in the proximal third is performed from the dorsal side (7).

Surgical techniques:

Palmar approach:

The palmar skin incision is made radial to the flexor carpi radialis (FCR) tendon and bends distally radial on the linea rascetae in an angle of 45 °. The joint capsule is opened so that the palmar branch of the radial artery is preserved. A targeting device (jig) is used to reposition and fix the scaphoid, and the screw is inserted. After osteosynthesis, the wrist capsule must be closed again (9).

Dorsal approach

In the dorsal approach, the 2nd - 4th extensor tendon compartment is opened while preserving the retinaculum extensorum. The wrist capsule is also opened and the fracture can be reduced under visual control. Here, the Mini-HCS can be used for osteosynthesis of the often small pole fragments. Before the surgery is completed, the capsule and the extensor retinaculum must be reconstructed (9).

Percutaneous osteosynthesis:

Minimally invasive percutaneous osteosynthesis with cannulated CCS can be performed for transverse mid-third fractures without dislocation. A guide wire is inserted through a palmar stitch incision at the level of the scaphotrapezoidal joint and checked using image intensification. If correctly positioned, the CCS can now be inserted via this wire (9).

In all these procedures, the correct, completely intraosseous screw position must be checked during the surgery using an image converter. Protruding screw components can have fatal consequences for the adjacent joint surfaces (9).

Postoperative procedure:

The advantage of surgical treatment over conservative therapy is the possibility of early mobilization. Immobilization with a palmar splint for 2 weeks is sufficient for fractures in the distal and middle thirds. Proximal pole fractures are immobilized for 3 - 4 weeks. Sports are prohibited for 3 months. Radiographic examinations are performed initially at 2-week intervals and after 6 weeks at 4-week intervals to monitor healing (9).

1.4.2.4 medartis® TriLock 1.5 Scaphoid Plate

The medartis® TriLock 1.5 Scaphoid Plate is an anatomically shaped plate that is positioned on the palmar side of the scaphoid. The plate can be fixed at a stable angle with up to 3 TriLock screws on each side of the fracture. This allows bridging of the unstable zone caused by the fracture (internal fixator principle) (16).

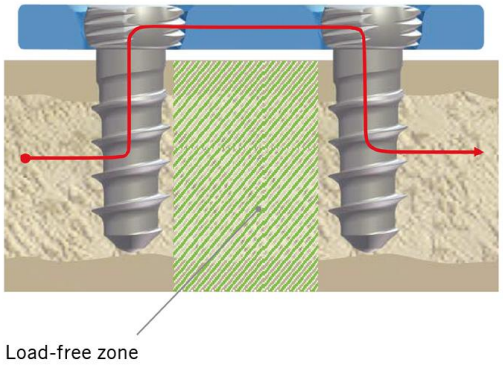


Figure 15 medartis® TriLock 1.5 Scaphoid Plate (16)

(With kind permission © **Medartis AG**. All rights reserved)

Figure 16 Internal fixator principle (16)

(With kind permission © **Medartis AG**. All rights reserved)

Advantages/disadvantages of medartis® TriLock 1.5 Scaphoid Plate:

Advantages:

Angle stable implant with TriLock locking of the screw in the plate

Low profile plate (0.8 mm)

Anatomically pre-shaped plate for correction of humpback deformity

Angle of locking of the screw freely selectable (±15°)

Three screw holes each for the distal and proximal fragment

Biomechanically higher rotational stability than a HCS

Prevents protrusion of the attached cancellous bone

Disadvantages:

Plate removal necessary after healing

Arrosion of the palmar radial joint lip possible

Only one plate size currently available (5)

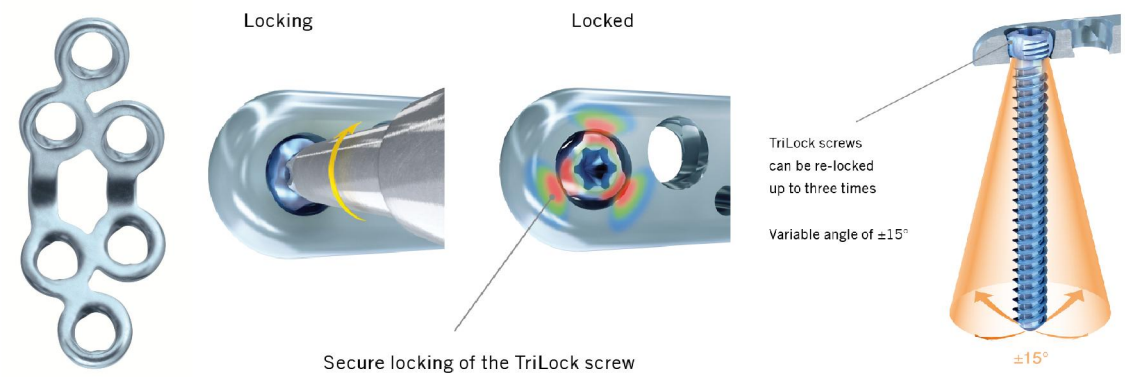


Figure 17 medartis® TriLock 1.5 Scaphoid Plate (16)

Figure 18 Locking of the TriLock screw (16)

Figure 19 Freely selectable locking angle of the screw (±15°) (16)

Indications of the medartis® TriLock 1.5 Scaphoid Plate:

- Scaphoid pseudarthrosis with flexion-side defect and humpback deformity
- Type D2 according to Herbert with flexor resorption cavity, humpback deformity or cyst formation in the pseudarthrosis gap
- Second/third intervention after already failed reconstruction attempt
- Primary stabilization of scaphoid fractures with large comminuted zone (5)

Surgical technique:

The surgical technique of the medartis® TriLock 1.5 Scaphoid Plate is well described in the paper of Quadlbauer (5). The palmar approach is made through an incision over the flexor carpi radialis (FCR) tendon, which is extended distally in a radial direction to the tuberculum ossis scaphoidei. A deeper incision is made between the FCR tendon and the superficial palmar branch of the radial artery, the radioscaphocapitatum ligament is longitudinally split, and the scaphoid can be seen. Additional injury to the ligaments and lateral and dorsal vessels should be avoided.

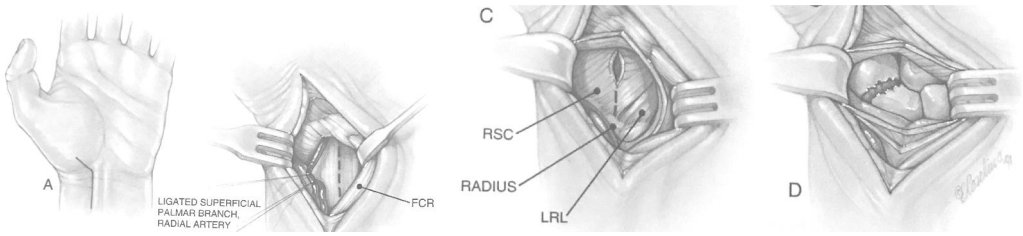


Figure 20 Palmar approach (11)

Under image intensifier control, the lunate is straightened from DISI deformity (See chapter 2.2.3.5 Dorsal intercalated Segment Instability (DISI deformity)) and temporarily fixed to the radius with a drill wire. This helps in correcting the humpback deformity (See chapter 2.2.3.1 Humpback deformity).

To straighten the scaphoid, an additional drill wire can be placed in the proximal and distal fragments as "joysticks". After intraoperative X-ray control of the humpback deformity correction, two drill wires are inserted in the longitudinal axis of the scaphoid for temporal fixation of the reduction result (5).

At the pseudarthrosis, the sclerosis is completely removed and a bone window is formed at the palmar side of the scaphoid. The pseudarthrosis cavity is now filled with harvested cancellous bone (See chapter 1.4.2.5 Autologous bone chip – Matti-Russe) and then compressed. Under image converter control, the medartis® TriLock 1.5 Scaphoid Plate is now precisely aligned and, after predrilling and length measurement, fixed with variable angle-stable screws (5).

Postoperative procedure

After surgery, the patient is immobilized for 8 weeks in a forearm cast with inclusion of the metacarpophalangeal joint of the thumb. No heavy manual activities or high-risk sports should be performed for up to 12 weeks postoperatively. After 8 weeks postoperatively X-ray control (a.-p., lateral, Stecher) and start of hand therapy. After 12 weeks CT control and start of increasing weight load. Plate removal after 6 months if bony healing is assured. CT control after one year postoperatively recommended (5).

1.4.2.5 Autologous corticocancellous graft - Matti-Russe

For the therapy of scaphoid pseudoarthrosis, a surgical procedure is required. The greatest advancement in this treatment is the Matti Russe technique. All sclerotic and avital parts of the bone are removed and the resulting defect is filled with corticocancellous graft from the iliac crest. The Matti Russe technique is now combined with HCS or plate, as this can reduce the immobilization period to 4-6 weeks (6).

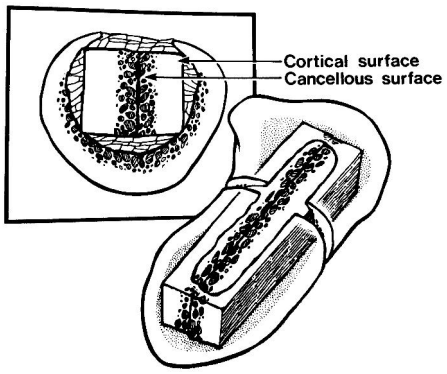


Figure 21 Conventional Matti Russe technique (11)

1.4.2.6 Future prospects: Shark Screw®

The Shark Screw® is a fine-thread screw made of human bone matrix (allogeneic bone graft). It can be used as an osteosynthesis in fractures and pseudarthroses without the use of inorganic materials (e.g. metal) and therefore it does not require metal removal. The fracture is fixed with K-wires. After predrilling, the Shark Screw® is inserted to the desired depth and the excess screw portion is shortened to bone level. According to the product information, the screw is supposed to be overgrown by the body's own cells and tissue after only a few weeks (17).

Figure 22 Shark Screw® (17)

1.5 Aim of the study

Since 2016 the “medartis® 1.5 TriLockScaphoid Plate" has been available for the treatment of scaphoid fractures at the Department of Orthopedics and Traumatology at the University Hospital Graz as an additional osteosynthesis procedure besides the Headless Compression Screw (HCS).

For the clinic, the results of both osteosynthesis procedures are of interest, since scaphoid fractures - as already described above under chapter 1.1 Anatomical specifics of the scaphoid and complications - can lead to delayed union and to pseudoarthrosis (nonunion) and subsequently to arthrosis in the wrist.

Therefore, in this study, we evaluated the radiological and functional outcome as well as standardized patient self-assessment scores (See chapter 2 Materials and methods) for all patients with scaphoid fractures after surgical osteosynthesis in a 5 year period from March 2014 to March 2019.

2 Materials and methods

2.1 Study design

This is a retrospective case workup and follow-up study to evaluate the outcome. An openMedocs search (See chapter 2.1.1 Data Acquisitation) for existing patients was performed. Radiological data could be assessed and measured in the “Picture Archiving and Communication System” (PACS).
Patients were invited to the clinic for a clinical assessment and to complete standardized patients self-assessment questionnaires (See chapter 2.2.5 Patient’s self-assessment). They were initially contacted by mail. If there was no response to the letter within 2 weeks, the patients were also contacted by telephone. Corresponding templates (See appendix) for the telephone conversation were created. If patients were interested in participating, a written informed consent (Created according to the template of Univ. FA Priv.-Doz. Mag. DDr. Fischerauer. - See Appendix) was obtained and a patient ID was created on an encrypted data cloud (RedCap® - Research Electronic Data Capture) licensed for the Medical University of Graz.

2.1.1 Data acquisition

The retrospective patient population survey was from an openMEDOCS evaluation performed by the Institute of Medical Informatics, Statistics, and Documentation (IMI). Special thanks at this point to Univ.-Prof. Dipl.-Ing. Dr.techn. Andrea Berghold.

Surgery reports from the Department of Orthopaedics and Traumatology were searched for the following search criteria from March 2014 to March 2019:

Under the item "diagnosis", the ICD-10 codes "S62.0*" (fracture of the scaphoid bone of the hand, including: navicular bone) and "S62.1*" (fracture of one or more other carpal bones), and a free-text search for " Handwurzelfraktur” (carpal fracture), "Kahnbeinfraktur” (scaphoid fracture), "Scaphoidfraktur” (scaphoid fracture), and " Navicularefraktur” (navicular fracture). Under "Therapy or Service", a free

text search was performed for “Osteosynthese“ (osteosynthesis), " Verplattung” (plating), "ORIF", "Medartis" and "Schraube” (screw).

Search criteria under "diagnosis":
ICD-10 codes: *S62.0* or S62.0**
Free text: **handwurzel* or *kahnbein* or *s?apho* or *navi?ular* and *fra[kc]**

Search criteria under "therapy or service":
Free text: **osteosynthese* or *verplattung* or *orif* or *medartis* or *schraube**

A second openMEDOCS survey specifically searching for "Matti Russe" found some more patients:

Search criteria under "diagnosis":
Free text: *kahn* or *s[kc]aphoid* or *wurzel* (root) or *S62* or *S61* or *russ[ie]*.

Search criteria under "therapy or service":
Free text: *osteosynthese* (osteosynthesis) or *MD010* or *russe*.

2.1.2 Data storage

Personal data on these patients (patient-ID), by which the patients are directly identifiable (e.g. name, date of birth, address, etc.), could be collected from the openMEDOCS-system and was stored only at the study center (University Hospital Graz). These personal data were converted to pseudonymized (encrypted) personal data records and replaced by an identification number (study-ID) to make them unrecognizable.

The pseudonymized (encrypted) personal data records were collected and stored via the MedUni-licensed and encrypted online portal RedCap®. The code for decryption (study-ID → patient-ID) is strictly separated from the encrypted data sets and is also stored only at the study center. This means that the data can no longer be assigned to the person without the help of additional information and without disproportionate effort.

patient-ID.....personal data
study-ID.....code for pseudonymized (encrypted) data

2.2 Patients and methods

2.2.1 Patients characteristics

All patients of the University Hospital of LKH Graz with confirmed scaphoid fracture and surgical treatment in the 5-year period from the end of March 2014 to the end of March 2019 were included in this study. Ethics approval was obtained from the relevant research ethics committee.

2.2.1.1 Inclusion and exclusion criteria

Inclusion criteria:

- Patient consent
- Age≥ 18 years
- Confirmed scaphoid fracture (radiograph or CT scan).
- Surgical treatment (screw/plate)
- Wrist CT after surgery

Exclusion criteria:

- Current pregnancy in the absence of a CT scan

2.2.1.2 Epidemiological data

The following data were collected from the openMEDOCS system:

Demographic data:

- Age in years
- Gender
- Smoker/Non-smoker
- Dominant hand

Injury-specific data:

- Injured hand
- Age of patient at injury in years
- Period of injury until surgery in days
- Number of surgical interventions

Surgical data:

- Osteosynthesis procedure (plate/screw).
- Matti-Russe
- Metal removal after consolidation or after complications

2.2.2 Fracture classification

2.2.2.1 Herbert classifikation

The fracture classification on CT scans was performed by means of Herbert classification as already described in chapter 1.3 Fracture classification.

2.2.3 Radiological outcome

After appropriate training by a specialist in orthopedics/traumatology, the radiological data was collected by me. Standard CTs already performed according to the SOP of the University Hospital Graz were re-evaluated. These CTs were taken from the PACS (Picture Archiving and Communication System) and could be measured and evaluated there.

Prior to osteosynthesis, the fracture was assessed using the Herbert classification in standard CTs (See chapter 1.3 Fracture classification). After osteosynthesis, radiological outcome was assessed similarly to the Paper of Quadlbauer (2018) (15) with regard to the following criteria: humpback deformity, union of fracture fragments, postoperative osteoarthritis (POA), DISI (Dorsal Intercalated Segment Instability) and SNAC-Wrist (Scaphoid Nonunion Advanced Collapse).

2.2.3.1 Humpback deformity

As described in the paper of Langer (2019) (1), a spiral tension acts on the fracture in the proximal row. The radial section of the proximal carpal row has a tendency to palmar flexion, while the ulnar section has a tendency to dorsal flexion. This causes the scaphoid to flap up dorsally and it may shorten and form a humpback. This is referred to as a humpback deformity.

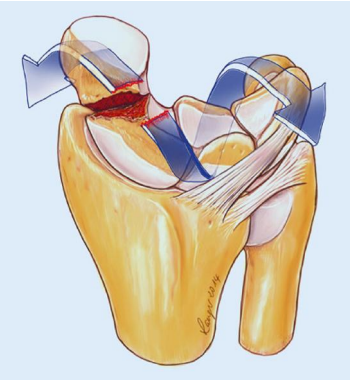


Figure 23 Pathobiomechanics Humpback Deformity (View from dorsal side!) (1)

According to the Paper of Bain 1997 (18), a computed tomogram was made with the wrist held in radial deviation and neutral flection. The middle image between the capitatum and the radial border of the scaphoid was chosen for evaluation. If there was no middle image there, the image closer to the capitate was chosen.

In the longitudinal axis of the scaphoid a baseline was drawn along the palmar aspect of the scaphoid. Based on this line, the length from the most proximal to the most distal part of the scaphoid could be determined. The maximum height of the scaphoid was measured perpendicular to the baseline.

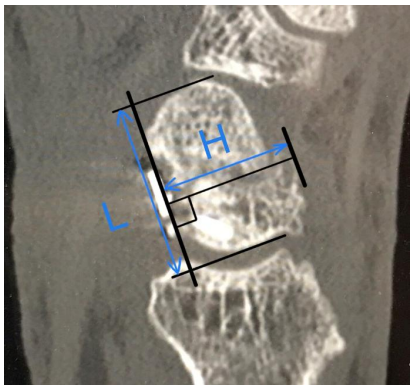


Figure 24 Humpback Deformity: Height/Length ratio (Own illustration acc. (18))

The humpback deformity was calculated from a height to length ratio by dividing the height by the length and expressed as a percentage. A height-to-length (H/L) ratio greater than 0.65 was considered as a malalignment (15).

2.2.3.2 Union of the fracture parts

The union of fracture parts was evaluated in the CTs according to the paper of Grewal (19). To quantify the mean percentage of the union, each single sagittal section containing the fracture line was equally analyzed. The length of the united bone along the fracture line was measured and divided by the total width at the fracture line, giving a percentage for each slice.

$$\textbf{Percentage of union} = \frac{\text{Sum of the total length of united scaphoid (mm)}}{\text{Sum of the total length of fracture (mm)}} \times 100\%$$

Then these percentages were averaged to get a value for the overall percentage of the united bone in the fracture. The results were classified into one of three categories: union, partial union or tenuous union (See table 3).

Union of the fracture parts	
75%-100%	United
50%-75%	Partially united
≤50%	Tenuously united

Table 3 Union of the fracture parts (19)

2.2.3.3 Postoperative osteoarthritis

Scaphoid fractures can lead to arthrosis and thus to persistent pain and movement restrictions in the wrist. The degree of arthrosis in the radiocarpal or radioulnar joint was classified from 0 (no arthrosis) to 3 (extensive arthrosis) as described in the paper of Haus (2009) (20). Anterior-posterior and lateral computed tomogram images of the wrist were assessed as shown in Table 4.

Grade	Arthritis Grading System Findings
0	None
1	Slight joint-space narrowing
2	Marked joint-space narrowing, osteophyte formation
3	Bone-on-bone, osteophyte formation, cyst formation

Table 4 Arthritis Grading System Findings (20)

2.2.3.4 Dorsal intercalated segment instability (DISI deformity)

A scapoid fracture or SL-ligament rupture can lead to carpal instability, as the lunate tends to slide out of the carpal bone row to the palmar side and simultaneously rotates in dorsal extension. This malalignment is known as dorsal intercalcated segment instability (DISI) (4).

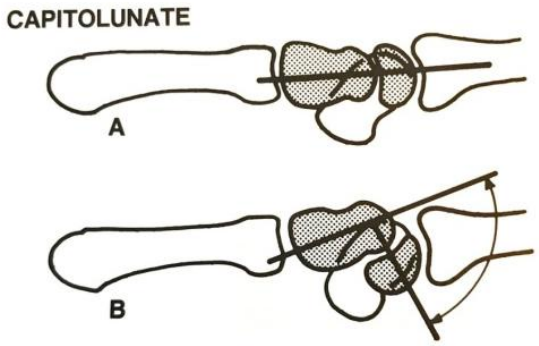


Figure 25 DISI-Deformity: Capitolunate angle (11)

We evaluated the DISI-deformity by the capitolunate (CL) angle in lateral CT scans. This angle is formed by the intersection of the longitudinal axis of the lunate and the capitate (See figure 27) and is normally between 0 to 30 degrees (11). According to the paper of Quadlbauer (2018) (15) we considered an angle greater than 30° as DISI-deformity.

2.2.3.5 Scaphoid Nonunion Advanced Collapse (SNAC wrist)

As described in the paper of Krimmer (2000) (4), unstable scaphoid pseudarthrosis leads to a break in continuity of the proximal carpal row, resulting in instability. This leads to arthrotic changes over time.

Depending on the severity of the arthrosis, Watson classifies it into three stages. Osteoarthritis begins at the processus styloideus radii (stage I). Subsequently, the radioscaphoidal joint between the distal fragment and the radius is affected (stage II). Later, osteoarthritis occurs between the capitatum and the articular surfaces of the lunatum and the proximal scaphoid fragment (stage III) (4). See table in 5 and in figure 28.

Staging of the SNAC-wrist according to Watson:	
Stage 1	arthrosis of the processus styloideus radii
Stage 2	additionally arthrosis radioscaphoidal joint
Stage 3	additionally mediocarpal arthrosis between lunatum and capitatum and proximalization of the capitatum

Table 5 SNAC-wrist according to Watson (4)

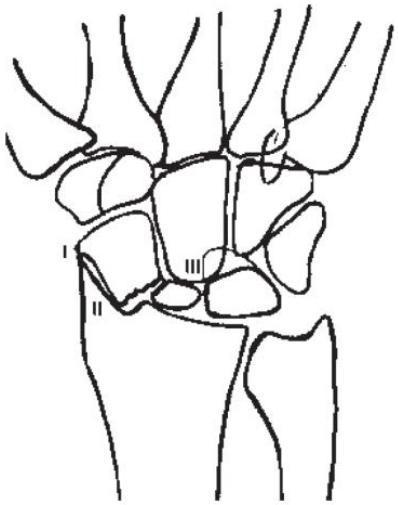


Figure 26 SNAC-wrist according to Watson (4)

2.2.4 Pain and functional outcome

For the functional outcome the patients were invited to the clinic for a clinical assessment. The assessment included the numeric rating scale (NRS), the range of motion (ROM) and the grip strength. These data could be transferred to the Mayo and Krimmer (See appendix) score and were evaluated (15).

2.2.4.1 Numeric rating scale (NRS)

Pain was measured using the Numeric Rating Scale (NRS 1-10). This is a standardized procedure in which it is defined: < 1 = no pain and 10 = worst possible pain (21).

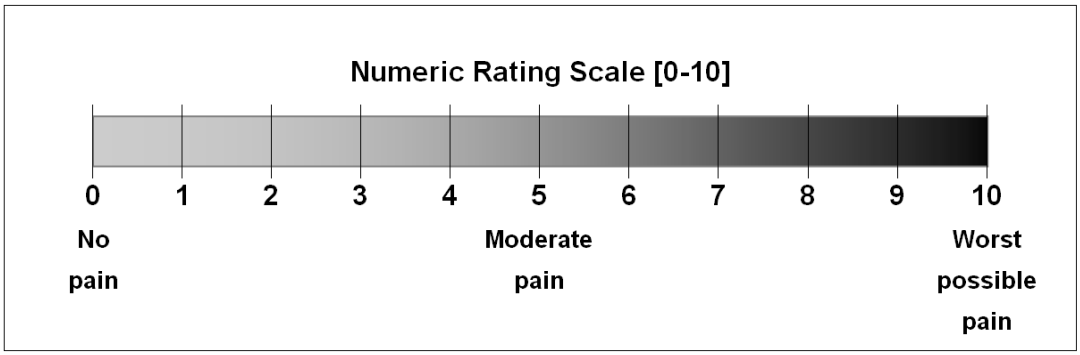


Figure 27 NRS numeric rating scale (Own illustration)

2.2.4.2 Range of motion (ROM)

A goniometer (See figure 28) was used to assess the range of motion (ROM). Extension/flexion, radial/ulnar deviation, and pronation/supination were measured and the injured hand was compared to the uninjured hand. The movement from each starting position was expressed in angular degrees.

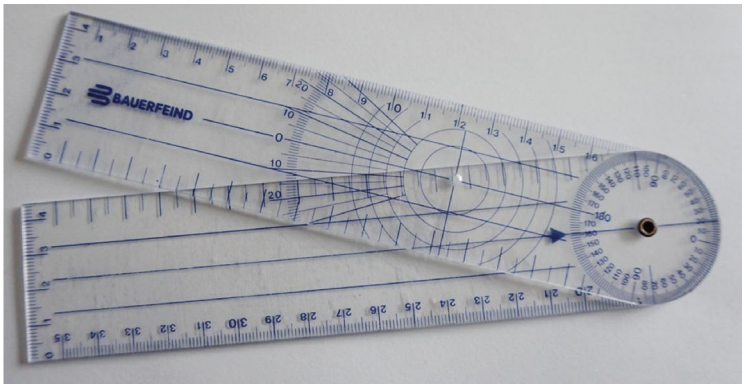


Figure 28 Goniometer for ROM assessment (22)

Extension/flexion:

From the starting position, dorsal extension and palmar flexion (See figure 29) are performed around a transversal axis. Movement occurs in the proximal as well as distal carpal joint (23).

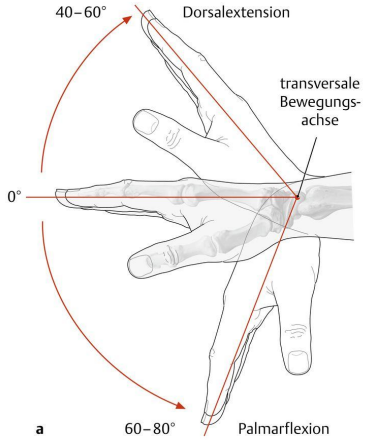


Figure 29 ROM: dorsal extension/palmar flexion (23)

Radial and ulnar deviation:

Radial and ulnar deviation occurs around an imaginary dorsal-palmar axis (23) (See figure 30). (The actual movements are around Henke's axes – Anatomy lectures Medical University Graz).

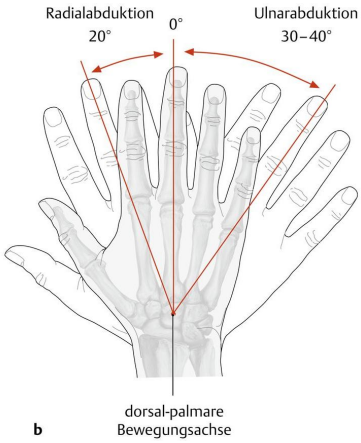


Figure 30 ROM: radial/ulnar deviation (23)

Supination/pronation:

In the supination position of the hand, the elbow is bent and the palmar surface of the hand points upward. In the pronation position, the palmar surface of the hand points downward with the elbow bent. The axis of motion runs through the caput radii and the ulnar styloid process (24). Supination and pronation position of the hand with bent elbow in front view (See figure 31):

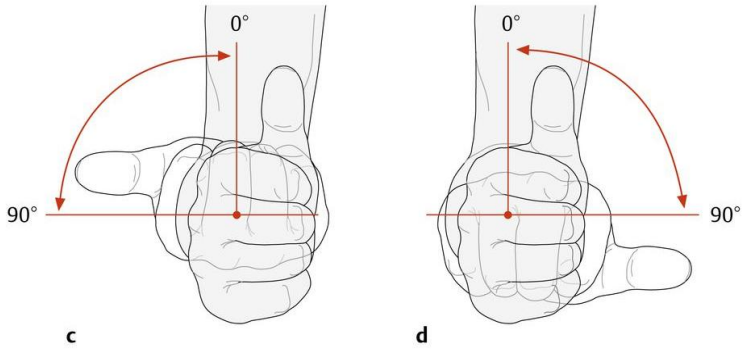


Figure 31 ROM: supination/pronation (24)

The physiological range of motion (ROM) of the wrist is shown in table 6. Any restriction of joint mobility can be accurately documented using range of motion (ROM) (25).

Physiological range of motion (ROM) of the wrist	
Extension/flexion	60°-0°-70°
Radial/ulnar deviation	30°-0°-40°
Pronation/supination	80°-0°-80°

Table 6 Physiological ROM of the wrist (25)

2.2.4.3 Grip strength

The grip strength in kilograms (kg) was measured using a hydraulic hand dynamometer (Jamar®) (See figure 32). For correct execution the elbow is flexed 90°, the shoulder is adducted, the forearm is in neutral position and the wrist is extended between 0 and 30° and ulnar deviated between 0 and 15° (26).

Then the patients were asked to squeeze the Jamar® dynamometer as hard as possible. Three measurements were taken alternately with the injured and uninjured hand. The mean value for each side was calculated and the two sides were compared.

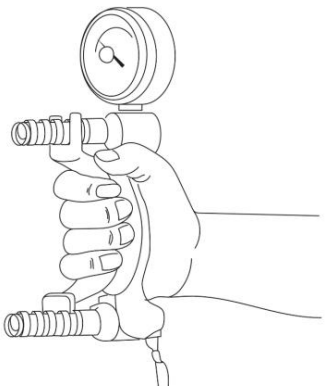


Figure 32 Jamar® dynamometer (27)

2.2.4.4 Mayo wrist score

The Mayo wrist score (Modiefied Green O'Brien Wrist Score) was used to summarize the functional outcome. Patients were asked about pain and functional status, range of motion and grip strength were taken from the clinical assessment. Points from 0 to 25 could be assigned in each subgroup. Thus, a maximum of 100 points could be achieved. The interpretation is shown in table 7 (28). The Mayo wrist score is attached (See appendix).

Mayo wrist score	
100-90 points	Excellent
89-80 points	Good
79-60 points	Fair
<60 points	Poor

Table 7 Mayo wrist score (28)

2.2.4.5 Krimmer score

The Krimmer score is similar to the Mayo wrist score and it is also possible to represent the functional outcome with just one score. Patients could rate pain from 0 (most severe pain) to 20 points (no pain) and hand usability from 0 to 30 points. The range of motion with points from 0 to 20 and the grip strength with 0 to 30 points could again be taken from the clinical assessment. 100 points could be achieved at maximum. See the scoring in table 8 (29). The Krimmer score is attached (See appendix).

Krimmer score	
100-81 points	Excellent
80-66 points	Good
65-51 points	Fair
<51 points	Poor

Table 8 Krimmer score (29)

2.2.5 Patient's self-assessment

In addition to the functional assessment at the clinic, patients were surveyed for patient self-assessment using standardized questionnaires, as in the paper of Quadlbauer (2018) (15). This makes the results comparable with other studies. Patients were able to complete the questionnaires on a tablet and these data were then recorded and stored directly in the encrypted online portal RedCap®.

Patient's self-assessment scores:

Functional scores (See functional outcome above)

- Mayo score (0-100)
- Krimmer score (0-100)

Satisfaction in the performance of activities of daily living

- Disability of the Arm Shoulder and Hand Score (DASH 0-100)
- Patient-rated Wrist Evaluation (PRWE 0-100)
- Michigan Hand Questionaire (MHQ 0-100)

Impacts of catastrophizing on pain experience

- Pain Catastrophizing Scale (PCS 0-100)

2.2.5.1 Disabilities of the arm, shoulder and hand (DASH)

The Disabilities of the arm, shoulder and hand score (DASH) asks about symptoms as well as the ability to perform certain activities of daily living in the past week, regardless of which hand or arm you used to perform the activity (30).

30 questions were answered with possible values from 1 (no difficulties) to 5 (unable). The answer points of the questions were summed and formed the raw score (maximum 150/minimum 30 points). The scatter range was 120 points. The raw score is converted to the DASH score as follows:

$$\frac{(\text{raw score} - 30)}{1.2} = \text{DASH score [0-100]}$$

The DASH score ranges from 0 for no limitation to 100 for high limitation. If 3 or more questions have not been answered, the DASH may not be calculated (30). The DASH score is attached (See appendix).

2.2.5.2 Patient-rated wrist evaluation score (PRWE)

The patient-rated wrist evaluation score (PRWE) was used to assess 5 questions about pain (0=No pain - 10=Worst ever) and 10 questions about wrist function (0=No difficulty - 10=Unable to do) in the past week. If a question was not answered, the mean score was inserted. The Total score ranged from 0 (Best score) to 100 (Worst score) (31)(32). The PRWE is attached (See appendix).

PRWE scoring		
Pain subscore	= Sum of the 5 pain items	(0=Best score/50=Worst score)
Function subscore	= Sum of the 10 function items divided by 2	(0=Best score/50=Worst score)
Total score	= Sum of the pain and function score	(0=Best score/100=Worst score)

Table 9 PRWE scoring (31)(32)

2.2.5.3 Michigan hand questionaire (MHQ)

The Michigan hand questionaire (MHQ) consists of 6 subscores: overall hand function, activities of daily living, work performance, pain, aesthetics and satisfaction with the hand function. For each question, 1 to 5 points could be assigned for the performance of the hand in the past week. Higher scores mean better hand performance, in the pain scale higher scores mean more pain (Therefore, the pain score must be reversed in the overall evaluation.) (33).

For the raw scores, the sums were made and converted to a range from 0 to 100. For the overall MHQ, the individual scores (note: reversed pain score) were summed and divided by 6. This in turn results in a range from 100 (best score) to 0 (worst score) for the overall MHQ (33). The MHQ is attached (See appendix).

2.2.5.4 Pain catastrophizing scale (PCS)

Severe or prolonged pain can lead to clinically relevant levels of pain catastrophizing and subsequently chronicity of pain. The Pain Catastrophizing Scale (PCS) was used to evaluate the impact of catastrophizing on pain experience (34).

As described in the user manual (Sullivan 2009) (34), this questionnaire consists of “13 thoughts or feelings when experiencing pain” (Sullivan 2009) which are rated from 0 (not at all) to 4 (all the time) points. It examines various elements of catastrophizing such as rumination (questions 8, 9, 10, 11), magnification (ques-

tions 6, 7, 13), and helplessness (questions 1, 2, 3, 4, 5, 12). However, the individual categories only provide information about the way of catastrophizing (34).

The total score (ranging from 0 to 52) could be converted to percentiles as in Appendix A of the Sullivan 2009 paper. Scores below the 50th percentile (<20 points) were classified as low risk, between the 50th and 75th percentiles (20-30 points) as moderate risk, and scores above the 75th percentile (>30 points) as high risk for developing chronicity of pain (34). The PCS scale is attached (See appendix).

PCS – Pain catastrophizing scale		
Total points	Percentiles	Risk for development of chronicity
<20	$<50^{th}$	Low risk
20-30	50^{th}-75^{th}	Moderate risk
>30	$>75^{th}$	High risk

Table 10 PCS Pain catastrophizing scale (34)

2.2.6 Statistical methods and data analysis

In the statistical analysis, a descriptive evaluation of the variables (relative frequencies, mean, range and standard deviation) was performed where the number of cases allowed.

In the radiological outcome, due to the higher number of cases, an overall collective and various subgroups could be formed and compared with each other or with individual cases. The functional outcome and the patient's self-assessment scores could only be compared with individual cases and presented as case series due to the low number of cases.

The data was analyzed using Microsoft Excel 2010.

3 Results

3.1 Patients characteristics

3.1.1 Demographic data and interventions

A total of 37 patients with a surgically treated scaphoid fracture were found in the MEDOCS system. 29 (4 women and 25 men) patients with a mean age of 31 (range 18-66) matched the inclusion criteria (See table 11), were radiologically re-evaluated. The included patients were divided into 21 recent fractures (72%) with a mean interval between injury and surgery of 15 days (range 0-97) and 8 pseudarthroses (28%) with a mean interval of 99 months (range 6-344). These patients were also invited for study participation. However, 5 were not available and 11 declined to participate. Thus, 13 patients participated in the follow-up investigation on functional outcome and patient's self assessment and were processed in case series (See flowchart). In table 11 detailed demographic data are presented.

Table 11. Demographic data, interventions and metal removal [mean (range, SD)], in patients fulfilling the inclusion criteria

	Included patients (n=29)
Demographic data	
Sex (female/male, %)	4/25, 14%/86%
Age (years) at time of injury	31 (18-66, 11)
Right/left hand, %	11/18, 38%/62%
Dominant hand %	11/18, 38%/62%
Recent fracture (RF)/pseudarthrosis(PA), %	21/8, 72%/28%
RF intervall injury and surgery (days)	15 (0-97, 21)
PA intervall injury and surgery (months)	99 (6-344, 131)
Interventions	
Screw/plate, %	16/13, 55%/44%
Recent fracture (RF) screw/plate, %	13/8, 62%/38%
RF screw MR/ØMR, %	1/12, 8%/92%
RF plate MR/ØMR, %	2/6, 25%/75%
Pseudarthrosis (PA) screw/plate, %	3/5, 38%/62%
PA screw MR/ØMR, %	3/0, 100%/0%
PA plate MR/ØMR, %	5/0, 100%/0%
Metal removal	
Screw MEX/ØMEX, %	2/14, 12%/88%
Plate MEX/ØMEX, %	8/5, 62%/38%
Intervall surgery and MEX (months)	13 (6-25, 6)

SD standard deviation, n sample size, RF recent fracture, PA pseudarthrosis, MR matti russe, MEX metal removal

Table 11 Demographic data, interventions and metal removal

3.1.2 Fracture classifications

In the classification according to Herbert (See chapter 1.3 Fracture classification) this means 21 unstable acute fractures (Type B) and 8 established nonunions (Type D). The 21 type B fractures could be further subdivided into 2 type B1 (distal oblique fracture), 10 type B2 (complete fracture of the waist), 2 type B3 (proximal pole fracture) and 7 type B4 (transscaphoidal perilunate dislocation fracture - De Quervain fracture). The 8 type D fractures could all be assigned to subtype D2 (pseudarthrosis).

3.1.3 Surgical treatment

Of the 21 recent fractures, 13 were treated with screws (1 with Matti Russe and two screws) and 8 with plates (2 with Matti Russe). Of the 8 pseudarthroses, 3 were treated with screws and Matti Russe and 5 with plates and Matti Russe (See flowchart).

3.1.3.1 Metal removal

Of the total 16 screws, only 2 required metal removal (12%), but of the plates, 8 of 13 plates (62%) had to be removed during another surgery. The mean interval between surgery and metal removal was 13 (range 6-25) months (See table 11).

3.1.3.2 Complications

In 2 plate implantations (ID16 and ID22), the drill tip was broken off. In the plate removal of ID37 (= Case 13), a screw broke off. However, the metal parts were interosseous in each case and could remain in the scaphoid.

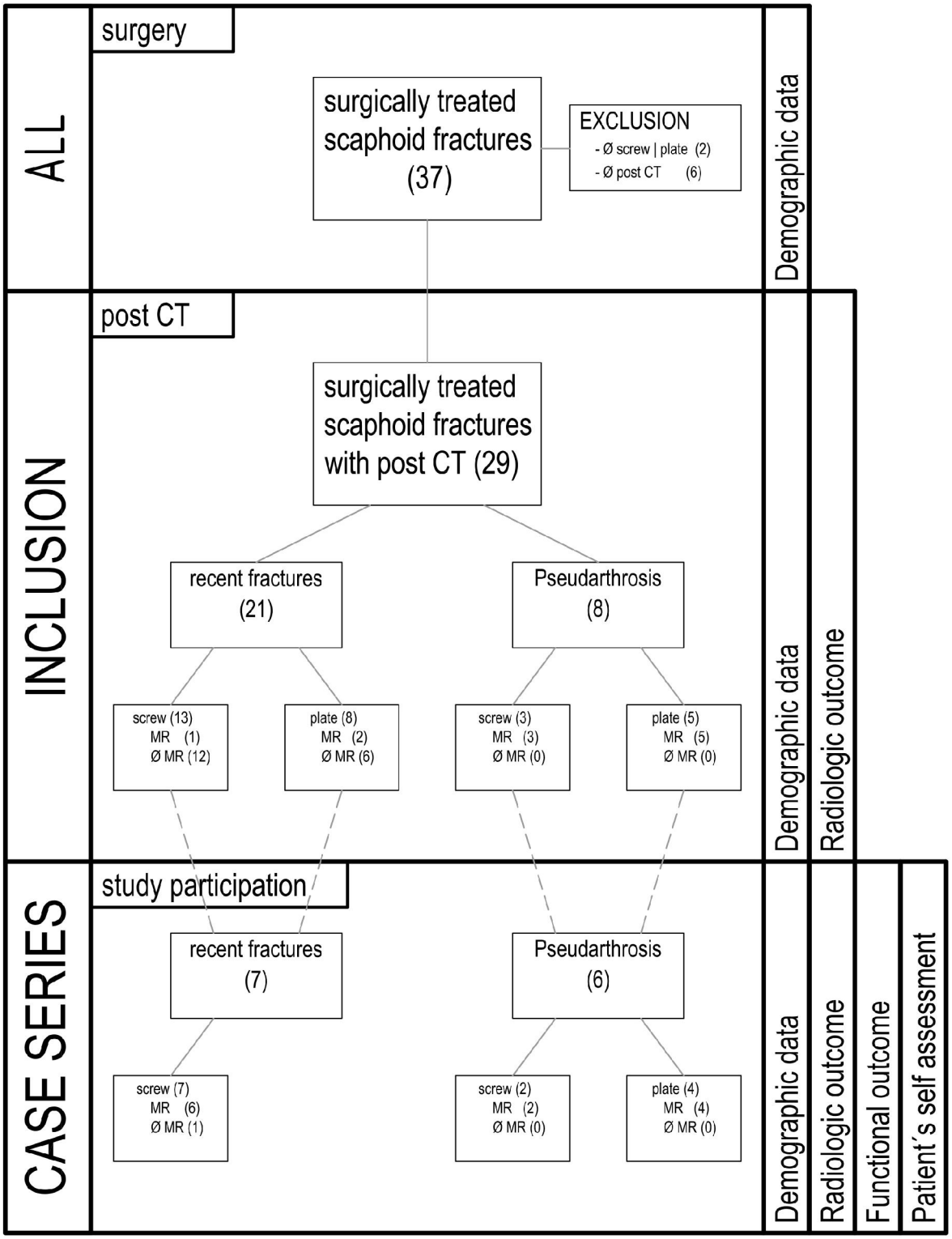


Figure 33 Flowchart: Overview

3.2 Radiological outcome

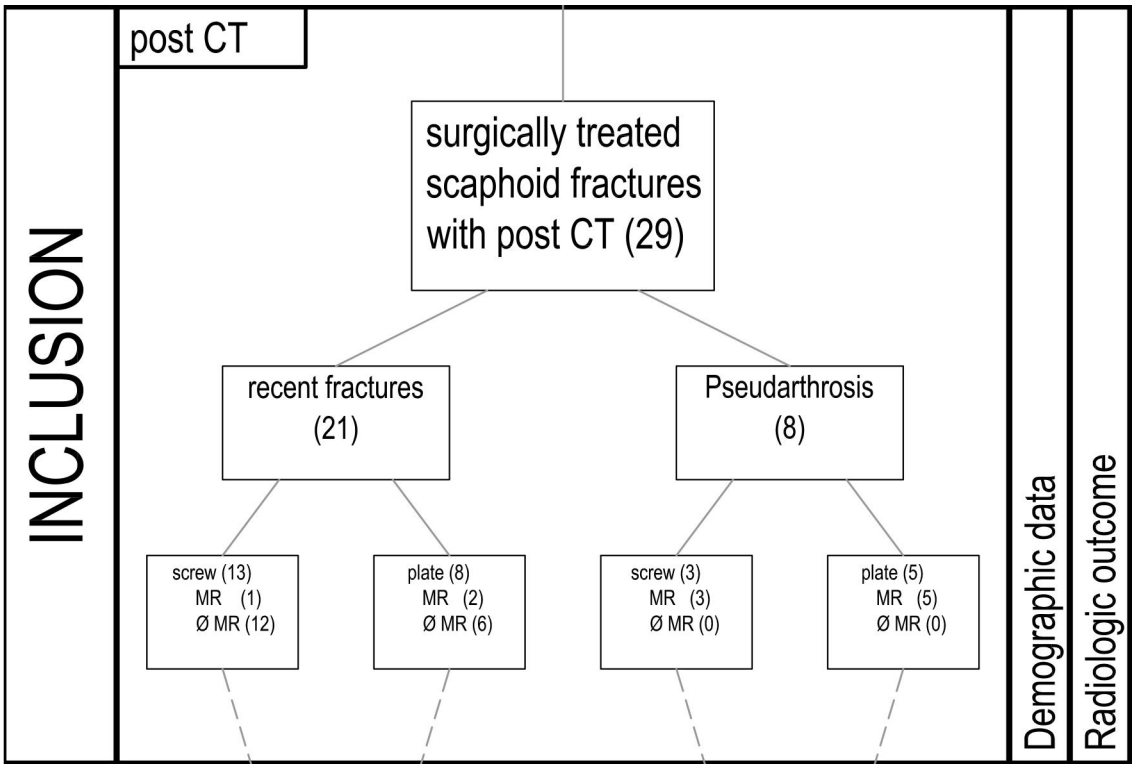


Figure 34 Flowchart: Included patients

Of all included patients, 90% of scaphoid fractures showed bony healing (17 united, 9 partially united) on final CT with a mean follow-up of 8 months (range 1-44, SD 9). 72% (21 of 29) had humpback deformity, 10% (3 of 29) DISI deformity – as a consequence of nonunion. 15 patients showed no postoperative osteoarthrosis, 6 slight joint-space narrowing (grade 1), 3 joint-space narrowing and osteophytes (grade 2) and 5 bone on bone with osteophyte and cyst formations (grade 3). Of the 21 patients, 2 could be assigned to SNAC wrist stage 1 (osteoarthritis at the styloid process), 5 to stage 2 (additional radioscaphoidal osteoarthrosis), and 1 to stage 3 (additional mediocarpal osteoarthrosis) (See table 12).

3.2.1 Recent fractures

The recent fractures achieved a union rate (united and partially united) of 90% (19/2) with a mean follow-up of the final CT of 8 months (range 1-44, SD 10). Humpback deformity was detected in 71% (15 of 21) and DISI deformity in 5% (1 of 21). Postoperative osteoarthritis was found in 5 cases with grade 1 and in 2 cases with grade 2, in one case a SNAC wrist stage 1.

3.2.1.1 Recent fractures: screw vs plate

The recent fractures treated with screw showed a humpback deformity in 69% (9 of 13) and no (0%) DISI deformity in any case (0 of 13). In the recent fractures treated with a plate, a humpback deformity was found in 6 of 8 (75%) and a DISI deformity in 1 of 8 (13%). For more detailed information, see table 12.

3.2.1.2 Recent fractures: with or without Matti Russe

Recent fractures had an excellent union rate. For screws, the one case with Matti Russe (100%) was united; without Matti Russe, 11 of 12 were united (92%). For plates with Matti Russe, 2 of 2 cases showed union (100%), without Matti Russe 83% (5 of 7). See table 12 for more detailed information.

3.2.2 Pseudarthroses

The pseudarthroses were united (united and partially united) in 88% (7 of 8) on final CT at a mean follow-up of 9 months (range 3-25, SD 7). Humpback deformity was seen in 6 of 8 cases (75%), DISI deformity in 2 of 8 cases (25%). Postoperative osteoarthrosis showed grade 1 in 1 case, grade 2 in 1 case and grade 3 in 5 cases. 5 wrists could be found on SNAC stage 2 and 1 each on stage 1 and 3. For further information, see table 12.

3.2.2.1 Pseudarthroses: screw vs plate

Pseudarthroses treated with screws showed humpback deformity in 67% (2 of 3) and DISI deformity in 33% (1 of 3). Pseudarthroses fixed with a plate showed a humpback deformity in 80% (4 of 5) and a DISI deformity in 20% (1 of 5).

3.2.2.2 Pseudarthroses: screw and plate with Matti Russe

All 3 pseudarthroses with screw and Matti Russe were (3 of 3, 100%) united. In 80% (4 of 5) of the pseudarthroses with plate and Matti Russe, a union was detected. See table 12 for further information.

Table 12. Radiological data [mean (range, SD)], in patients with surgically treated scaphoid fractures divided into several groups

Group	Follow up final CT [months]	H/L ratio	HB deformity [HB/øHB %]	Union [mean %]	Union [Union/ nonunion %]	POA [POA 0/1/2/3]	CL angle (°)	DISI-Deformity [DISI/ øDISI %]	SNAC wrist [SNAC 0/1/2/3]
INCLUDED (n=29)	8 (1-44, 9)	0.7 (0.6-1.0, 0.1)	21/8 (72)	0.8 (0.4-1.0, 0.2)	26/3 (90)	15/6/3/5	15 (4-50, 12)	3/26 (10)	21/2/5/1
RECENT FRACTURES (n=21)	8 (1-44, 10)	0.7 (0.6-0.8, 0.1)	15/6 (71)	0.8 (0.4-1.0, 0.2)	19/2 (90)	14/5/2/0	14 (4-50, 12)	1/20 (5)	20/1/0/0
Screws (n=13)	10 (1-44, 13)	0.7 (0.6-0.8, 0.1)	9/4 (69)	0.8 (0.5-1.0, 0.2)	12/1 (92)	9/3/1/0	12 (4-27, 9)	0/13 (0)	12/1/0/0
Screws and MR (n=1)	12	0.7	1/0 (100)	0.9	1/0 (100)	1/0/0/0	9	0/1 (0)	1/0/0/0
Screws øMR (n=12)	10 (1-44, 13)	0.7 (0.6-0.8, 0.1)	8/4 (67)	0.8 (0.5-1.0, 0.2)	11/1 (92)	8/3/1/0	12 (4-27, 9)	0/12 (0)	11/1/0/0
Plates (n=8)	5 (2-12, 3)	0.7 (0.6-0.8, 0.1)	6/2 (75)	0.7 (0.4-0.9, 0.2)	7/1 (88)	5/2/1/0	17 (6-50, 15)	1/7 13)	8/0/0/0
Plates and MR (n=2)	9 (7-12, 4)	0.7 (0.6-0.7, 0.0)	1/1 (50)	0.9 (0.9-0.9, 0.0)	2/0 (100)	1/1/0/0	19 (9-28, 13)	0/2 (0)	2/0/0/0
Plates øMR (n=6)	3(2-6, 2)	0.7 (0.6-0.8, 0.1)	5/1 (83)	0.7 (0.4-0.9, 0.2)	5/2 (83)	4/1/1/0	17 (6-50, 17)	1/5 (17)	6/0/0/0
PSEUDARTHROSIS (n=8)	9 (3-25, 7)	0.8 (0.6-1.0, 0.1)	6/2 (75)	0.7 (0.5-0.9, 0.1)	7/1 (88)	1/1/1/5	17(6-38, 12)	2/6 (25)	1/1/5/1
Screws (n=3)	13 (3-25, 11)	0.7 (0.6-0.8, 0.1)	2/1 (67)	0.8 (0.8-0.9, 0.0)	3/0 (100)	1/0/0/2	18 (8-38, 17)	1/2 (33)	1/0/1/1
Screws and MR (n=3)	13 (3-25, 11)	0.7 (0.6-0.8, 0.1)	2/1 (67)	0.8 (0.8-0.9, 0.0)	3/0 (100)	1/0/0/2	18 (8-38, 17)	1/2 (33)	1/0/1/1
Screws øMR (n=0)	-	-	-	-	-	-	-	-	-
Plates (n=5)	6 (3-10, 3)	0.9 (0.6-1.0, 0.2)	4/1 (80)	0.7 (0.5-0.9, 0.1)	4/1 (80)	0/1/1/3	17 (6-32, 11)	1/4 (20)	0/1/4/0
Plates and MR (n=5)	6 (3-10, 3)	0.9 (0.6-1.0, 0.2)	4/1 (80)	0.7 (0.5-0.9, 0.1)	4/1 (80)	0/1/1/3	17 (6-32, 11)	1/4 (20)	0/1/4/0
Plates øMR (n=0)	-	-	-	-	-	-	-	-	-

SD standard deviation, H/L ratio height/lenght ratio, HB deformity humpback deformity, POA postoperative arthrosis, CL angle Capitatum Lunatum angle, DISI dorsal intercalated segment instability, SNAC scaphoid nonunion advanced collapse, MR matti russe

Table 12 Radiological data included patients

3.3 Case series

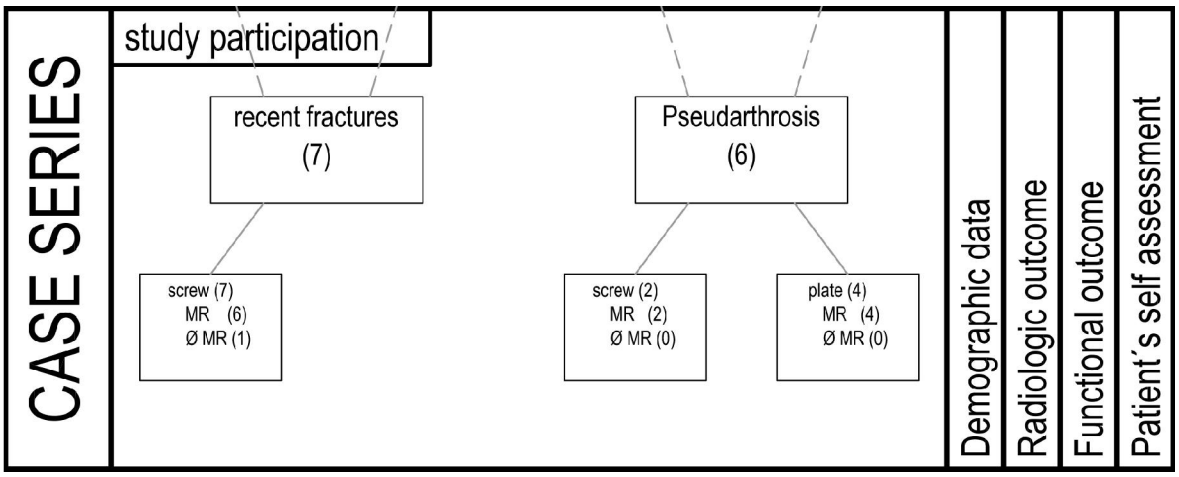


Figure 35 Flowchart: Case series

3.3.1 Demographic Data and interventions

2 women and 11 men with a mean age of 39 years (range 22-66, SD 12) participated the study. There were 7 recent fractures with a mean interval between injury and surgery of 9 days (range 1-15, SD 6) and 6 pseudarthroses with a mean interval between injury and surgery of 97 months (range 6-344, SD 143). The recent fractures were all treated with screw, one of them also with Matti Russe due to a cyst. In the 6 pseudarthroses, 2 were fixed by a screw with Matti Russe and 4 by a plate with Matti Russe.

Additional injuries were present in 4 patients. Case 1 and case 4 had a radius fracture of the same hand, case 2 had a forearm fracture of the other hand and case 11 underwent surgery for carpal tunnel syndrome in addition.

According to Herbert classification, the CTs before surgery (See case 8 figure 38) were evaluated.
The recent fractures were type B fractures (unstable fractures), including 1 of subtype B1 (distal oblique fracture), 2 of subtype B2 (complete waist fracture), 1 of subtype B3 (pole fracture), and 3 of subtype B4 (transscaphoidal perilunate dislocation fracture - De Quervain fracture). The pseudarthroses (by definition type D) were all subtype D2 (unstable pseudarthrosis).

Only 1 of the 7 (12,5%) screws had to be removed after 25 months. However, all 4 plates (100%) required a further surgery for metal removal after 9-13 months. In the overall collective, 12% of screws and 62% of plates had to be removed after a mean interval of 13 (6-25, 6) months. (See case 8 figure 41) In table 13 detailed demographic data are presented.

Table 13. Patients and Interventions

Case	Age [years]	Sex [M/F]	Side	Dominant hand	Additional injury	PA/RF	Type Herbert	Subtype Herbert	Treatment	Matti Russe	Interval injury surgery [days]	MEX	Interval surgery MEX [months]
1	47	M	Left	Right	Yes	PA	D	D2	Screw	Yes	517	No	
2	31	M	Right	Left	Yes	PA	D	D2	Screw	Yes	277	Yes	25
3	25	M	Left	Right	No	RF	B	B2	Screw	Yes	14	No	
4	35	M	Left	Right	Yes	RF	B	B2	Screw	No	1	No	
5	22	M	Right	Right	No	RF	B	B4	Screw	No	4	No	
6	29	M	Right	Right	No	RF	B	B1	Screw	No	9	No	
7	34	W	Left	Right	No	PA	D	D2	Plate	Yes	5981	Yes	13
8	48	M	Right	Right	No	PA	D	D2	Plate	Yes	242	Yes	12
9	33	M	Left	Right	No	RF	B	B3	Screw	No	15	No	
10	66	W	Left	Right	No	RF	B	B4	Screw	No	4	No	
11	39	M	Left	Right	Yes	PA	D	D2	Plate	Yes	10331	Yes	9
12	54	M	Right	Right	No	RF	B	B4	Screw	No	13	No	
13	44	M	Left	Right	No	PA	D	D2	Plate	Yes	185	Yes	10

M male, F female, PA Pseudarthrosis, RF recent fracture, MEX metal removal

Table 13 Case series: Patients and interventions

Case 8 (ID20):

X-ray July 2016 (injury):

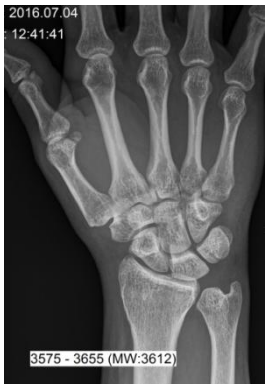


Figure 36 Case 8: X-rays 2016

X-ray January 2017 (persistent complaints):

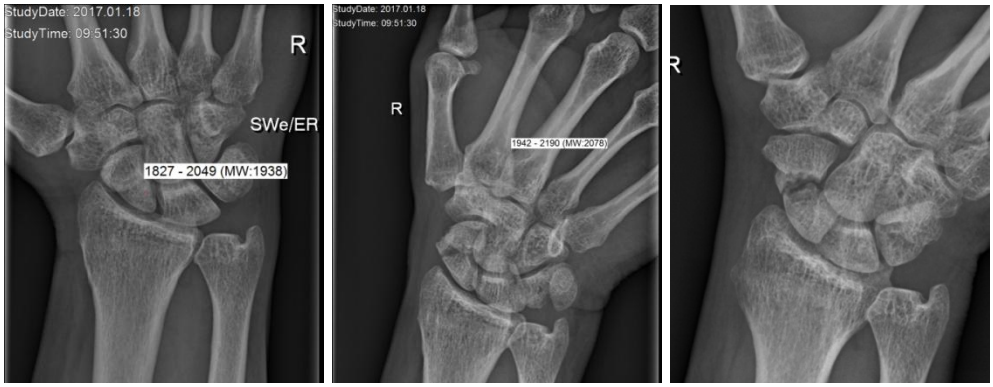


Figure 37 Case 8: X-rays 2017

CT-scan January 2017 (pre surgery):

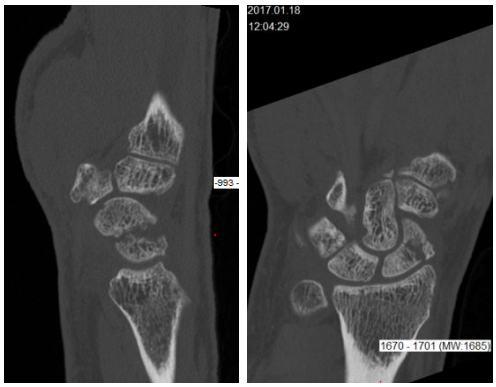


Figure 38 Case 8: CT scan 2017

3.3.2 Radiological outcome

All 13 patients had a final CT (See case 8 figure 39) with a mean follow up (interval surgery and final CT) of 13 months (2-44, SD 12).
All except 2 cases (Case 8: Plate and Matti Russe; Case 10: Screw without Matti Russe) were united or partially united (85%) at the time of the final CT. In the total population of included patients, this was 90% (See table 14). In some cases the low rate of union can be explained by the short follow-up interval to the final CT. As in example Case 8, after one CT (Case 8 see figure 39), only radiographs (Case 8 see figure 40) were taken at further follow-up visits. In case 8, bony healing had progressed to the point where metal removal (Case 8 see figure 41) was possible.

In many cases (77% - 6 of 7 recent fractures and 4 of 6 pseudarthroses) a humpback deformity could be found. Only case 1 (pseudarthrosis with screw and Matti Russe), case 6 (recent fracture with screw) and case 8 (pseudarthrosis with plate and Matti Russe) did not show humpback deformity. DISI deformities could only be detected in cases 1 (pseudarthrosis with screw and Matti Russe) and 13 (pseudarthrosis with plate and Matti Russe), i.e. in 15%. Compared to the total collective, 72% had a humpback deformity and 10% a DISI deformity (See table 14).

In the 7 recent fractures postoperative arthrosis could only be seen in case 12 (screw without Matti Russe) with slight joint-space narrowing (POA grade1). In the 6 pseudarthroses, 4 were affected with POA3 (grade 3) and 1 with POA2 (grade 2). Only in case 1 (screw with Matti Russe) no POA was found. In the SNAC wrist evaluation, no recent fracture was affected. However, 5 of 6 pseudarthroses could be assigned to stage SNAC 2, excluding only case 1 (screw with Matti Russe).

Compared to the overall collective of all 29 included patients: Here, 15 (52%) showed no postoperative arthrosis and 21 (72%) showed no SNAC wrist (See table 14).

Table 14. Radiological Outcome

Case	Follow-up final CT [months]	Union [%]	Union	H/L ratio [%]	Humpback deformity	POA [0-3]	CL angle [degree]	DISI	SNAC wrist [0-3]
1	3	0,78	United	0,6	No	0	38	Yes	0
2	25	0,78	United	0,8	Yes	3	9	No	2
3	12	0,85	United	0,7	Yes	0	9	No	0
4	14	0,76	United	0,8	Yes	0	6	No	0
5	14	0,90	United	0,7	Yes	0	12	No	0
6	44	1,00	United	0,6	No	0	8	No	0
7	10	0,67	Partially united	0,9	Yes	3	9	No	2
8	3	0,49	Tenuously united	0,6	No	2	6	No	2
9	2	0,62	Partially united	0,7	Yes	0	27	No	0
10	3	0,46	Tenuously united	0,7	Yes	0	4	No	0
11	7	0,62	Partially united	0,9	Yes	3	24	No	2
12	22	0,98	United	0,7	Yes	1	27	No	0
13	6	0,88	United	1,0	Yes	3	32	Yes	2

SD standard deviation, H/L ratio height/lenght ratio, HB deformity humpback deformity, POA postoperative arthrosis, CL angle Capitatum Lunatum angle, DISI dorsal intercalated segment instability, SNAC scaphoid nonunion advanced collapse, MR matti russe

Table 14 Case series: Radiological outcome

Case 8 (ID20):

CT-scan May 2017 (post surgery):

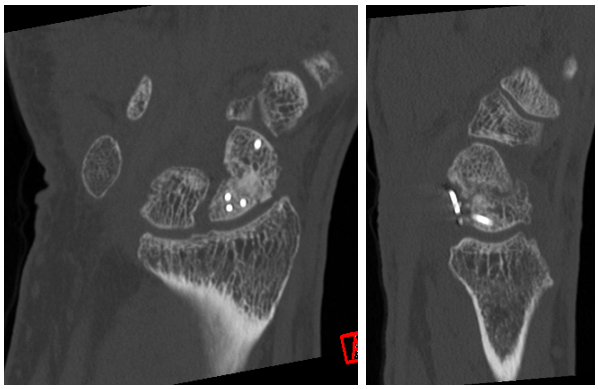


Figure 39 Case 8: CT scan 2017 (post surgery)

X-ray September 2017 (post surgery):

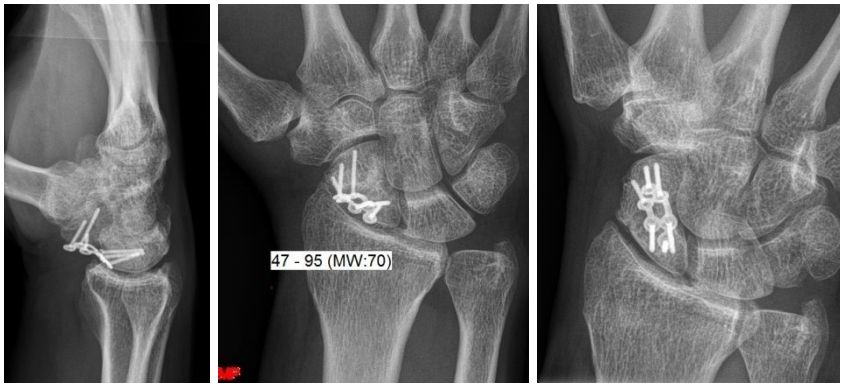


Figure 40 Case 8: X-rays 2017 (post surgery)

X-ray February 2018 (post MEX):

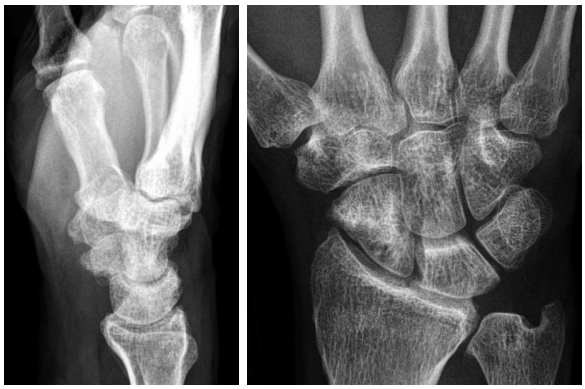


Figure 41 Case 8: X-rays 2018 (post metal removal)

3.3.3 Functional outcome

The 13 participants of the study were clinically evaluated after a mean follow-up interval between surgery and examination of 45 (17-78, 20) months.

All patients had very little pain with a range of 1-3 (mean 2, SD 1) on the NRS scale. The patients achieved a mean range of motion in extension/flexion of 110 (55-170, 31)°, in supination/pronation of 178 (175-180, 3)° and in radial/ulnar deviation of 51 (30-70, 11)°. Compared to the unaffected hand, this was a mean range of motion in extension/flexion of 84%, in supination/pronation of 103% and in radial/ulnar deviation 85%. The mean grip strength was 35 (10-52, 13) kg or 83% from the unaffected side. (Information on case 2: The patient had a forearm fracture on the other hand) (See table 15/16 and figures 42/43). The functional scores (Mayo and Krimmer score) are listed in the next chapter Patients self-assessment (See table 17).

Table 15. Functional outcome (NRS and ROM)

Case	Side	Dominant hand	NRS 0-10	Follow-up [months]	ROM affected Flexion/ Extension	ROM unaffected Flexion/ Extension	% ROM affected/ unaffected	ROM affected Radial/ Ulnar	ROM unaffected Radial/ Ulnar	% ROM affected/ unaffected	ROM affected Pronation/ Supination	ROM unaffected Pronation/ Supination	% ROM affected/ unaffected
1	Left	Right	1	73	155	140	111	60	60	100	180	180	100
2	Right	Left	2	78	170	95	179	70	50	140	180	120	150
3	Left	Right	2	65	130	130	100	60	70	86	180	180	100
4	Left	Right	3	60	110	135	81	55	65	85	175	180	97
5	Right	Right	1	51	105	165	64	40	65	62	175	180	97
6	Right	Right	1	44	100	140	71	40	60	67	175	180	97
7	Left	Right	3	43	90	145	62	30	50	60	180	180	100
8	Right	Right	3	41	115	130	88	50	65	77	180	180	100
9	Left	Right	2	35	115	130	88	60	70	86	175	180	97
10	Left	Right	2	30	120	150	80	55	50	110	180	180	100
11	Left	Right	2	25	70	130	54	45	70	64	175	180	97
12	Right	Right	3	22	55	130	42	40	55	73	175	175	100
13	Left	Right	3	17	95	130	73	60	65	92	180	180	100

ROM range of motion

Table 15 Case series: Functional outcome (NRS and ROM)

Table 16. Functional outcome (Grip strength)						
Case	Side	Dominant hand	Follow-up [months]	Grip strength affected	Grip strength unaffected	% Grip strength affected/ unaffected
1	Left	Right	73	42	47	90
2	Right	Left	78	37	27	138
3	Left	Right	65	31	32	95
4	Left	Right	60	52	61	84
5	Right	Right	51	29	60	49
6	Right	Right	44	42	37	114
7	Left	Right	43	27	37	72
8	Right	Right	41	52	52	101
9	Left	Right	35	40	49	82
10	Left	Right	30	20	25	80
11	Left	Right	25	46	53	88
12	Right	Right	22	10	54	19
13	Left	Right	17	25	36	70

Table 16 Case Series: Functional outcome (Grip strength)

Case 8 (ID20):

ROM July 2020:

Figure 42 Case 8: ROM extension/flexion

Figure 43 Case 8: ROM supination/pronation

3.3.4 Patient's self assessment

In addition to functional outcome, patients were asked various questionnaires after a mean interval between surgery and interview of 45 (17-78, 20) months. The functional scores showed "fair" results with mean Mayo with 75 (50-90, 12) points and "good" results with mean Krimmer with 80 (40-100, 18) points. The mean DASH score of 9 (0-27, 9) points [0 no limitation/100 high limitation], the mean PRWE of 12 (0-27, 10) points [0 best score/100 worst score] and the mean MHQ of 85 (60-100, 11) points [100 best score/0 worst score] demonstrated the satisfaction in activities of daily living. Except in case 9 (moderate risk), a mean PCS of 8 (2-60, 16) points indicated only low risk for catastrophizing and developing chronicity of pain in all others. See table 17 below:

Table 17. Patient's self assessment

Case	Side	Follow-up [months]	MAYO [0-100]	MAYO	Krimmer [0-100]	Krimmer	DASH [0-100]	PRWE [0-100]	MHQ [0-100]	PCS [0-100]	PCS risk
1	Left	73	90	exellent	100	exellent	0	0	100	11	low risk
2	Right	78	70	fair	70	good	3	17	90	2	low risk
3	Left	65	90	exellent	100	exellent	1	5	97	2	low risk
4	Left	60	75	fair	85	exellent	20	27	77	2	low risk
5	Right	51	65	fair	60	fair	18	26	70	2	low risk
6	Right	44	90	exellent	85	exellent	8	1	89	2	low risk
7	Left	43	65	fair	65	fair	7	15	80	5	low risk
8	Right	41	85	good	90	exellent	1	2	71	2	low risk
9	Left	35	75	fair	85	exellent	18	15	68	60	moderate risk
10	Left	30	85	good	95	exellent	8	12	90	2	low risk
11	Left	25	70	fair	90	exellent	3	5	96	2	low risk
12	Right	22	50	poor	40	poor	27	27	80	2	low risk
13	Left	17	70	fair	70	good	7	6	96	5	low risk

Table 17 Patient's self assessment

4 Discussion

Scaphoid fractures remain a major challenge in diagnosis and treatment. A differentiation must be made between recent fractures and pseudarthroses. Recent fractures are mainly treated with plaster (See chapter 1.4.1 Conservative Treatment) or HCS (See chapter 1.4.2.3 Headless Compression Screw (HCS)). The primary use of plates for osteosynthesis in recent fractures is only exceptional - in scaphoid fractures with a large zone of comminution (5).

Pseudarthrosis develops when patients do not visit the doctor despite fracture due to few complaints, fractures are overlooked on X-rays, insufficient diagnostics, too short immobilization or do not heal due to inappropriate treatment. The doctor has to exclude a fracture (6).

A main reason for delayed union or nonunion (pseudarthrosis) after surgical treatment (besides poor blood circulation) is the lack of rotational stability (35). A single screw has worse results in biomechanical studies especially against rotational forces compared to fixation with two screws or with a plate (36)(37)(38). There are no significant differences between plate and two screws in the biomechanical results of these two osteosynthesis procedures (37). In scaphoid pseudarthroses, higher healing rates were achieved with two HCS or with a plate (15) as well as in recent unstable type B2 scaphoid fractures with two HCS (39) due to higher stability.

In cases of pseudarthrosis (See chapter 1.4.2.5 Autologous bone chip – Matti-Russe) and for filling cysts of larger comminuted zones, an autologous bone chip according to the Matti Russe technique is used in addition. A healing rate after autologous corticocancellous graft is generally reported between 80-90% (40).

The aim of osteosynthesis is union, correction of deformities, reduction of symptoms, improvement of range of motion and prevention of formation or progression of osteoarthrosis (15).

In our study a total of 16 screws and 13 plates were used for osteosynthesis. Only 2 screws (12 %) had to be removed. In 62 % of the cases the plate was already taken out. In some cases, the follow-up time is still too short and removal will probably be necessary in all patients at a later time. The need for a second intervention is a disadvantage of plate osteosynthesis (5).

The Matti Russe technique was used three times in recent fractures to compensate a cyst or larger fracture zones with the bone chip. In pseudarthroses all were treated with Matti Russe. As in the paper of Buijze (40) healing rates between 80 - 90% could be achieved with Matti Russe.

In recent fractures, a plate was used in 38% (13 screws/8 plates) of the cases. According to the paper of Quadlbauer (5), the indication for recent fractures is only under certain conditions (See above). In the radiological outcome - unfortunately not as hoped - no better results could be achieved regarding humpback deformity (screw 69%/plate 57%) and DISI deformity (screw 0%/plate13%). However, the disadvantage of a second intervention remains.

The union rate in recent fractures was very high with 90% (screws 92%/plates 83%). POA and SNAC were, as expected, lower in recent fractures than in pseudarthroses. However, with a mean interval between surgery and final CT in recent fractures of 8 (1-44, 10) months, late complications may still occur in the further course.

Regarding pseudarthroses, an evaluation of radiological and functional initial situations as well as of the initial patients' self assessment scores would be interesting for a prospective planning. Questions such as "Was the limitation already present to this extent?", "Did the operation improve the initial situation?", "Was rescue possible at all?" could be answered.

This also relates to the radiological outcome. Many pseudarthroses were classified high in POA and SNAC or had a humpback or DISI deformity, but without assessing the initial situation.

When assessing humpback deformity, there was also the question of whether the section plane was exactly in the long axis of the scaphoid on standard CT scans. This could easily result in different values for the length, for the H/L ratio and consequently falsely provide a higher number of humpback deformities.

The union rate in pseudarthroses of 88% (screws 100%/plates 80%) was very good compared to Quadlbauer (15) with a union rate of 75-81%. The mean interval between surgery and final CT in the pseudarthroses was with 9 (3-25, 7) months in some cases very short, because in the rest of the course only control X-rays were taken. So the union rate could even improve with a longer follow-up interval.

The number of patients who participated in the study was unfortunately very small with 13 persons, therefore they were only presented as case series. However, the radiological outcome of individual cases can be compared to the total population of included patients and individual groups from this population.

For the functional outcome and the scores, it must be noted that 4 patients had additional injuries to the same or the other hand, which influenced the results.

With a mean follow-up interval of 45 (17-78, 20) months, patients achieved a mean range of motion in extension/flexion of 110 (55-170, 31)°, in supination/pronation of 178 (175-180, 3)° and in radial/ulnar deviation of 51 (30-70, 11)° and a mean grip strength of 35 (10-52, 13) kg. Compared to the other hand, patients regained a mean of 84% in extension/flexion, 103% in supination/pronation, 85% in radial/ulnar deviation, and mean grip strength of 83%. Case 2 slightly distorts the results because the patient additionally had a forearm fracture of the other hand. In comparison to (15) - where a mean of 88% in extension/flexion, 96% in supination/pronation, 87% in radial/ulnar deviation and 84% of the grip strength of the other hand could be achieved at a mean follow-up of 52 months - these are very good results. As in the radiological outcome, an evaluation of the initial situation prior to surgery would have been interesting for the pseudarthroses.

In the same follow-up period, patients achieved only a "fair" functional outcome in the Mayo-wrist score. In the study carried out by Quadlbauer (15), a "good" result was shown. A mean DASH-score of 9 (0-27, 9) points, a PRWE of 12 (0-27, 10) points and a MHQ of 85 (60-100, 11) points resulted in better scores compared to Quadlbauer (15) (mean DASH 13 points, mean PRWE 16 points, mean MHQ 84 points). Therefore, the patients have only slight limitations in daily activities. Again, in the pseudarthroses, an evaluation of the scores prior to surgery would have been of great interest.

Despite the moderate results in humpback deformity, the good results in functional outcome and patient’s self-assessment scores raise the question of what the most important goal is. Is it mainly the union of the fracture parts, and the full anatomical reconstruction only secondary, or have the late effects simply not yet occurred?

4.1 Limitations

Limitations need to be discussed for interpreting the results of the study. The study was a retrospective case review and re-evaluation of radiological data with follow-up on functional outcome and patients' self-assessment. Due to the fact that the study did not take place next to the normal control examinations, there were very different time intervals from the surgery to the clinical evaluation and to the collection of the scores. There was also a wide variation in the follow-up periods for the final CTs, as some patients only had radiographs taken for further follow-up. Some patients had to be excluded from radiological evaluation because no final CT was performed.

The assessment of functional outcome and the collection of the scores took place years after surgery in some patients. This long follow-up time, resulting in patients moving or becoming unavailable due to a change in contact details, and the ongoing Covid19 pandemic at the time of the survey explain the low interest and low number of participants in the case series. A lot of patients refused to take part at a clinical follow-up with X-ray or CT-control.

The difficult comparability of recent fractures and pseudarthroses, as well as the different treatment methods - screw vs plate or with Matti Russe vs without Matti Russe - made a division into groups necessary. Due to the small number of participants (especially in the case series), this resulted in very small groups. Consequently, no meaningful results could be obtained. Since only 4 women (14%) were included, the results could differ for females.

The surgeries where done by different surgeons with different performances.

I was responsible for collecting the data and evaluating the results. Before the study, I had little experience and routine in practice. After appropriate introduction, I was able to keep on learning during the implementation.

4.2 Conclusio

HCS is still the method of choice for recent unstable fractures. With proper surgery, the screw is located interosseously and usually does not require a second intervention for removal (9).

Very good results can be achieved by osteosynthesis with angular stable plate (15) and Matti Russe bone chip in the right indication, such as pseudarthrosis with humpback deformity or cyst formation, in previously failed stabilization attempts, but also as a primary intervention in recent scaphoid fractures with a large zone of comminution (5). Plate osteosynthesis can also be used to try to improve humpback and DISI deformity compared to the initial situation. However, as in our study, this is only possible to a limited extent depending on the initial situation. And the disadvantage of a second intervention for metal removal remains (5).

For statistically significant conclusions, prospectively planned studies with larger patient populations and unified follow-up intervals would have to be designed. Furthermore, a study that takes place in addition to normal follow-up examinations would lead to more participants. In pseudarthrosis, it would be interesting to collect initial radiological and functional data and to assess scores prior to and after surgery. Thus, it could be determined if improvement was achieved by surgery or not.

As a possible future perspective, the results of osteosynthesis using Shark Screw® (See chapter 1.4.2.6 Future prospects: Shark Screw®) should be followed.

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Appendix - Template for telephone contact

Version 1.1

Template für die telefonische Kontaktaufnahme:

Begrüßung und Vorstellung:

Sehr geehrte/r Frau/Herr TITEL, ZUNAME,
Hier spricht Balthasar Johannes Langegger, Student der Medizinischen Universität Graz.

Grund des Anrufs:

Ich rufe bei Ihnen an, da Sie im [Monat und Jahr] eine operative Versorgung Ihrer Kahnbeinfraktur an der Universitätsklinik für Orthopädie und Traumatologie am LKH Graz hatten.

Anliegen:

Im Rahmen eines Forschungsprojekts der Medizinischen Universität Graz möchte ich Ihnen nun die Möglichkeit zur Teilnahme an einer Studie zum Thema „Evaluierung von Kahnbeinfrakturen" nach erfolgter chirurgischer Versorgung bieten.

Vorteil für den/die Patienten/Patientin:

Durch die Teilnahme an der Studie profitieren Sie von einer nochmaligen Kontrolle Ihrer Kahnbeinfraktur. Sollte eine unzureichende Frakturheilung vorliegen, kann weiteres Vorgehen besprochen werden. Sollte ein Röntgen bzw. eine Computertomographie sinnvoll erscheinen, kann diese/s ärztlich angeordnet durchgeführt werden.

Hätten Sie grundsätzlich daran Interesse? Ja/Nein

Bei keinem Interesse:
Bedankung und Verabschiedung.

Bei Interesse:
Weitere Informationen zu

Durchführung und Zeitaufwand:

Die Durchführung der Studie erfolgt im Universitätsklinikum Graz, Abteilung Orthopädie und Traumatologie, Ambulanz, Auenbruggerplatz 5, 8036 Graz.

Ihre Teilnahme erfolgt nach ausführlicher Aufklärung und Zustimmung. Sie werden danach gebeten, einen Fragebogen auszufüllen. (Dieser Prozess dauert ungefähr 15 Minuten.) Des Weiteren werden Bewegungsumfang und Griffstärke jeweils im Seitenvergleich gemessen. Dauer in etwa weitere 10 Minuten. Insgesamt sollte ein Zeitaufwand von ca. 30-45 Minuten eingeplant werden. Zusätzlich erfolgt eine erneute radiologische Beurteilung der Fraktur.

Haben Sie noch Fragen? Ja/Nein

Bei weiteren Fragen:
Beantwortung dieser Fragen.

Version 1.1

Bei keinen weiteren Fragen:
Besteht weiterhin Interesse an der Teilnahme und darf ich sie zu einem Termin einladen?

Bei keinem Interesse:
Bedankung und Verabschiedung

Bei weiterhin bestehendem Interesse:
Einladung zu einem Termin

Hinweis zur Kontaktaufnahme:

Für weitere, ausführliche Informationen zur Studie können Sie sich gerne mit uns in Verbindung zu setzen.

Bedankung und Verabschiedung

Appendix - Template for postal contact

Landeskrankenhaus - Universitätsklinikum Graz

Universitätsklinik für Orthopädie und Traumatologie

Klinikvorstand: Univ.-Prof. Dr. Andreas Leithner
A-8036 Graz, Auenbruggerplatz 5, Tel.: 0316/385 14807

Steiermärkische Krankenanstaltengesellschaft m.b.H. *Medizinische Universität Graz*

Ansprechpartner:
Balthasar Johannes Langegger
Telefon mobil: [redacted]
Telefon: [redacted]
Email: [redacted]
Univ.-Prof. Mag. phil. Dr. med. univ. Franz Seibert [redacted]
Priv.-Doz. Mag. rer. nat. Dr. med. univ. Dr. scient. med. Stefan Fischerauer [redacted]

TITEL, VORNAME, ZUNAME
STRASSE
PLZ, ORT

Sehr geehrte/r Frau/Herr TITEL, ZUNAME,

im Rahmen eines Forschungsprojekts der Medizinischen Universität Graz wird Ihnen die Möglichkeit zur Teilnahme an einer Studie Thema „Evaluierung von Kahnbeinfrakturen" nach erfolgter chirurgischer Versorgung geboten.

Das Ziel dieser Studie ist zu erforschen, ob PatientInnen mit Kahnbeinfrakturen nach Versorgung mittels winkelstabiler Plattenosteosynthese gegenüber Versorgung mittels Herbertschraube hinsichtlich postoperativer Zufriedenheit, Lebensqualität und Schmerzen, der Handgelenksfunktion, des Bewegungsumfanges und der Griffstärke Unterschiede zeigen. Zusätzlich wird eine radiologische Beurteilung der Fraktur vorgenommen.

Gesucht werden Frauen und Männer ab 18 Jahren mit Kahnbeinfraktur in der Krankengeschichte.

Da Sie bereits eine Kahnbeinfraktur hatten, fallen Sie in diese Patientengruppe. Aus diesem Grund erlauben wir uns, Sie zur Teilnahme an der dieser Studie

am TERMIN
in die Universitätsklinik für Orthopädie und Traumatologie
Trauma-/Sportambulanz, Auenbruggerplatz 5, 8036 Graz

einzuladen.

Ihre Teilnahme erfolgt nach ausführlicher Aufklärung und Zustimmung. Sie werden danach gebeten, einen Fragebogen auszufüllen. (Dieser Prozess dauert ungefähr 15 Minuten.) Des Weiteren werden Bewegungsumfang und Griffstärke jeweils im Seitenvergleich gemessen. Dauer in etwa weitere 10 Minuten. Insgesamt sollte ein Zeitaufwand von ca. 30-45 Minuten eingeplant werden.

Durch die Teilnahme an der Studie profitieren Sie von einer nochmaligen Kontrolle Ihrer Kahnbeinfraktur. Sollte eine unzureichende Frakturheilung vorliegen, kann weiteres Vorgehen besprochen werden. Sollte ein Röntgen bzw. eine Computertomographie sinnvoll erscheinen, kann diese/s ärztlich angeordnet durchgeführt werden.

Um weitere, ausführliche Informationen zur Studie zu erhalten, dürfen wir Sie bitten, sich unter untenstehender Kontaktadresse mit uns in Verbindung zu setzen.

Balthasar Johannes Langegger
Telefon mobil: [redacted]
Telefon: [redacted]
Email: [redacted]
Univ.-Prof. Mag. phil. Dr. med. univ. Franz Seibert [redacted]
Priv.-Doz. Mag. rer. nat. Dr. med. univ. Dr. scient. med. Stefan Fischerauer [redacted]

Mit freundlichen Grüßen

Balthasar Johannes Langegger
Univ.-Prof. Mag. phil. Dr. med. univ. Franz Seibert
Priv.-Doz. Mag. rer. nat. Dr. med. univ. Dr. scient. med. Stefan Franz Fischerauer

Seite **2** von **2**

Appendix – Informed consent

PatientInncninformation und Einwilligungserklärung zur Teilnahme an der Studie

Evaluierung von Kahnbeinfrakturen nach Versorgung mittels winkelstabiler Plattenosteosynthese

Untertitel:
Ergebnisse nach Versorgung von Kahnbeinfrakturen mittels "Medartis 1.5 TriLockSkaphoidplatte"

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer!

Wir laden Sie ein, an der oben genannten Studie teilzunehmen.

Ihre Teilnahme an dieser Studie erfolgt freiwillig. Sie können jederzeit ohne Angabe von Gründen aus der Studie ausscheiden. Die Ablehnung der Teilnahme oder ein vorzeitiges Ausscheiden aus dieser Studie hat keine nachteiligen Folgen für Ihre medizinische Betreuung.

Studien sind notwendig, um verlässliche neue medizinische Forschungsergebnisse zu gewinnen. Unverzichtbare Voraussetzung für die Durchführung einer Studie ist jedoch, dass Sie Ihr Einverständnis zur Teilnahme an dieser Studie schriftlich erklären. Bitte lesen Sie den folgenden Text als Ergänzung zum Informationsgespräch sorgfältig durch und zögern Sie nicht Fragen zu stellen.

Bitte unterschreiben Sie die Einwilligungserklärung nur

- wenn Sie Art und Ablauf der Studie vollständig verstanden haben,
- wenn Sie bereit sind, der Teilnahme zuzustimmen und
- wenn Sie sich über Ihre Rechte als TeilnehmerIn an dieser Studie im Klaren sind.

Zu dieser Studie, sowie zur Patienteninformation und Einwilligungserklärung wurde von der zuständigen Ethikkommission eine befürwortende Stellungnahme abgegeben.

1. Was ist der Zweck der Studie?

Das Ziel dieser Studie ist zu erforschen, ob PatientInnen mit Kahnbeinfrakturen nach Versorgung mittels winkelstabiler Plattenosteosynthese gegenüber Versorgung mittels Herbertschraube hinsichtlich postoperativer Zufriedenheit, Lebensqualität und Schmerzen, der Handgelenksfunktion, des Bewegungsumfanges und der Griffstärke Unterschiede zeigen. Zusätzlich wird eine radiologische Beurteilung der Fraktur vorgenommen.

2. Worin liegt der Nutzen einer Teilnahme an der Studie?

Seit einigen Jahren werden an der Universitätsklinik für Orthopädie und Traumatologie am LKH Graz Platten zur Versorgung von Kahnbeinfrakturen eingebracht – bei frischen Frakturen, aber vor allem bei verzögerten Frakturen (delayedunion) und bei Pseudoarthrosen. Die Ergebnisse im Vergleich zu der alternativ einsetzbaren Schraubenosteosynthese sind für die Klinik interessant.

3. Wie läuft die Studie ab?

Ihre Teilnahme erfolgt nach ausführlicher Aufklärung und Zustimmung. Sie werden gebeten Fragebögen auszufüllen. Dieser Prozess dauert ungefähr 15 Minuten. Des Weiteren werden Ihr Bewegungsumfang und Ihre Griffstärke jeweils im Seitenvergleich gemessen. Dauer in etwa weitere 10 Minuten.

4. Entstehen Risiken, Beschwerden oder Begleiterscheinungen durch eine Teilnahme?

Rein studienbedingt werden keine strahlenbelastenden Untersuchungen durchgeführt. Die radiologische Evaluierung erfolgt anhand von vorhandenen Röntgen bzw. Computertomografien. Sollte bei der klinischen Untersuchung eine erneute radiologische Untersuchung aufgrund von unzureichender Frakturheilung für den Patienten von Vorteil sein, kann dies ärztlich angeordnet werden.Allerdings führt die Durchführung eines konventionellen Röntgens zu einer Strahlenbelastung geringer Dosis von ca. 0.01 bis 0.1 mSv, vergleichbar mit einem 2-Stundenflug auf 12.000m Höhe. Die Strahlenbelastung einer CT-Untersuchung des Handgelenks entspräche ca. 0.3 bis 0.4 mSv, dies wäre vergleichbar mit drei Transatlantikflügen hin und zurück.

5. Gibt es durch eine Teilnahme einen potentiellen Benefit?

Sie erhalten eine nochmalige Kontrolle Ihrer Kahnbeinfraktur. Sollte eine unzureichende Frakturheilung vorliegen, kann weiteres Vorgehen besprochen werden.

6. Datenschutz: In welcher Weise werden die im Rahmen dieser Studie erhobenen Daten verwendet und geschützt?

Bei den Daten, die über Sie im Rahmen dieser klinischen Studie erhoben und verarbeitet werden, ist grundsätzlich zu unterscheiden zwischen

1) jenen personenbezogenen Daten, anhand derer Sie direkt identifizierbar sind (z.B. Name, Geburtsdatum, Adresse, Bildaufnahmen...),

2) pseudonymisierten (verschlüsselten) personenbezogenen Daten, bei denen alle Informationen, die direkte Rückschlüsse auf Ihre Identität zulassen, durch einen Code (z. B. eine Zahl) ersetzt bzw. (z.B. im Fall von Bildaufnahmen) unkenntlich gemacht werden. Dies bewirkt, dass die Daten ohne Hinzuziehung zusätzlicher Informationen und ohne unverhältnismäßig großen Aufwand nicht mehr Ihrer Person zugeordnet werden können und

3) anonymisierten Daten, bei denen eine Rückführung auf Ihre Person nicht mehr möglich ist.

Der Code zur Verschlüsselung wird von den verschlüsselten Datensätzen streng getrennt und nur an Ihrem Prüfzentrum aufbewahrt.

Zugang zu Ihren nicht verschlüsselten Daten haben der Prüfarzt und andere Mitarbeiter des Studienzentrums, die an der klinischen Studie oder Ihrer medizinischen Versorgung mitwirken. Die Daten sind gegen unbefugten Zugriff geschützt. Zusätzlich können autorisierte und zur Verschwiegenheit verpflichtete Beauftragte des Sponsors (Medizinische Universität Graz) sowie Beauftragte von in- und/oder ausländischen Gesundheitsbehörden und jeweils zuständige Ethikkommissionen in die nicht verschlüsselten Daten Einsicht nehmen, soweit dies für die Überprüfung der ordnungsgemäßen Durchführung der klinischen Studie notwendig bzw. vorgeschrieben ist.

Eine Weitergabe der Daten, insbesondere an den Sponsor (Medizinische Universität Graz) erfolgt nur in verschlüsselter oder anonymisierter Form. Auch für etwaige Publikationen werden nur die verschlüsselten oder anonymisierten Daten verwendet.

Sämtliche Personen, die Zugang zu Ihren verschlüsselten und nicht verschlüsselten Daten erhalten, unterliegen im Umgang mit den Daten der Datenschutz-Grundverordnung (DSGVO) sowie den österreichischen Anpassungsvorschriften in der jeweils gültigen Fassung. Im Rahmen dieser klinischen Studie ist keine Weitergabe von Daten in Länder außerhalb der EU vorgesehen.

Sie können Ihre Einwilligung zur Erhebung und Verarbeitung Ihrer Daten jederzeit widerrufen.

Nach Ihrem Widerruf werden keine weiteren Daten mehr über Sie erhoben. Die bis zum Widerruf erhobenen Daten können allerdings weiter im Rahmen dieser klinischen Studie verwendet werden.

Aufgrund der gesetzlichen Vorgaben haben Sie außerdem, sofern dies nicht die Durchführung der klinischen Studie voraussichtlich unmöglich macht oder ernsthaft beeinträchtigt, das Recht auf Einsicht in die Ihre Person betreffenden Daten und die Möglichkeit der Berichtigung, falls Sie Fehler feststellen. Sie haben auch das Recht, bei der österreichischen Datenschutzbehörde eine Beschwerde über den Umgang mit Ihren Daten einzubringen (www.dsb.gv.at).

Die Dauer der Speicherung Ihrer Daten über das Ende der klinischen Studie hinaus ist durch Rechtsvorschriften geregelt.

Falls Sie Fragen zum Umgang mit Ihren Daten in dieser klinischen Studie haben, wenden Sie sich zunächst an den/die Versuchsleiter/in. Dieser kann Ihr Anliegen ggf. an die Personen, die beim Sponsor oder am Studienzentrum für den Datenschutz verantwortlich sind, weiterleiten.

Kontaktstelle zum Datenschutz in den Krankenanstalten der KAGes:datenschutz@kages.at
Kontaktstelle zum Datenschutz am LKH-Univ.Klinikum: datenschutz@medunigraz.at

7. Wann wird die Studie vorzeitig beendet?

Sie können jederzeit auch ohne Angabe von Gründen, Ihre Teilnahmebereitschaft widerrufen und aus der klinischen Prüfung ausscheiden ohne dass Ihnen dadurch irgendwelche Nachteile für Ihre weitere medizinische Betreuung entstehen. Ihre bis dahin erhobenen Daten werden gelöscht, es sei denn, sie stimmen der weiteren Verwendung ihrer Daten explizit zu.

8. Entstehen für die Teilnehmer Kosten? Gibt es einen Kostenersatz oder eine Vergütung?

Durch Ihre Teilnahme an dieser Studie entstehen für Sie keine zusätzlichen Kosten. Ein Kostenersatz oder eine Vergütung sind nicht vorgesehen.

9. Möglichkeit zur Diskussion weiterer Fragen

Für weitere Fragen im Zusammenhang mit der Studie stehen Ihnen alle Durchführenden der Studie zur Verfügung. Auch Fragen, die Ihre Rechte als Patient und Teilnehmer an dieser Studie betreffen, werden Ihnen gerne beantwortet. Namen der Kontaktpersonen und deren Durchwahlnummern (unter der Nummer 0316 - 385 DW 82156 ist ständig jemand erreichbar):

Univ.-Prof. Mag.phil. Dr.med.univ. Franz Seibert [redacted]
PD Mag. DDr. Stefan Fischerauer [redacted]

10. Einwilligungserklärung

Name des/r Patienten/in in Druckbuchstaben (oder PatientInnenetikett)

_____ Geb.Datum:_____

Ich erkläre mich bereit, an der Studie „Evaluierung von Kahnbeinfrakturen nach Versorgung mittels winkelstabiler Plattenosteosynthese - Ergebnisse nach Versorgung von Kahnbeinfrakturen mittels Medartis 1.5 TriLockSkaphoidplatte“ teilzunehmen.

Ich bin von Herrn/Frau_____ ausführlich und verständlich über mögliche Belastungen und Risiken aufgeklärt, sowie über das Wesen, die Bedeutung und Tragweite der Studie aufgeklärt worden. Ich habe darüber hinaus den Text dieser Patientenaufklärung und Einwilligungserklärung, die insgesamt 5 Seiten umfasst gelesen. Aufgetretene Fragen wurden mir vondem/der Versuchsleiter/in verständlich und genügend beantwortet. Ich hatte ausreichend Zeit, mich zu entscheiden. Ich habe zurzeit keine weiteren Fragen mehr.

Ich werde den Anordnungen, die für die Durchführung der klinischen Prüfung erforderlich sind, Folge leisten, behalte mir jedoch das Recht vor, meine freiwillige Mitwirkung jederzeit zu beenden, ohne dass mir daraus Nachteile für meine weitere medizinische Betreuung entstehen.

Ich stimme ausdrücklich zu, dass meine im Rahmen dieser klinischen Prüfung erhobenen Daten wie im Abschnitt „Datenschutz“ dieses Dokuments beschrieben verwendet werden.

Eine Kopie dieser Patienteninformation und Einwilligungserklärung habe ich erhalten. Das Original verbleibt am Klinikum.

_____
(Datum und Unterschrift des/r Patienten/in)

_____
(Datum, Name und Unterschrift des/r Versuchsleiters/in)
(Der/die Patient/in erhält auf Wunsch eine unterschriebene Kopie der Patienteninformation und Einwilligungserklärung, das Original verbleibt im Studienordner.)

Appendix – Demography form

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Demography Form

Study ID _____

GENERAL INFORMATION

Email (optional) _____

date_of_birth _____

sex ○ male ○ female

smoker ○ Yes ○ No ○ N/A

diabetes ○ Yes ○ No ○ N/A

ANAMNESIS:

date_of_injury _____

injured_hand ○ right ○ left

injured_is_dominant_hand ○ Yes ○ No
(0=no/1=yes)

additional_injury/s ○ Yes ○ No

type_additional_injury/s _____
(short summary of additional injuries)

De_Quervain ○ Yes ○ No ○ N/A

SURGERY

date_of_surgery _____

age_surgery _____
(in years)

period_injury_surgery _____
(in days)

number_surgical_interventions
○ 0
○ 1
○ 2
○ 3
○ 4
○ 5
(before the actual intervention)

surgeon _____

surgical_intervention ○ Herbert Screw ○ Medartis TriLock Scaphoid Plate

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number of Herbert Screws ○ 1 ○ 2

Matti_Russe ○ Yes ○ No

extraction point _____

complications_surgery ○ Yes ○ No
(during surgery)

type_of_complications _____
(during surgery)

POST_SURGERY:

metal_explantation ○ Yes ○ No ○ N/A

date_of_MEX _____

period_surgery_MEX _____
(in days)

comments_df _____

Appendix – Radiological assessment

Radiological Assessment_Student

Study ID _____

PRE SURGERY

HERBERT CLASSIFICATION

date_of_pre_CT _____

period_surgery_pre_CT _____
(in days)

Herbert classification
- ◯ A stable fracture
- ◯ B instable fracture
- ◯ C delayed union
- ◯ D pseudarthrosis

Herbert classification subtype
- ◯ A1 fracture tuberculum
- ◯ A2 incomplete waist fracture
- ◯ B1 distal oblique fracture
- ◯ B2 complete waist fracture
- ◯ B3 pole fracture
- ◯ B4 de Quervain luxation fracture
- ◯ C delayed union
- ◯ D1 stable pseudarthrosis
- ◯ D2 instable pseudarthrosis
- ◯ D3 ascierotic pseudarthrosis
- ◯ D4 avascular pseudarthrosis

POST SURGERY

HUMPBACK DEFORMITY

date_of_last_CT _____

period_surgery_lastCT _____
(in days)

hb_height _____
([mm] at the longest point)

hb_lenght _____
([mm] at the longest point)

H/L-ratio _____
([%])

humpback_deformity _____
(0=no/1=yes)

UNION

union_section1 _____
([mm] sagittal!)

bone_section1 _____
([mm] sagittal!)

union/bone_section1 _____
([%])

union_section2 _____
([mm] sagittal!)

bone_section2 _____
([mm] sagittal!)

union/bone_section2 _____
([%])

union_section3 _____
([mm] sagittal!)

bone_section3 _____
([mm] sagittal!)

union/bone_section3 _____
([%])

union_section4 _____
([mm] sagittal!)

bone_section4 _____
([mm] sagittal!)

union/bone_section4 _____
([%])

union_section5 _____
([mm] sagittal!)

bone_section5 _____
([mm] sagittal!)

union/bone_section5 _____
([%])

union_section6 _____
([mm] sagittal!)

bone_section6 _____
([mm] sagittal!)

union/bone_section6 _____
([%])

union_section7 _____
([mm] sagittal!)

bone_section7 _____
([mm] sagittal!)

union/bone_section7 _____ ([%])

union_section8 _____ ([mm] sagittal!)

bone_section8 _____ ([mm] sagittal!)

union/bone_section8 _____ ([%])

union_section9 _____ ([mm] sagittal!)

bone_section9 _____ ([mm] sagittal!)

union/bone_section9 _____ ([%])

union_section10 _____ ([mm] sagittal!)

bone_section10 _____ ([mm] sagittal!)

union/bone_section10 _____ ([%])

number of sections _____ (insert the number of the evaluated sections)

POSTOPERATIVE ARTHROSIS - POA

postoperative_arthrosis
- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3

(p.a.+lateral: 0=none/1=slight/2=marked/3=bone_on_bone)

DORSAL INTERCALATED SEGMENT INSTABILITY - DISI

capitolunate_angle _____ ([degrees] lateral!)

DISI_deformity _____ (0=no/1=yes)

SCAPHOID NONUNION ADVANCED COLLAPSE

SNAC_wrist
- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3

(0=none/1=proc_styl/2=+rad+scaph/3=+lun+cap)

COMMENTS

comments_ra _____

Appendix – Clinical assessment

Clinical Assessment

Study ID _____

date_of_examination _____

period_surgery_examinaton _____ (in days)

RANGE OF MOTION - ROM

ROM LEFT HAND

left flexion _____ (in degrees [60-90])

left extension _____ (in degrees [60-80])

left_ROM_flexion_extension _____ (in degrees)

left radial abduction _____ (in degrees [25-30])

left ulnar abduction _____ (in degrees [30-40])

left_ROM_radial_ulnar _____ (in degrees)

left pronation _____ (in degrees [85-90])

left supination _____ (in degrees [85-90])

left_ROM_pronation_supination _____ (in degrees)

ROM RIGHT HAND

right flexion _____ (in degrees [60-90])

right extension _____ (in degrees [60-80])

right_ROM_flexion_extension _____ (in degrees)

right radial abduction _____ (in degrees [25-30])

right ulnar abduction _____ (in degrees [30-40])

right_ROM_radial_ulnar _____ (in degrees)

right pronation _____ (in degrees [85-90])

right supination _____ (in degrees [85-90])

right_ROM_pronation_supination _____ (in degrees)

GRIP STRENGHT LEFT

left grip strenght 1 _____ (in kg [60 seconds break!])

left grip strenght 2 _____ (in kg [60 seconds break!])

left grip strenght 3 _____ (in kg [60 seconds break!])

left mean grip strenght _____ (in kg)

left maximum grip strenght _____ (in kg)

GRIP STRENGHT RIGHT HAND

right grip strenght 1 _____ (in kg [60 seconds break!])

right grip strenght 2 _____ (in kg [60 seconds break!])

right grip strenght 3 _____ (in kg [60 seconds break!])

right mean grip strenght _____ (in kg)

right maximum grip strenght _____ (in kg)

NUMERIC RATING SCALE - NRS

numeric rating scale

○ 0 no pain ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 worst pain

COMMENTS

comments_ca _____

Appendix – Scores

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Scaphoid Osteosynthesis
Page 1 of 1

Mayo

Study ID _____

Mayo Wrist Score

Mittels Mayo Wrist Score werden Schmerz, funktioneller Status, Bewegungsumfang und Griffstärke beurteilt.

In den vergangenen vier Wochen....

Schmerz	◯ kein Schmerz ◯ wenig, manchmal ◯ mäßig, tolerabel ◯ stark bis unerträglich
Funktioneller Status	◯ zurückgekehrt zu normaler Arbeit ◯ eingeschränkte Arbeit ◯ kann arbeiten, arbeitslos ◯ kann wegen Schmerzen nicht arbeiten
Bewegungsumfang	◯ 100% / 120° oder mehr ◯ 75-99% / 91-119° ◯ 51-75% / 61-90° ◯ 25-49% / 31-60° ◯ 0-24% / 30° oder weniger
Griffstärke	◯ 100% ◯ 75-99% ◯ 50-74% ◯ 25-49% ◯ 0-24%

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Scaphoid Osteosynthesis
Page 1 of 1

Nur alternativ zu Mayo: Krimmer

Study ID _____

Krimmer Score

Mittels Krimmer-Score werden Kraft, Bewegungsumfang, Schmerz und Gebrauchsfähigkeit beurteilt.

In den vergangenen vier Wochen...

Kraft (in % der kontralateralen Hand)	◯ 0 - 25 (0) ◯ >25 - 50 (10) ◯ >50 - 75 (20) ◯ >75 - 100 (30)
Bewegungsumfang	◯ Extension/Flexion < 30°, Ulnar-/Radialabduktion < 10°, Pronation/Supination < 80° (0) ◯ Extension/Flexion 31° - 60°, Ulnar-/Radialabduktion 10° - 35°, Pronation/Supination 81°- 110° (10) ◯ Extension/Flexion 61° - 100°, Ulnar-/Radialabduktion 36° - 50° , Pronation/Supination 111° - 140° (15) ◯ Extension/Flexion >100° , Ulnar-/Radialabduktion >50° , Pronation/Supination >140° (20)
Schmerz	◯ sehr stark, extrem (0) ◯ ohne / mit Belastung (10) ◯ nur bei Belastung (15) ◯ schmerzfrei (20)
Gebrauchsfähigkeit	◯ starke Einschränkung bei täglichen Aktivitäten (0) ◯ maßige Einschränkung (10) ◯ Einschränkung bei bestimmten Aktivitäten (20) ◯ normal, keine Einschränkung (30)

DASH - Disabilities of the arm, shoulder and hand

Bitte füllen Sie den folgenden Fragebogen aus.

Vielen Dank!

heutiges Datum _____

DASH - DISABILITIES OF THE ARM, SHOULDER AND HAND

ANLEITUNG: Dieser Fragebogen beschäftigt sich so-wohl mit Ihren Beschwerden als auch mit Ihren Fähigkeiten, bestimmte Tätigkeiten auszuführen. Bitte beantworten Sie alle Fragen gemäß Ihrem Zustand in der vergangenen Woche, indem Sie einfach die entsprechende Zahl ankreuzen. Wenn Sie in der vergangenen Woche keine Gelegenheit gehabt haben, eine der unten aufgeführten Tätigkeiten durchzuführen, so wählen Sie die Antwort aus, die Ihrer Meinung nach am ehesten zutreffen würde. Es ist nicht entscheidend, mit welchem Arm oder welcher Hand Sie diese Tätigkeiten ausüben. Antworten Sie Ihrer Fähigkeit entsprechend, ungeachtet, wie Sie die Aufgaben durchführen konnten.

Bitte schätzen Sie Ihre Fähigkeit ein, wie Sie folgende Tätigkeiten in der vergangenen Woche durchgeführt haben, indem Sie die entsprechende Zahl ankreuzen.

	1. Keine Schwierigkeiten	2. Geringe Schwierigkeiten	3. Mäßige Schwierigkeiten	4. Erhebliche Schwierigkeiten	5. Nicht möglich
1. Ein neues oder festverschlossenes Glas öffnen	○	○	○	○	○
2. Schreiben	○	○	○	○	○
3. Einen Schlüssel umdrehen	○	○	○	○	○
4. Eine Mahlzeit zubereiten	○	○	○	○	○
5 .Eine schwere Tür aufstoßen	○	○	○	○	○
6. Einen Gegenstand über Kopfhöhe auf ein Regal stellen	○	○	○	○	○
7. Schwere Hausarbeit (z.B. Wände abwaschen, Boden putzen)	○	○	○	○	○
8. Garten- oder Hofarbeit	○	○	○	○	○
9. Betten machen	○	○	○	○	○
10. Eine Einkaufstasche oder einen Aktenkoffer tragen	○	○	○	○	○
11. Einen schweren Gegenstand tragen (über 5kg)	○	○	○	○	○

12. Eine Glühbirne über Ihrem Kopf auswechseln	○	○	○	○	○
13. Ihre Haare waschen oder fönen	○	○	○	○	○
14. Ihren Rücken waschen	○	○	○	○	○
15. Einen Pullover anziehen	○	○	○	○	○
16. Ein Messer benutzen, um Lebensmittel zu schneiden	○	○	○	○	○
17. Freizeitaktivitäten, die wenig körperliche Anstrengung verlangen (z. B. Karten spielen, Stricken, usw.)	○	○	○	○	○
18. Freizeitaktivitäten, bei denen auf Ihren Arm, Schulter oder Hand Druck oder Stoß ausgeübt wird (z.B. Golf, Hämmern, Tennis, usw.)	○	○	○	○	○
19. Freizeitaktivitäten, bei denen Sie Ihren Arm frei bewegen(z. B. Badminton, Frisbee)	○	○	○	○	○
20. Mit Fortbewegungsmitteln zurecht zu kommen (um von einem Platz zum anderen zu gelangen)	○	○	○	○	○
21. Sexuelle Aktivität	○	○	○	○	○

	1. Überhaupt nicht	2. Ein wenig	3. Mäßig	4. Ziemlich	5. Sehr
22. In welchem Ausmaß haben Ihre Schulter-, Arm- oder Handprobleme Ihre normalen sozialen Aktivitäten mit Familie, Freunden, Nachbarn oder anderen Gruppen während der vergangenen Woche beeinträchtigt? (Bitte kreuzen Sie die entsprechende Zahl an)	○	○	○	○	○

	1. Überhaupt nicht eingeschränkt	2. Ein wenig eingeschränkt	3. Mäßig eingeschränkt	4. Sehr eingeschränkt	5. Nicht möglich
23. Waren Sie in der vergangenen Woche durch Ihre Schulter-, Arm- oder Handprobleme in Ihrer Arbeit oder anderen alltäglichen Aktivitäten eingeschränkt? (Bitte kreuzen Sie die entsprechende Zahl an)	○	○	○	○	○

Bitte schätzen Sie die Schwere der folgenden Symptome während der letzten Woche ein.
(Bitte kreuzen Sie in jeder Zeile die entsprechende Zahl an)

	1. Keine	2. Leichte	3. Mäßige	4. Starke	5. Sehr starke
24. Schmerzen in Schulter, Arm oder Hand	○	○	○	○	○
25. Schmerzen in Schulter, Arm oder Hand während der Ausführung einer bestimmten Tätigkeit	○	○	○	○	○
26. Kribbeln (Nadelstiche) in Schulter, Arm oder Hand	○	○	○	○	○
27. Schwächegefühl in Schulter, Arm oder Hand	○	○	○	○	○
28. Steifheit in Schulter, Arm oder Hand	○	○	○	○	○
29. Wie groß waren Ihre Schlafstörungen in der letzten Woche aufgrund von Schmerzen im Schulter-, Arm- oder Handbereich?	○	○	○	○	○

	1.Stimme überhaupt nicht zu	2.Stimme nicht zu	3.Weder Zustimmung noch Ablehnung	4.Stimme zu	5.Stimme sehr zu
30. Aufgrund meiner Probleme im Schulter-, Arm- oder Handbereich empfinde ich meine Fähigkeiten als eingeschränkt, ich habe weniger Selbstvertrauen oder ich fühle, dass ich mich weniger nützlich machen kann. (Bitte kreuzen Sie die entsprechende Zahl an)	○	○	○	○	○

SPORT- UND MUSIK-MODUL

	Ja	Nein
Betreiben Sie Sport oder spielen Sie ein Musikinstrument?	○	○

Die folgenden Fragen beziehen sich auf den Einfluss Ihres Schulter-, Arm- oder Handproblems auf das Spielen Ihres Musikinstrumentes oder auf das Ausüben Ihres Sports oder auf beides. Wenn Sie mehr als ein Instrument spielen oder mehr als eine Sportart ausüben (oder beides), so beantworten Sie bitte die Fragen in bezug auf das Instrument oder die Sportart, die für Sie am wichtigsten ist. Bitte geben Sie dieses Instrument bzw. diese Sportart hier an: _____

Bitte kreuzen Sie die Zahl an, die Ihre körperlichen Fähigkeiten in der vergangenen Woche am besten beschreibt. Hatten Sie irgendwelche Schwierigkeiten:

	1. Keine Schwierigkeiten	2. Geringe Schwierigkeiten	3. Mäßige Schwierigkeiten	4. Erhebliche	5. Nicht möglich
1. In der üblichen Art und Weise Ihr Musikinstrument zu spielen oder Sport zu treiben?	○	○	○	○	○
2. Aufgrund der Schmerzen in Schulter, Arm oder Hand Ihr Musikinstrument zu spielen oder Sport zu treiben?	○	○	○	○	○
3. So gut Ihr Musikinstrument zu spielen oder Sport zu treiben wie Sie es möchten?	○	○	○	○	○
4. Die bisher gewohnte Zeit mit dem Spielen Ihres Musikinstrumentes oder mit Sporttreiben zu verbringen?	○	○	○	○	○

ARBEITS- UND BERUFS-MODUL

	Ja	Nein
Sind Sie berufstätig (einschließlich Haushaltsführung, falls dies Ihre Hauptbeschäftigung ist)?	○	○

Die folgenden Fragen beziehen sich auf den Einfluss Ihres Schulter-, Arm- oder Handproblems auf Ihre Arbeit (einschließlich Haushaltsführung, falls dies Ihre Hauptbeschäftigung ist).Bitte geben Sie Ihre/n Arbeit/Beruf hier an: _____

Bitte kreuzen Sie die Zahl an, die Ihre körperlichen Fähigkeiten in der vergangenen Woche am besten beschreibt. Hatten Sie irgendwelche Schwierigkeiten:

	1. Keine Schwierigkeiten	2. Geringe Schwierigkeiten	3. Mäßige Schwierigkeiten	4. Erhebliche Schwierigkeiten	5. Nicht möglich
1. In der üblichen Art und Weise zu arbeiten?	○	○	○	○	○
2. Aufgrund der Schmerzen in Schulter, Arm oder Hand Ihre übliche Arbeit zu erledigen?	○	○	○	○	○
3. So gut zu arbeiten wie Sie es möchten?	○	○	○	○	○
4. Die bisher gewohnte Zeit mit Ihrer Arbeit zu verbringen?	○	○	○	○	○

MHQ

Bitte füllen Sie den folgenden Fragebogen aus.

Vielen Dank!

MHQ - Michigan Hand Outcome Questionaire

Bitte beantworten Sie die folgenden 37 Multiple-Choice-Fragen. Die Fragen beziehen sich auf die Funktion Ihrer Hand und/oder Ihres Handgelenks in der vergangenen Woche...

		Sehr gut	Gut	Mittel	Schlecht	Sehr schlecht
1)	1. Wie gut hat Ihre Hand generell funktioniert?	○	○	○	○	○
2)	2. Wie gut haben Sie Ihre Finger bewegen können?	○	○	○	○	○
3)	3. Wie gut haben Sie Ihr Handgelenk bewegen können?	○	○	○	○	○
4)	4. Wie gut ist die Kraft in/Griffstärke Ihrer Hand gewesen?	○	○	○	○	○
5)	5. Wie ist die Sensibilität/das Gefühl in Ihrer Hand gewesen?	○	○	○	○	○

Bitte schätzen Sie ein, wie schwer sind Ihnen die folgenden Tätigkeiten in der vergangenen Woche gefallen sind:

		Sehr leicht	Leicht	Mittel	Schwer	Sehr schwer
6)	6. Das Betätigen eines Türgriffs	○	○	○	○	○
7)	7. Das Aufheben einer Münze	○	○	○	○	○
8)	8. Das Halten eines Wasserglases	○	○	○	○	○
9)	9. Das Umdrehen eines Schlüssels	○	○	○	○	○
10)	10. Das Halten einer Pfanne	○	○	○	○	○
11)	11. Das Öffnen eines Marmelade-/Gurken-/Honigglases	○	○	○	○	○
12)	12. Das Zuknöpfen einer Bluse oder eines Hemdes	○	○	○	○	○
13)	13. Das Essen mit Messer und Gabel	○	○	○	○	○
14)	14. Das Tragen einer Einkaufstasche	○	○	○	○	○
15)						

	15. Das Spülen von Geschirr	○	○	○	○	○
16)	16. Das Waschen der Haare	○	○	○	○	○
17)	17. Das Binden von Schuhbändern oder Knoten	○	○	○	○	○

Bitte beschreiben Sie, wie oft Ihnen die folgenden Tätigkeiten Probleme bereitet haben:

		Immer	Oft	Manchmal	Selten	Nie
18)	18. Wie oft ist es Ihnen aufgrund der Probleme mit Ihrer Hand und/oder Ihres Handgelenks nicht möglich gewesen, Ihre Arbeit zu verrichten?	○	○	○	○	○
19)	19. Wie oft haben Sie aufgrund der Probleme mit Ihrer Hand und/oder Ihres Handgelenks Ihre Arbeit abbrechen müssen?	○	○	○	○	○
20)	20. Wie oft haben Sie sich aufgrund der Probleme mit Ihrer Hand und/oder Ihres Handgelenks in der Arbeit schonen müssen?	○	○	○	○	○
21)	21. Wie oft haben Sie aufgrund der Probleme mit Ihrer Hand und/oder Ihres Handgelenks weniger Ihrer zu leistenden Arbeit geschafft?	○	○	○	○	○
22)	22. Wie oft haben Sie aufgrund der Probleme mit Ihrer Hand und/oder Ihres Handgelenks länger für Ihre Arbeitsaufgaben gebraucht?	○	○	○	○	○

23) 23. Wie oft haben Sie Schmerzen in Ihrer Hand und/oder Ihrem Handgelenk gehabt?

○ Immer ○ Oft ○ Manchmal ○ Selten ○ Nie

		Sehr leicht	Leicht	Mittel	Stark	Sehr stark
24)	24. Bitte beschreiben Sie die Schmerzen in Ihrer Hand und/oder Ihrem Handgelenk:	○	○	○	○	○

Bitte beschreiben Sie, wie oft folgende Situationen aufgetreten sind:

		Immer	Oft	Manchmal	Selten	Nie
25)	25. Wie oft haben Schmerzen in Ihrer Hand und/oder Ihrem Handgelenk Ihren Schlaf beeinträchtigt?	○	○	○	○	○
26)	26. Wie oft haben Schmerzen in Ihrer Hand und/oder Ihrem Handgelenk Ihre täglichen Aktivitäten (wie z.B. Essen oder Baden) beeinträchtigt?	○	○	○	○	○
27)	27. Wie oft haben Sie sich aufgrund von Schmerzen in Ihrer Hand und/oder Ihrem Handgelenk frustriert gefühlt?	○	○	○	○	○

Wie sehr stimmen Sie den folgenden Aussagen zu:

28) 28. Ich bin mit dem Aussehen meiner Hand zufrieden gewesen.

○ Stimme sehr zu ○ Stimme zu ○ Weder Zustimmung noch Ablehnung ○ Stimme nicht zu ○ Stimme gar nicht zu

		Stimme sehr zu	Stimme zu	Weder Zustimmung noch Ablehnung	Stimme nicht zu	Stimme gar nicht zu
29)	29. Aufgrund des Aussehens meiner Hand habe ich mich in der Öffentlichkeit unwohl gefühlt.	○	○	○	○	○
30)	30. Aufgrund des Aussehens meiner Hand habe ich mich deprimiert/schlecht gefühlt.	○	○	○	○	○
31)	31. Das Aussehen meiner Hand hat Auswirkungen auf meine sozialen Aktivitäten gehabt.	○	○	○	○	○

Wie zufrieden sind Sie mit den folgenden Funktionen Ihrer Hand gewesen:

		Sehr zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Etwas unzufrieden	Sehr unzufrieden
32)	32. Generelle Funktion Ihrer Hand?	○	○	○	○	○
33)	33. Beweglichkeit Ihrer Finger?	○	○	○	○	○
34)	34. Beweglichkeit Ihres Handgelenks?	○	○	○	○	○
35)	35. Griffstärke/Kraft Ihrer Hand?	○	○	○	○	○
36)	36. Schmerzniveau Ihrer Hand?	○	○	○	○	○
37)	37. Sensibilität (Gefühl) Ihrer Hand?	○	○	○	○	○

PRWE

Bitte füllen Sie den folgenden Fragebogen aus.

Vielen Dank!

PRWE - Patient-Rated Wrist Evaluation Score

Die unten aufgeführten Fragen sollten uns helfen, das Ausmaß der Schwierigkeiten, die Sie wegen Ihres Handgelenks in der letzten Woche hatten, zu verstehen. Sie werden gebeten, auf einer Skala von 0 bis 10 anzugeben, wie stark Ihre Handgelenksbeschwerden bei den folgenden Tätigkeiten in der letzten Woche durchschnittlich waren.
Bitte beantworten Sie ALLE Fragen. Wenn Sie eine (oder mehrere) der Tätigkeiten in der letzten Woche nicht ausgeführt haben, SCHÄTZEN Sie bitte das Ausmaß der Schmerzen oder Schwierigkeiten ein, die Sie erwarten würden. Wenn Sie eine Tätigkeit niemals ausgeführt haben, kreuzen Sie bitte jeweils "trifft nicht zu" an.

1. SCHMERZEN

Bitte geben Sie die durchschnittliche Stärke der Schmerzen in Ihrem Handgelenk in der letzten Woche an, indem Sie die Zahl auf der Skala von 0 bis 10 ausfüllen, die Ihre Schmerzen am besten beschreibt. Null (0) bedeutet, dass Sie keinerlei Schmerzen hatten und Zehn (10) bedeutet, dass Sie die schlimmsten Schmerzen hatten, die Sie je erlebt haben oder, dass Sie die Tätigkeit aufgrund der Schmerzen nicht ausführen konnten.

Bitte geben Sie die Stärke Ihrer Schmerzen an:

		0 keinerlei Schmerzen	1	2	3	4	5	6	7	8	9	10 schlimmste Schmerzen
1)	1. In Ruhe	○	○	○	○	○	○	○	○	○	○	○
2)	2. Bei Tätigkeiten mit wiederholter Bewegung des Handgelenks	○	○	○	○	○	○	○	○	○	○	○
3)	3. Beim Heben eines schweren Gegenstandes	○	○	○	○	○	○	○	○	○	○	○
4)	4. Wenn sie am stärksten sind	○	○	○	○	○	○	○	○	○	○	○
		0 nie	1	2	3	4	5	6	7	8	9	10 immer

5)

	5. Wie häufig haben Sie Schmerzen?	○	○	○	○	○	○	○	○	○	○	○	

2. FUNKTION

Funktionsfähigkeit - Bestimmte Tätigkeiten

Bitte geben Sie an, wie viele Schwierigkeiten Sie in der letzten Woche bei jeder der unten aufgeführten Tätigkeiten hatten. Bitte kreuzen Sie die Zahl von 0 bis 10 an, die das Ausmaß Ihrer Schwierigkeiten am besten beschreibt.
Null (0) bedeutet, dass Sie keinerlei Schwierigkeiten hatten und Zehn (10) bedeutet, dass die Schwierigkeiten so groß waren, dass Sie die Tätigkeit nicht ausführen konnten.
Wenn Sie eine Tätigkeit niemals ausgeführt haben, kreuzen Sie bitte den Punkt "trifft nicht zu" an.

		0 keinerlei Schwierigkeiten	1	2	3	4	5	6	7	8	9	10 nicht möglich	trifft nicht zu
6)	6. Mit der betroffenen Hand einen Türknauf drehen	○	○	○	○	○	○	○	○	○	○	○	○
7)	7. Mit der betroffenen Hand Fleisch mit dem Messer schneiden	○	○	○	○	○	○	○	○	○	○	○	○
8)	8. Ein Hemd oder eine Bluse zuknöpfen	○	○	○	○	○	○	○	○	○	○	○	○
9)	9. Die betroffene Hand nutzen, um von einem Stuhl aufzustehen	○	○	○	○	○	○	○	○	○	○	○	○
10)	10. Mit der betroffenen Hand einen 5 kg schweren Gegenstand tragen	○	○	○	○	○	○	○	○	○	○	○	○
11)	11. Mit der betroffenen Hand das Toilettenpapier benutzen	○	○	○	○	○	○	○	○	○	○	○	○

Funktionsfähigkeit - Gewöhnliche Tätigkeiten

Bitte geben Sie an, wie viele Schwierigkeiten Sie in der letzten Woche bei Ihren gewöhnlichen Tätigkeiten in jedem der unten genannten Bereiche hatten. Bitte füllen Sie die Zahl von 0 bis 10 aus, die das Ausmaß Ihrer Schwierigkeiten am besten beschreibt. Unter "gewöhnliche Tätigkeiten" verstehen wir die Aktivitäten, die Sie ausführten, bevor die Probleme mit Ihrem Handgelenk begannen. Null (0) bedeutet, dass Sie keinerlei Schwierigkeiten hatten und Zehn (10) bedeutet, dass Sie so große Schwierigkeiten hatten, dass Sie keine dieser gewöhnlichen Tätigkeit ausführen konnten. Wenn Sie eine Tätigkeit niemals ausgeführt haben, kreuzen Sie bitte den Punkt "trifft nicht zu" an.

		0 keinerlei Schwierigkeiten	1	2	3	4	5	6	7	8	9	10 nicht möglich	trifft nicht zu
12)	12. Persönliche Körperpflege (Anziehen, Waschen)	○	○	○	○	○	○	○	○	○	○	○	○
13)	13. Hausarbeit (Putzen, Aufräumen, kleine Reparaturen)	○	○	○	○	○	○	○	○	○	○	○	○
14)	14. Arbeit (Beruf oder Alltagstätigkeiten)	○	○	○	○	○	○	○	○	○	○	○	○
15)	15. Freizeitaktivitäten	○	○	○	○	○	○	○	○	○	○	○	○

PCS

Bitte füllen Sie den folgenden Fragebogen aus.

Vielen Dank!

PCS - Pain Catastrophizing Scale

Hier finden Sie verschiedene Fragen vor. Bitte lesen Sie jeweils die Einleitung und füllen Sie alle nachfolgenden Fragen aus.

Irgendwann im Leben erleidet jeder Mensch einmal Schmerzen. Dies können z.B. Kopf-, Zahn-, Gelenk- oder Muskelschmerzen sein. Menschen sind oft Situationen ausgesetzt, die Schmerzen verursachen, wie Krankheiten, Verletzungen, Zahnbehandlungen oder Operationen. Wir sind an den Gedanken und Gefühlen interessiert, die Sie haben, wenn Sie Schmerzen erleiden.

Die folgenden dreizehn Sätze beschreiben verschiedene Gedanken und Gefühle, die bei Schmerzen auftreten können. Bitte markieren Sie auf der folgenden Skala, wie stark diese Gedanken und Gefühle auf Sie zutreffen, wenn Sie Schmerzen haben.

Wenn ich Schmerzen habe, beschäftigen mich folgende Gedanken...

		0 trifft überhaupt nicht zu	1 trifft eher nicht zu	2 Teils-teils	3 trifft eher zu	4 trifft immer zu
1)	1. Ich mache mir ständig Sorgen, ob die Schmerzen wohl jemals wieder aufhören werden.	○	○	○	○	○
2)	2. Ich denke, ich kann nicht mehr	○	○	○	○	○
3)	3. Der Zustand ist schrecklich und ich denke, dass es nie mehr besser wird.	○	○	○	○	○
4)	4. Der Zustand ist furchtbar und droht mich zu überwältigen.	○	○	○	○	○
5)	5. Ich habe das Gefühl, ich halte es nicht mehr aus.	○	○	○	○	○
6)	6. Ich bekomme Angst, dass die Schmerzen noch stärker werden.	○	○	○	○	○
7)	7. Ich denke ständig an andere Situationen, in denen ich Schmerzen hatte.	○	○	○	○	○
8)						

	8. Ich wünsche mir verzweifelt, dass die Schmerzen weggehen.	○	○	○	○	○
9)	9. Ich kann nicht aufhören, an die Schmerzen zu denken.	○	○	○	○	○
10)	10. Ich denke ständig daran, wie sehr es schmerzt.	○	○	○	○	○
11)	11. Ich denke ständig daran, wie sehr ich mir ein Ende der Schmerzen herbeiwünsche.	○	○	○	○	○
12)	12. Es gibt nichts, was ich tun kann, um die Schmerzen zu lindern.	○	○	○	○	○
13)	13. Ich mache mir Sorgen, dass die Schmerzen auf etwas Schlimmes hindeuten.	○	○	○	○	○