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ARTICLE

Satisfactory function 12 years after triscaphoid arthrodesis for chronic scapholunate ligament injury

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ABSTRACT

Scapholunate ligament (SLL) injury represents a hazard to the wrist and the treatment of these injuries has been the focus of much debate. We performed a long-term follow (>10 years) of triscaphoid arthrodesis for symptomatic chronic SLL injuries in 10 (8 men) patients 37 (22–49) years of age. All arthrodesis healed. One patient was converted to total wrist arthrodesis during the follow-up period, and three had minor additional surgeries. At final follow-up, the patients had reduced active range of motion (AROM, 55%) and grip strength (85%) compared to the opposite side, but reported low Quick Disability of Arm, Shoulder and Hand (QDASH) (11), Patient-Rated Wrist and Hand Evaluation (PRWHE) (25) and visual analog scale (VAS) pain scores (0 and 10 at rest and activity). Radiographs found minimal degenerative changes in four patients, while CT scans demonstrated changes in seven patients, in three of these scaphoid was subluxed on the rim of the radius. The patients working prior to surgery were working at follow-up. A triscaphoid arthrodesis for SLL renders a functional wrist function in most patients for many years and has postponed more extensive surgery like total wrist arthrodesis or wrist arthroplasty. The patients are still young, and the degenerative changes seen especially on CT scans warrants attention.

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Introduction

Scapholunate ligament (SLL) injury represents a hazard to the wrist. A dynamic, reduceable SLL injury diagnosed at arthroscopy without radiological findings [increased scapholunate (SL) angel and SL interval] can be tolerated without any treatment although a reduced wrist function should be expected at follow-up [1]. A static S–L ligament injury is potentially devastating to the wrist with carpal collapse and secondary osteoarthritis [2]. Untreated SLL injury is one of the most common posttraumatic indications for total wrist arthroplasty or arthrodesis [3–5]. The natural course of asymptomatic, untreated static SLL injuries has to our knowledge not been described.

Treatment of SLL injuries has been the focus of much debate. A variety of ligament reconstructions have been introduced [6–9], and new methods are being introduced regularly. No studies have compared the different reconstruction methods, and the vast majority of studies are retrospective case series with a small number of patients and short follow-up. Some reserve ligament reconstruction for dynamic (reducable) SL injuries, other for static and some for both static and dynamic instabilities [10]. A review by Andersson et al. on ligament reconstruction found no evidence to support one method over the other, and an overall lack of scientific evidence for any method [11]. Long term results are scarce [12].

Triscaphoid arthrodesis as a treatment for SLL injury was first described in 1980 by Watson and Hempton [13] and has later been popularized for treatment of primary triscaphoid osteoarthritis [14] and lunate malacia [15]. Long-term follow-up after arthrodesis or ligament reconstruction has not been reported. We have performed triscaphoid arthrodesis for chronic SLL injuries without secondary osteoarthritis and present minimum 10 years of follow-up.

Patients and methods

Between 1999 and 2006, 10 (eight male) patients median 37 (22–49) years of age with wrist pain and static SLL injury (S–L angle > 70° and S–L gap > 2.5 mm on plain radiographs) confirmed by arthroscopy/arthrotomy (7/10) without secondary osteoarthritis were operated with triscaphoid arthrodesis, the dominant side in seven patients. Seven had prior wrist surgery, three out of six arthroscopies were performed to confirm the diagnosis and in three out of six arthroscopies TCFF ruptures/synovitis was resected. One patient had a prior open arthrotomy and a bone–ligament–bone reconstruction.

Surgical procedure

A dorsoradial incision was utilized, radial nerve branches protected and the triscaphoid joint exposed. Cartilage and subchondral bone were removed. The scapholunate angle was corrected. Cancellous (9) or corticocancellous (1) bone grafts from the distal radius (5) or iliac crest (5) were harvested and the arthrodeses fixed using 3 (2–7) 1.1 mm K-wires. One K-wire was passed through the trapezium into the scaphoid, one through the trapezoid into the scaphoid (a third K wire always through the trapezium-trapezoid joint and supplementary K-wires placed at the surgeon's preference). The K-wires were cut under the skin.

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Postoperative regime

A forearm plaster cast immobilizing the wrist and the metacarpophalangeal (MCP) joint was applied for 8 weeks when fusion was confirmed radiologically. The K-wires were removed within additional 4 weeks as outpatient procedures (having an image intensifier available), two in general anesthesia and eight in local anesthesia/wrist block.

Follow-up and patient assessment

The patients were followed-up 12 (10–17) years after surgery and all attended. They had a minimum of three controls prior to the final follow-up. At the final follow-up, they rated pain on the radial (r) and ulnar (u) sides of the wrist at rest and activity using a visual analog scale (VAS, 0–100, 100 denoting unbearable pain). They completed the Norwegian versions of the Quick Disability of Arm, Shoulder and Hand (QDASH) [16] score and the Patient-Rated Wrist and Hand Evaluation (PRWHE) [17]. They were asked if regretting the surgery knowing the outcome. Active range of wrist motion (AROM) (flexion, extension, radial and ulnar deviation) and forearm pro- and supination were measured using a handheld goniometer. The Kapandji thumb opposition score was assessed, which is the ability to reach the lateral fingers using the thumb ranging from 1 (touching the lateral side of the index finger) to 10 (touching the mcp crease of the 5 Finger) [18]. Grip- and key pinch strength were measured with JAMAR dynamometers (JA 88 Preston, Corp., Clifton, NJ) and compared to the opposite side. Patients converted to total wrist arthrodesis were excluded from the final clinical evaluation.

Archived radiographs were retrieved and compared with new ones of both wrists (anteroposterior, lateral, supinated and oblique) and a CT scan of the affected side was obtained. The arthrodesis was considered healed if bony trabeculae crossing the gap were visible on all radiographic projections and on all CT projections. The carpal height, the revised carpal height ratio [19], and the S–L angle [20] were measured, as well as the S–L gap on the frontal view preoperatively and at follow-up [21]. Osteoarthritis was graded according to the scapho-lunate advanced collapse (SLAC) system [2] by Watson.

The study was registered as a quality study by the Data Protection Official for Research at our hospital (2013/16882). The patients gave written informed consent.

Statistical methods

We used non-parametric statistical methods as the distribution of data was skewed. Results are presented as medians (min–max). Mann–Whitney *U* test was applied for continuous data and the

Figure 1. Patient 6. (a) Frontal radiograph, S–L injury confirmed by cinegraphy and arthroscopy. (b) Postoperative radiograph, prior to K-wire removal, standard method of fixation one K-wire through each joint including the trapezium-trapezoid joint. The latter K wire is also engaging the capitate. The oversized corticocancellous graft is protruding radially. (c) CT 12 years postoperatively, radial impingement of the exostosis. (d) Radiograph at 16 years. The exostosis has been removed, no secondary osteoarthritis. The wrist functions well.

chi-square or Fisher's exact tests for categorical data. $p < 0.05$ was considered significant.

Results

All arthrodeses healed. One K-wire irritation of flexor tendons and radial nerve branches resolved after wire adjustment and shortening of the wire in regional anesthesia. Two wrists received oversized crista grafts. In one, a resulting exostosis was removed due to painful impingement (Figure 1(a–d)).

Three other patients required additional surgeries caused by complications without relation to S–L issues during the follow-up period (partial synovectomy and removal of a residual screw in the lunate from prior surgery, radial styloidectomy/wafer procedure after an earlier distal radius fracture, and arthroscopic TFCC resection). In one patient, the triscaphoid-capitate articulation fused spontaneously (Figure 2(a–d)).

One wrist was converted to arthrodesis at her local orthopedic department after 6 years due to pain and increasing radiocarpal osteoarthritis.

Figure 2. Patient 9. Static scapholunate ligament instability. (a) Preoperative radiograph. (b) Postoperative radiograph of triscaphoid arthrodesis. (c) Frontal radiograph at 11 years demonstrating spontaneous triscaphoid-capitate fusion. Some persistent widening of the S–L interval. Minimal SLAC osteoarthritis (0–1). (d) Lateral CT view demonstrating more extensive radiolunate as well as midcarpal osteoarthritis. Good clinical function.

Table 1. Subjective outcome at follow-up.

Case no.	QDASH	PRWHE	Pain radial rest	Pain radial activity	Pain ulnar rest	Pain ulnar activity
1	0	0	0	0	0	0
2	52	60	0	0	0	80
3	0	0	0	0	0	0
4	21	32	20	50	20	50
5	2	4	0	10	0	0
6	11	25	20	60	0	0
7	36	34	10	60	0	0
8	61	28	0	10	10	30
9	3	10	0	20	0	0
Median (min–max)	11 (0–61)	25 (0–60)	0 (0–20)	10 (0–60)	0 (0–20)	0 (0–80)

Table 2. Objective outcome at follow-up.

Case no	AROM operated hand (°)	AROM non-operated hand (°)	Supination operated hand (°)	Supination non-operated hand (°)	Pronation operated hand (°)	Pronation non-operated hand (°)	Grip strength operated hand (kg)	Grip strength non-operated hand (kg)	Key Pinch operated hand (kgs)	Key Pinch non-operated hand (kgs)	Kapandji operated hand	Kapandji non-operated hand
1	120	190	90	90	80	80	52	52	12	12	7	9
2	80	230	80	80	80	80	31	52	11	12	7	10
3	160	230	80	80	70	80	57	60	13	13	9	9
4	80	175	90	90	70	80	42	61	11	11	10	10
5	190	220	90	90	90	90	85	78	14	12	9	9
6	175	225	90	90	90	90	64	71	13	13	9	9
7	110	210	90	90	90	90	38	54	11	13	10	10
8	75	170	20	90	45	80	22	30	8	6	10	10
9	130	245	90	90	90	90	51	64	8	9	9	9
Median (range)	120 (75–190)	225 (170–245)	90 (20–90)	90 (80–90)	80 (45–90)	80 (80–90)	51 (22–85)	60 (30–78)	11 (8-14)	12 (6-13)	9 (7-10)	9 (9-10)

Figure 3. Patient 3. (a) Radiograph showing successful triscaphoid arthrodesis prior to K-wire removal. (b) 10-year follow-up AP radiographs, no degenerative changes. (c) CT confirmed preserved articular surfaces. Good function.

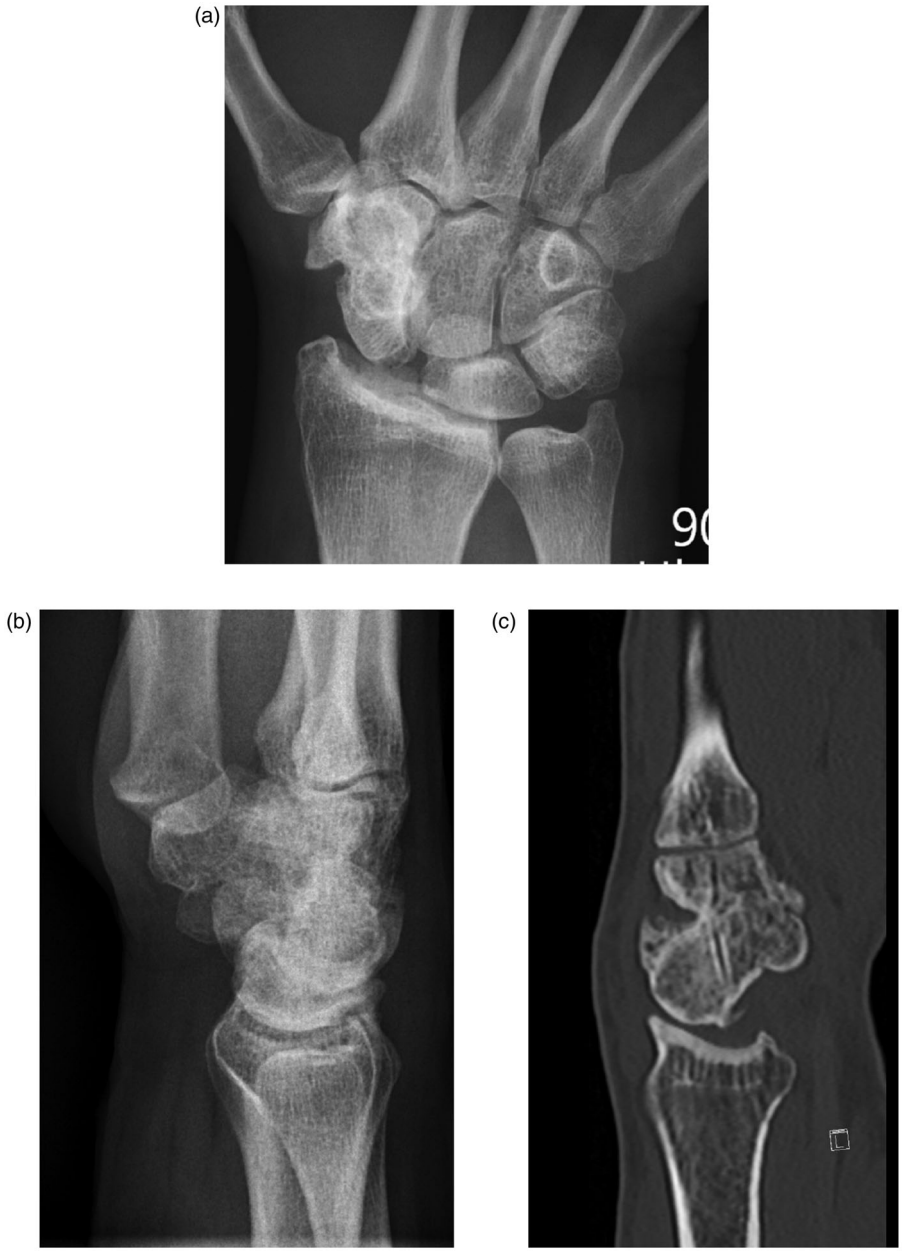

Figure 4. Patient 7. A 12-year follow-up triscaphoid arthrodesis. (a) frontal radiograph showing a 3.5 mm scapholunate interval. Exostosis on the trapezium after oversized cancellous bone block from the iliac crest. SNAC 0. (b) Lateral radiograph suggesting DISI, but otherwise difficult to interpret. (c) Axial CT demonstrates subluxation of the scaphoid dorsally on to the rim of the radius and degenerative changes with joint narrowing, subchondral sclerosis and osteophytes.

The remaining nine had satisfactory clinical results [median QDASH = 11 (0–61) and PRWHE = 25 (0–61)]. Most of the patients were pain free at rest, but 5 had varying activity-related pain (Table 1).

Wrist AROM and grip strength were reduced to 55 and 85% compared to the non-operated side (110° versus 210° and 46 versus 54 kg). Only the difference in AROM was statistically significant ($p < 0.001$). The AROM was centered around neutral in all patients. A minor difference in key pinch was not significant ($p = 0.73$). Forearm rotation was unaffected (Table 2). None regretted the surgery in hindsight.

The surgery reduced the S–L angle from 68 (48–84)° to 53 (40–70)° compared to 52 (41–64)° on the non-operated side (in one patient the preoperative radiographs had been discarded). The distance between the scaphoid and lunate was reduced from 5.8 (2.7–8.0) mm preoperatively to 3.5 (1.5–5.7) mm at follow-up as compared to 1.8 (1.3–2.4) mm on the opposite side. We found a minor decrease in carpal height and revised carpal height ratio compared to the uninjured side (38 (34–43) versus 40 (36–48) mm and 1.44 (1.40–1.59) versus 1.52 (1.43–1.61), the difference was not statistically significant ($p = 0.19$ and $p = 0.16$).

Radiographs demonstrated no osteoarthritis in five (Figure 3(a–c)) and minimal degenerative changes in four patients corresponding to SLAC 1 in three and SLAC 2 in one.

The CT scans revealed more degenerative changes than X-rays. There were mild degenerative changes in seven radioscaphoid joints, four of these with changes also in the mid-carpal joint (Figure 2). The scaphoid was subluxed on to the dorsal rim of the distal radius in 3/9, demonstrated on the CT scans (Figure 4(a–c)). All three had secondary degenerative changes.

9/10 patients were working preoperatively, one was disabled due to other illness. All nine were working at follow-up. Three out of four manual workers had changed to less strenuous work (two due to occupational promotion, one due to wrist problems). The remaining patients pursued similar occupations at follow-up. None were interested in further surgery, i.e. more extensive wrist arthrodesis or total wrist arthroplasty.

Discussion

We found satisfactory clinical results 12 (10–17) years after triscaph arthrodesis for static SLL injury in 9/10 active patients. Our study revealed reduced AROM (55% of the uninjured side) similar to Kleinman's 4.5-year follow-up of 41 wrists [22] and Kalb's 3-year follow-up of 32 wrists [23]. Eckenrode et al. found reduced grip strength by 25%, key pinch by 14% and AROM similar to ours after 19 months in 9 patients [24]. These early clinical results were reproduced in our patients after 12 years, implying a lasting clinical situation if healing in adequate position of the scaphoid is achieved. The main long-term concern is wrist osteoarthritis, which we found in the majority of patients. It seems that the surgery has slowed the degenerative process. We found SLAC 1 osteoarthritis in 4/9 on plain radiographs, and 7/9 on CT. The patients were still relatively young and active and progressing osteoarthritis may necessitate further surgery in the future.

The results after triscaphoid arthrodesis for scapholunate injuries vary. Non-union or secondary osteoarthritis necessitating more extensive surgery are the most common complications. Frykman et al. experienced > 25% non-unions in 14 S–L injured patients [25] after 2 years. Arthrodesis was achieved after reoperation in four (in one after two attempts). In two other patients, the arthrodesis was expanded to include the lunate and capitate, and two others were scheduled for wrist arthrodesis. They explained the high number of non-unions with the use of CT scan for confirmation of union as compared to contemporary papers where standard radiographs where used. Reducing the non-union rate is important to avoid reoperations and poor results.

A retrospective triscaphoid arthrodesis chart review (5 years of follow-up) by Kleinman et al. revealed a complication rate of 52% in 46 patients. Amongst their complications were osteomyelitis due to pin track infection (2), non-union (8), lunate necrosis (1) and progressive carpal osteoarthritis (9) or carpal translation (2) leading to total wrist arthrodesis or wrist arthroplasty in nine. Some of these complications can be attributed to the use of transverse K-wires from radial to ulnar (through the scaphoid or the trapezium/trapezoid to the capitate), inadequate reduction of the scaphoid and systematically removing K-wires after 6 weeks. Clinical outcome was not reported [26].

Fortin and Louis reported similar results in 14/19 patients followed for 5 years. Cross pinning of the distal scaphoid to the capitate with two K-wires was done in the majority of cases. They reported a high complication rate including three non-unions and four conversions to arthrodesis (one because of non-union); three patients had no complications or reoperations. Some of the complications were attributed to technical errors and the learning curve of this surgery [27]. Our technique includes routinely spanning all three articulations with the K-wires, cutting them short under the skin and leaving them for 12 weeks. We believe that we have avoided many of the complications by using this regimen.

We recommend using CT for accurate assessment of union and secondary osteoarthritis [28]. Although changes on CT scans not necessarily mirror the patient's symptoms, the findings may explain the residual pain experienced by some patients despite standard radiographs being normal. Although CT scans are superior to standard radiographs in the assessment of bony healing, alignment and osteoarthritis, it is rarely performed or reported in SLL surgery. Hence, a comparison of wrist degeneration following different methods is difficult. Subluxation of the scaphoid to the dorsal rim of the radius is difficult to evaluate on radiographs but easily seen on CT.

Although short term clinical results were satisfactory after scapholunate arthrodesis for scapholunate injuries [29], longer term follow-up have demonstrated a failure rate of 42% and unpredictable clinical results [30,31]. The method has largely been abandoned due to non-union rates of 33–85% and because the longest follow-up (7 years) revealed radiocarpal osteoarthritis in all patients [32].

Scaphocapitate arthrodesis has been used for SLL injuries, rendering comparable clinical results to ours in one long term (10 years) study and two shorter term (2 and 5 years) studies [33–35]. The studies found acceptable function, achieving 60% AROM and 60–80% grip strength compared to the uninjured wrist. Between 10 and 50% were pain-free, Non-union was reported in 5–23% of cases. DASH was reported in the 5 and 10-year studies [33,34], to 27 and 19, respectively. Osteoarthritis was seen in 33% in the long-term study. Unfortunately, the two long-term studies had a very high drop-out (47 and 66%), and CT was not part of the evaluation in any of the papers. In our opinion, a fusion between the scaphoid and the capitate gives a more constrained situation linking the radial side (scaphoid) to the central column (capitate), it is technically more demanding (has a higher risk of non-union) as well as the risk of overstuffing the intact midcarpal joint surfaces.

Follow-up studies on ligament reconstruction or capsulodesis demonstrates a consistent pattern of relapse of the SL gap and increased SL angle. The patients retain around 60–70% of wrist motion and grip strength, and radiocarpal osteoarthritis is seen after even shorter term follow-up [36]. Although more than 16 different soft-tissue methods are described, the results are non-conclusive, and no method has demonstrated superior results compared to others [11,12]. Hopefully a persistent and long-lasting soft tissue reconstruction can replace limited arthrodesis in the future.

The major limitation of our study is the retrospective design, the low number of patients and the lack of a comparative treatment group. Preoperatively we did not systematically evaluate wrist or forearm motion, grip or key pinch strength or pain levels, and we did not systematically perform CT scans. QuickDASH and PRWHE were not available at the time of surgery. The overall effect of the surgery (especially change in pain levels and function) compared to preoperatively could therefore not be evaluated. The strength of the study is the high rate and length of follow-up, as well as the combination of subjective, objective and radiological parameters evaluated.

Triscaphoid arthrodesis is an acceptable treatment option for SLL injuries rendering satisfactory pain relief and function after long-term follow-up in active patients. Despite successful union, wrist joint degeneration develops in the majority of patients. Radiographs consistently underestimate these changes, necessitating CT scans for proper evaluation of carpal joint surfaces [28,37].

Disclosure statement

None of the authors have any conflicts of interest to declare.

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