Special Aspects of Wrist Arthritis Management for SLAC and SNAC Wrists Using Midcarpal Arthrodesis

Results of Bilateral Operations and Conversion to Total Arthrodesis

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Abstract

Although midcarpal wrist arthrodesis is recognized as a standard procedure to treat scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC) of the wrist, little has been reported about patients with bilateral involvement and the number, cause, and results of failed cases requiring conversion to total wrist arthrodesis.

This study investigated the results of 20 patients with bilateral procedures and of 22 patients who underwent total wrist fusion after failed midcarpal arthrodesis out of an overall group of 907 patients treated by this method during a 12-year period. Of these, 16 bilateral and 20 converted cases were reexamined after an average of 48 months and 42 months, respectively.

Patients after bilateral midcarpal arthrodesis experienced a pain reduction by an average of 54% of the preoperative pain values at rest and by 56% at stress on the visual analog scale (scale range: 0 to 100) and from intolerable (3.7) to pain only during stress (1.9) on the verbal scale (scale range: 1 to 4). A mean arc of wrist extension and flexion of 53° on the right and 49° of the left wrist was preserved. The mean DASH score was 45 points and 70% of the patients felt impaired only during certain activities.

Total arthrodesis reduced pain in 18 of 20 reexamined wrists by 67% of the previous values after the failed partial arthrodesis at rest and by 46% at stress on the visual analog scale and from intolerable pain (3.7) to pain only during stress (2.1) on the verbal scale. Seven of the 20 reexamined patients noted complete pain relief at rest and two also under stress conditions. The DASH score averaged 39 points. A mean Krimmer score of 46 points and a mean Buck-Gramcko and Lohman evaluation of 6 points represented a satisfactory result. Grip strength of the operated hand averaged 53% of the opposite side. Subjectively, 30% felt impaired only during certain activities, 55% felt considerably and 15% strongly limited in daily life. However, all but two patients were satisfied with the secondary total wrist fusion as pain was considerably reduced.

Midcarpal arthrodesis reliably reduced pain and preserved valuable wrist mobility thus improving daily activity and quality of life also in bilateral carpal collapse. In the rare cases when midcarpal arthrodesis failed, total wrist arthrodesis markedly improved the complaints in most patients, but in contrast to other studies complete pain was seldom.

Wrist arthritis precludes adequate hand function due to stiffness and pain. Watson and coworkers found that 95% of all degenerative changes are centered around the scaphoid, mostly due to late sequelae of scapholunate dissociation or chronic scaphoid nonunion, termed SLAC (scapholunate advanced collapse) and SNAC (scaphoid nonunion advanced collapse) wrist.1-4 Both pathologies disrupt the proximal carpal row as part of a ring under tension which is essential for the equilibrium of the carpal forces as described by Lichtman and Martin5 and pathological carpal force transmission and instability will cause destruction of the radioscaphoid followed by the midcarpal articulation in a staged manner.

In scaphoid nonunion, the distal fragment is fixed in a malposition to the radius which leads to progressive
cartilage abrasion near the radial styloid (stage I) and the scaphoid fossa up to the level of the nonunion (stage II). Untreated scapholunate dissociation with a hyperflexed position of the scaphoid gives rise to cartilage degeneration between the joint surfaces of the dorsal radius and the scaphoid, equivalent to a stage II SNAC wrist. Additional arthrosis of the midcarpal articular surface around the head of the capitate characterizes stage III.2,3,6

Historically, most posttraumatic wrist disorders were treated by total arthrodesis which entirely abolished wrist motion except for forearm rotation and often caused significant functional disability.7,8 The observation that congenital carpal fusions or coalitions are frequently without pain, weakness, or instability encouraged the concept of intercarpal arthrodesis to eliminate not only the arthritic articulations but to also maintain mobility in the intact joint surfaces. Midcarpal arthrodesis, introduced by Watson and coworkers more than 20 years ago, relies on the principle that after fusion of the midcarpal articulations all the wrist load is borne by the radiolunate joint that usually escapes from periscaphoidal arthritis because of the spherical shape of its joint surfaces.1,3,9

In our department, midcarpal arthrodesis has become a standardized technique with excision of the ununited or malrotated scaphoid, neutral alignment of the remaining carpus by reducing the dorsal intercalary segment instability (DISI) position of the lunate, and intentional fusion of the articulating surfaces of the lunate, triquetrum, capitate, and hamate, termed “four-corner-fusion.”10

The procedure has been used by the senior author (U. L.) since 1987 and has become the treatment of choice for most cases of painful posttraumatic wrist arthrosis due to carpal collapse (SNAC and SLAC wrist).6,11-13

The objective of this study was to investigate the results of this procedure in patients with advanced carpal collapse of both wrists and to clarify the frequency, cause, and result of conversion to total wrist arthrodesis. At present, there is only scarce information concerning these rare but important patient groups as assessed by objective and subjective outcome measures.

**Patients**

Between May 1992 and May 2004 a total of 907 patients underwent midcarpal wrist arthrodesis with bone grafting and complete excision of the scaphoid at our institution.

**Bilateral Midcarpal Arthrodesis**

An evaluation of our computer database revealed 20 patients (19 male, 1 female) with a mean age of 53 (range: 37 to 70 years) who underwent bilateral procedures (Table 1, Figs. 1 and 2).

The ratio of unilateral versus bilateral cases was 44:1 or 2.3%. The interval between the first and second partial wrist fusion averaged 25 months (range: 3 to 99 months). The foremost indication for midcarpal arthrodesis was a scapholunate advanced collapse in 34 of the 40 wrists (Table 2).

**Conversion to Total Arthrodesis**

Of all patients treated by a midcarpal arthrodesis, 22 (18 male, 4 female) with an average age of 53 years (range: 32 to 79 years) required secondary total arthrodesis. Between the first conversion to total arthrodesis in June 1994 and the last in June 2003, 597 midcarpal arthrodeses were performed. Regarding the total number of 907 patients who underwent midcarpal arthrodesis, the conversion rate accounted for 2.4% during the entire 12-year study period.

The primary midcarpal arthrodesis had been indicated by a SLAC wrist in 17 patients and a SNAC in three cases, one after an intraarticular radius fracture and one resulting from a perilunate fracture dislocation.

Patients with previous midcarpal arthrodesis at other institutions or due to non-traumatic origin, such as chondrocalcinosis, were excluded from the study.

**Methods**

In addition to a review of all patients charts, 16 of the 20 patients with bilateral operations and 18 of the 22

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**Table 1** Patients with Bilateral Midcarpal Fusion and Conversion into Total Wrist Arthrodesis

<table>
<thead>
<tr>
<th></th>
<th>Bilateral Midcarpal Fusion</th>
<th>Converted Midcarpal Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Female to male ratio</td>
<td>1:19</td>
<td>4:18</td>
</tr>
<tr>
<td>Mean age at follow-up</td>
<td>53 (range, 37-70) years</td>
<td>53 (32-79) years</td>
</tr>
<tr>
<td>Follow-up time</td>
<td>42 (range, 6-144) months</td>
<td>48 (7-150) months</td>
</tr>
</tbody>
</table>

**Table 2** Indications for Bilateral Midcarpal Arthrodesis

<table>
<thead>
<tr>
<th>Indication</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral scapholunate advanced collapse (SLAC)</td>
<td>15</td>
</tr>
<tr>
<td>Bilateral scaphoid nonunion advanced collapse (SNAC)</td>
<td>1</td>
</tr>
<tr>
<td>SNAC wrist and opposite SLAC wrist</td>
<td>1</td>
</tr>
<tr>
<td>Unilateral SLAC wrist and opposite midcarpal arthrodesis</td>
<td>2</td>
</tr>
<tr>
<td>Unilateral SLAC wrist and opposite radioscaphoial arthrodesis</td>
<td>1</td>
</tr>
<tr>
<td>Overall</td>
<td>20</td>
</tr>
</tbody>
</table>
patients with conversion to total arthrodesis were evaluated pre- and postoperatively. Hand and wrist function was assessed clinically and radiographs were taken under standardized conditions. Pain was evaluated pre- and postoperatively using visual (0 = no pain, 100 = maximal) and verbal analog (1 = no pain, 4 = intolerable pain) scales. The functional result regarding daily activity and quality of life was estimated by the disabilities of arm, shoulder, and hand (DASH) score using part A (function) and B (symptoms) of the validated German version. In this score 0 points indicate no disability at all and 100 points indicate a maximum of disability. The modified Mayo wrist score according to Krimmer was used to assess the results after conversion to total wrist arthrodesis. In this scoring system, 0 points represents a maximum of disability and 100 points represents an excellent function with 80 points possible after wrist arthrodesis. Furthermore, the total wrist arthrodeses were rated according to Buck-Gramcko and Lohmann (9-10 = excellent, 7-8 = good, 5-6 = satisfactory, > 5 points = poor). Both rating systems are based on a comparison to the contralateral, unoperated side and therefore were not usable for bilateral cases.

Results

Bilateral Midcarpal Arthrodesis

Of a total of 40 midcarpal arthrodeses, one healed only after additional iliac bone grafting. Four wrists were converted to total wrist arthrodeses after a mean time of 26 months (range: 8 to 44 months): two due to nonunion, one after infection, and another due to technical error.

At a mean follow-up time of 42 months (range: 6 to 144 months) after the second of the bilateral midcarpal fusions, pain was reduced significantly in both wrists to 46% (17/100) of the preoperative value (37/100) at rest and to 44% (32/100) of the previous intensity (73/100) at stress on the visual analog scale, respectively. The patients noted that pain had diminished from intolerable (3.7) to pain only during stress (1.9) on the verbal scale. A useful average active wrist extension and flexion range of motion (ROM) of 53° (maximum: 80°) on the right and 49° (maximum: 75°) on the left wrist remained, pro- and supination averaged 137° (range: 85° to 160°) on the right and 138° (range: 110° to 150°) on the left side (Table 3). Grip strength measured with
a standardized Jamar dynamometer averaged 32 kg (range: 8 to 54 kg) on the right and 31 kg (range: 6 to 52 kg) on the left side. The mean total DASH score was 45 points (range: 10 to 81 points), representing an acceptable degree of disability. Fourteen of 20 (70%) patients felt impaired subjectively only regarding certain activities in their daily life and could resume their original job and activity level (Fig. 3).

**Conversion to Total Wrist Arthrodesis**
Plate arthrodesis using a dorsal approach was used in all cases. Nonunions required revision osteosynthesis and bone grafting in three patients, one hardware failure and one infection occurred and one patient developed ulnocarpal instability after subsequent hemiresection of the ulna head because of distal radioulnar joint arthrosis.

The mean time interval between midcarpal arthrodesis with complete scaphoid excision and conversion to total wrist arthrodesis averaged 25 months (range: 3 to 99 months).

A radiological explanation for persisting pain was found in 17 of the 22 patients. In ten of these patients, failure was retrospectively attributed to technical errors – in all six cases of persistent nonunion and in four cases of radiolunate degeneration this was due to incomplete reduction of the lunate or intraarticular positioning of the K-wire tip. In the remaining five cases total arthrodesis was performed due to pain persistence despite inconspicuous radiographs (Table 4).

After conversion to total wrist arthrodesis, pain diminished in 18 of 20 re-examined wrists from an average intensity of 55/100 to 18/100 (33%) under rest and from an average pain level of 72/100 to 46% (35/100) under stress conditions as judged by the visual analog scale and diminished from an average of intolerable pain (3.7) to pain only during strain (2.1) on the verbal scale.

One patient with primary nonunion noted that his symptoms remained unchanged despite solid bony union of the total arthrodesis. Another patient who had a simultaneous

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**Table 3** Preserved Range of Motion (ROM) after Bilateral Midcarpal Arthrodesis

<table>
<thead>
<tr>
<th>Average ROM</th>
<th>Extension/Flexion</th>
<th>Ulnar-/Radialduction</th>
<th>Pro-/Supination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right wrist</td>
<td>53° (0°-80°)*</td>
<td>35° (0°-50°)*</td>
<td>137° (85°-160°)</td>
</tr>
<tr>
<td>Left wrist</td>
<td>49° (0°-75°)*</td>
<td>37° (0°-55°)*</td>
<td>138° (110°-150°)</td>
</tr>
</tbody>
</table>

*Four patients with bilateral midcarpal arthrodesis had unilateral conversion into total wrist arthrodesis.

**Table 4** Indication for Conversion of Midcarpal into Total Wrist Fusion

<table>
<thead>
<tr>
<th>Radiological picture</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiolunate arthritis</td>
<td>6</td>
</tr>
<tr>
<td>Ulnar translocation of the carpus</td>
<td>4</td>
</tr>
<tr>
<td>Infection</td>
<td>1</td>
</tr>
<tr>
<td>Persistent nonunion</td>
<td>6</td>
</tr>
<tr>
<td>Unremitting pain without radiological correlate</td>
<td>5</td>
</tr>
<tr>
<td>Overall</td>
<td>22</td>
</tr>
</tbody>
</table>

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Figure 3 Radiograph of 44-year-old carpenter after bilateral midcarpal arthrodesis who noted only mild pain at stress, felt impaired only during special activities, and had a DASH score of 14 points (second best overall result).
ulna head hemiresection arthroplasty experienced a deteriorated of his overall pain situation due to a chronic and painful ulnocarpal instability.

However, despite a marked overall pain reduction, only 7 of 20 patients (35%) felt entirely pain free at rest and only two (10%) were pain free also under stress conditions. The mean DASH score averaged 39 points (range: 11 to 82 points). Grip strength of the operated hand averaged 54% (range: 16% to 100%) and forearm rotation 84% (range: 56% to 100%) compared to the opposite side. The mean wrist score according to Krimmer reached 46 points (range: 20 to 70 points) of a maximum of 80 points possible after wrist arthrodesis. The evaluation of the result after wrist fusion according to Buck-Gramcko and Lohmann averaged 6 points (range: 4 to 8 points) representing a satisfactory result.

Subjectively, no patient noted unimpaired wrist function, 30% felt impaired only during certain activities, 55% felt considerable and 15% strong limitations in their activities of daily living, but 13 of 22 patients said they could return to their previous occupation or activity level.

Retrospectively, all but two of the patients (90%) were satisfied with the outcome of the total wrist fusion compared to the previous situation after failed partial fusion (Fig. 4).

**Discussion**

During the last decade, numerous studies have confirmed that midcarpal arthrodesis reliably reduces pain, preserves useful motion and wrist function, and results in high patient satisfaction with an acceptable complication rate.\(^6,10^-13,16^-20\)

Despite that this procedure is today recognized as a classic operation, certain aspects remained unclear. Is the procedure applicable also in patients with bilateral involvement? How frequent is failure and if it occurs, does conversion to total arthrodesis really improve the situation of these patients? To investigate these issues we undertook the present review of our own results with a special regard to these patient groups.

**Table 5** Comparison of Wrist Function after Midcarpal Arthrodesis and Total Wrist Arthrodesis Regarding the DASH Score

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number of own patients (follow-up time)</th>
<th>Average DASH score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral midcarpal wrist arthrodesis</td>
<td>37 (8.1 years)</td>
<td>24</td>
</tr>
<tr>
<td>(Kitzinger et al., 2003)(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion of midcarpal to total wrist arthrodesis</td>
<td>22 (4.2 years)</td>
<td>39</td>
</tr>
<tr>
<td>(Present study, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral midcarpal arthrodesis</td>
<td>20 (3.5 years)</td>
<td>45</td>
</tr>
<tr>
<td>(Present study, 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral total arthrodesis</td>
<td>10 (5.5 years)</td>
<td>55</td>
</tr>
<tr>
<td>(Gohritz et al., 2004)(^a)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Footnotes:

\(^a\) Numbers of patients and follow-up time are rounded off to one significant digit; other studies used different inclusion criteria and follow-up times.
Table 6  Conversion Rates of Midcarpal into Total Wrist Arthrodesis as Reported in the Literature

<table>
<thead>
<tr>
<th>Authors</th>
<th>Mean follow-up (years)</th>
<th>Midcarpal fusions</th>
<th>Conversions</th>
<th>Conversion rate</th>
<th>Mean time interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watson et al, 1999⁹</td>
<td>4.3</td>
<td>252</td>
<td>1</td>
<td>0.4%</td>
<td>not specified</td>
</tr>
<tr>
<td>Sauerbier et al, 2000²⁷</td>
<td>2.1</td>
<td>43</td>
<td>2</td>
<td>5%</td>
<td>not specified</td>
</tr>
<tr>
<td>Kitzinger et al, 2003²⁶</td>
<td>8.1</td>
<td>108</td>
<td>7</td>
<td>7%</td>
<td>29 months</td>
</tr>
<tr>
<td>Wyrick et al, 1994³²</td>
<td>2.3</td>
<td>17</td>
<td>3</td>
<td>17%</td>
<td>not specified</td>
</tr>
<tr>
<td>Siegel and Ruby, 1996¹³</td>
<td>5.5</td>
<td>14</td>
<td>4</td>
<td>28%</td>
<td>29 months</td>
</tr>
<tr>
<td>Present study, 2004</td>
<td>3.5</td>
<td>597</td>
<td>22</td>
<td>4%</td>
<td>25 months</td>
</tr>
</tbody>
</table>

Bilateral cases are only very scarcely documented in contrast to unilateral midcarpal fusion, most probably due to its rare occurrence (only around 2% of the patients in this large patient cohort from a single institution).

However, bilateral scapholunate advanced collapse being the foremost etiology in our patient group, is not a new pathology, as findings of bilateral SLAC wrist on a prehistoric skeleton from Hassi-el-Abiod site in Malian Sahara provide paleopathological evidence of the existence of this disease 7,000 years ago.⁶ Characteristic features like bilateral styloid and posterior osteophytes of the distal radius rim and ivory sclerosis of the radioscapohoidal surfaces in a prehistoric skeleton are described and the investigators also mention five patients seen in their unit during a period of ten years who all had a history of repeated microtrauma due to intensive sport or manual work activity. Regrettably, the treatment and clinical course of these patients is not specified and, aside from this review, little has appeared in the literature concerning bilateral carpal collapse.²⁰,²²-²⁴ Only Ashmead and colleagues²⁵ mention four bilateral cases out of their 100 patients that could return to their original occupation after SLAC wrist salvage.

The mean DASH score of 45 points in our patients after bilateral midcarpal fusion represents an acceptable degree of impairment, though it was higher than the figures we know from unilateral cases.¹⁰,¹⁶,²⁶ On the other hand, according to this study, bilateral partial arthrodesis did not interfere with daily life activities in the majority of patients, but led to a significant rehabilitation of upper extremity function compared to the previous situation as can be seen from the subjective evaluation.

The most important reason for this may be the considerable pain reduction in all bilateral patients; the reduction of pain restored patients’ grip strength and thus most activities of daily living became feasible again. Additionally the preserved wrist motion in these patients is an advantage over total arthrodesis. Furthermore, a great capacity to compensate lost wrist mobility through elbow and shoulder movements can be observed in these patients. This was even more astonishing in our recent study²⁸ that also involved ten bilateral total wrist arthrodesis, thus confirming the results of Rayan and coworkers²⁹ who proved that, in absence of pain, even bilateral total wrist fusion is less disabling than formerly believed.

Total wrist fusion is commonly recommended when pain persists after a correctly performed midcarpal arthrodesis.¹⁶,¹⁷,³⁰ This trade-off trusts in the assumption that a total sacrifice of motion will reliably lead to complete pain relief. This has been a matter of controversy.⁷,⁸ Besides, there was a lack of objective information on the exact indication and timing of total wrist fusion in this specific indication.

Shin⁹ compiled the results of 8 different series comprising 431 four-corner fusions and found only 7 failures that led to total arthrodesis, giving an overall incidence of 2%. This contrasts to other smaller series that indicate conversion rates of up to 17% reported by Wyrick and associates³² or even 28% in the series reported by Siegel and Ruby,³³ whereas Watson and colleagues⁹ performed 252 SLAC reconstructions and within 4.3 years only had one conversion into total wrist arthrodesis accounting for a percentage of 0.4%. We report a failure rate of 2.4% after 4 years in a very large patient group from a single hospital. Similarly low rates of failure were reported by Sauerbier and associates,⁷ Kitzinger and coworkers,²⁶ and Krakauer and colleagues with an incidence of 5% after 2.1 years, 7% after 8.1 years, and 12% after 4.1 years, respectively. Of course, we cannot rule out the possibility that some of our patients continued treatment elsewhere when pain persisted or newly occurred after midcarpal arthrodesis and therefore our percentage of failure might be slightly higher than we are able to report. The dramatic increase of midcarpal arthrodesis during the recent years performed at our unit as a standard procedure for SLAC and SNAC wrist arthritis precluded our contacting all patients, but many of the patients have been reevaluated in the mid- and long-term as reported in several studies from our group.⁶,¹⁰,¹³,²⁶

Regarding the cause for conversion, most previously mentioned investigators described unremitting pain, but did not clarify the underlying pathology. In this study, in 17 of 22 cases, a possible explanation could be detected through the radiological reevaluation. Twelve patients had either progressive radiolunate degeneration or persisting nonunion, four patients had an incomplete reposition of the lunate with a persisting DISI position of the lunate or an ulnar translocation of the carpus. In retrospect, it is not always easy to decide whether these changes resulted from natural progression of the carpal collapse, a wrong indication, or a technical error on the part of the surgeon. A critical analysis of our failed procedures indicated that technical errors were the cause in over half of these cases – not a progressive
long-term degeneration of the intercarpal arthrodesis.

To prevent failure due to false indications and technical errors, advanced degeneration of the radiolunate joint and an unreducible ulnar translocation of the carpus should be seen as an absolute contraindication that indicates severe instability of the extrinsic ligaments. This impedes a physiological movement of the lunate in the fossa lunata and this incongruence promoted by increased load bearing will finally lead to a complete destruction of the joint. To prevent radiolunate degeneration, the position of the transfixing K-wires should also be checked thoroughly to ensure that the wire tips do not penetrate into the joint. Nonunion, the most frequent cause of failure, may be preventable by exposing enough cancellous bone during the resection of the joint surfaces.

Radiographically, progressive changes of the fossa lunata or an ulnar shift of the remaining carpus may occur over the long-term as observed recently by Kitzinger and colleagues, but these changes did not correlate with a clinical deterioration of the postoperative result.

The most important benefit of total arthrodesis was a marked reduction of pain. This, together with an only slightly impaired pronation-supination and a satisfactory grip strength of 54% of the contralateral side, improved the previous situation in all but two of our patients and reestablished useful hand function. This should not belie that subjectively, 55% of our patients felt considerably and 15% strongly limited in their daily life activities after salvaging a failed midcarpal arthrodesis. We share the experience of Sauerbier and associates who had comparable objective results in their series with a mean Krimmer wrist score of 50.5 points and an overall DASH score of 51.4 points. Even 80% of their patients complained of functional deficits, but 70% could adapt to the requirements of their professional life and resume previous occupation. These investigators reported that complete relief of symptoms was only achieved in 5%. This contrasts with other studies; for example, Weiss and Hastings reported that none of their 28 posttraumatic patients felt pain or instability after total wrist arthrodesis. This study revealed similar results as in the series of Kalb and coworkers who reported that only 3 of 35 patients were entirely pain free postoperatively and corresponds to the findings of Bolano and Green who reported that, although wrist arthrodesis significantly reduced preoperative pain, two thirds of their patients still have mild to moderate pain with heavy work despite a fusion.

Conclusion

Based on our experience with more than 900 cases, midcarpal arthrodesis with complete excision of the scaphoid appears to be a reliable method for managing wrist arthritis due to scapholunate dissociation (SLAC wrist) and scaphoid nonunion (SNAC). It markedly reduces pain and spares valuable wrist motion enabling a satisfactory outcome concerning the activities of daily living. The procedure works well also in cases of bilateral carpal collapse.

The treatment failure rate is very low. If technical errors, hardware problems, progressive degeneration patterns, or unremitting pain occur, total arthrodesis as a method of last resort may improve the complaints in most patients. However, in contrast to the widely accepted hypothesis “no motion, no pain,” an entirely asymptomatic wrist may result only in few cases.

References