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RESULTS OF TRI-LIGAMENT TENODESIS: A MODIFIED BRUNELLI PROCEDURE IN THE MANAGEMENT OF SCAPHOLUNATE INSTABILITY

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One hundred and sixty-two patients with a diagnosis of scapholunate instability underwent a modified Brunelli procedure over a 7-year period. One hundred and seventeen were assessed with the help of a questionnaire and, of these, 55 patients attended for clinical evaluation. The mean follow-up was 4 (1–8) years. There were 72 patients with dynamic scapholunate instability and 45 patients with static instability. The average age was 38 years. There were 50 males and 67 females. A total of 77 (62%) patients had no to mild pain with a mean visual analogue score of 3.67 (SD = 2.5). The loss in the arc of flexion–extension was due to a reduced range of flexion (mean loss 31%), while 80% of extension was maintained, compared with the contralateral side. The grip strength on the operated side was reduced by 20% of the non-operated side. There was no statistically significant difference ($P > 0.05$) in the range of movement or the grip strength between the static and dynamic group and patients with or without legal claims. Ninety (79%) patients were satisfied with the result of the surgery (good to excellent) and 88% of the patients felt that they would have the same surgery again. We feel that these results compare favourably with the early results published from this unit and recommend this procedure for dynamic and static scapholunate instability.

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Keywords: scapholunate dissociation, carpal instability, dynamic, static, tenodesis

INTRODUCTION

The commonest pattern of carpal instability seen in clinical practice is scapholunate dissociation (Gelberman et al., 2001). It is usually diagnosed late and, if left untreated, can result in scapholunate advanced collapse (Watson and Ballet, 1984) with a painful wrist and reduced grip strength (Linscheid and Dobyns, 1992).

Scapholunate instability may be divided into dynamic and static instability (Gelberman et al., 2001). Patients with dynamic instability present with tenderness over the scapholunate interval and a positive scaphoid shift manoeuvre, but with normal plain radiographs. A diagnosis is often made either by dynamic radiographs or at arthroscopy (Walsh et al., 2002). Numerous methods have been reported for the treatment of dynamic instability ranging from soft tissue reconstruction procedures to repair of the palmar ligaments (Van Den Abbeele et al., 1998; Weiss, 1998; Wintman et al., 1995). Patients with static instability have persistent carpal malalignment, which can be seen on standard anteroposterior and lateral radiographs (Gelberman et al., 2001). This may be further divided into a flexible static instability, in which it is possible to reduce the flexed scaphoid, thereby closing the scapholunate gap, and a fixed static instability, in which reduction of the scaphoid is not possible. In the latter type, surgical treatment is limited to bony procedures, such as partial, or total, wrist arthrodeses.

Brunelli and Brunelli (1995a,b) described a technique using a slip of flexor carpi radialis (FCR) tendon, which is inserted through the palmar, distal pole of the

scaphoid, exits through the dorsal proximal pole and inserts into the dorsoulnar side of the radius. In our institution, this procedure has been modified and, in its current form, involves tunneling the FCR tendon slip through the scaphoid in an anteroposterior direction and, then, under the radiolunotriquetral ligament in such a way that it does not cross the radiocarpal joint. The tendon slip is then attached to itself and the underlying lunate. This tendon reconstruction directly replicates the action of the scapholunate and lunotriquetral ligaments. Furthermore, by extending the scaphoid, it also enhances the scapho–trapezio–trapezoid complex (Coleman's ligament). Due to its influence on three important ligament complexes, this procedure has been called a tri-ligament tenodesis.

The early results of this procedure at a mean follow-up of 9 months have been reported previously (Van Den Abbeele et al., 1998) and were found to be encouraging. The purpose of this article is to compare the results of the modified Brunelli procedure in a group of patients with dynamic scapholunate instability with patients having reducible chronic static scapholunate instability at a mean follow-up of 4 years. It should be noted that these are the pooled results of four surgeons who work at a specialist centre.

PATIENTS AND METHODS

One hundred and sixty-two patients who underwent the modified Brunelli procedure between 1995 and 2002

were entered in this study (Fig 1). In the first part of the study, patients were sent a postal questionnaire. One hundred and seventeen patients (72%) replied. Eighty-nine (76%) of the patients who responded to the questionnaire agreed to come to clinic. Of these, 55 patients were available for clinical review. The patients were divided into two groups (Table 1) depending on whether the patient underwent surgery for dynamic or reducible static instability.

There were 72 patients in the dynamic group, including 27 males and 45 females with a mean follow-up of 4.1 (range 0.9–8.2) years. The static group had fewer patients and included 23 males and 22 females with a comparable follow-up of 3.7 (range 0.9–8.4) years.

Data concerning duration of symptoms prior to surgery was available for 32 patients seen in clinic ($n = 55$). In this group, 21 had dynamic instability and 11 patients had static instability. The duration of symptoms ranged from 6 to 26 months, with an average of 10 months wait between injury and surgery. Due to the tertiary referral pattern of the institution and prevailing waiting lists, the average wait would be 8 months for the rest of the patients for whom data was not available.

Although our study had more patients with dynamic instability, the groups were well matched for age, sex distribution and length of follow-up.

In patients with suspected carpal instability, the diagnosis of scapholunate dissociation is made by clinical examination, six “shot” X-rays (posteroanterior views in the neutral position, radial and ulnar deviation,

a clenched fist view, an anteroposterior view in the neutral position and a lateral view) screening and arthroscopy. We use the Geissler classification to grade carpal instability (Geissler et al., 2000). The range is from grade I instability, in which there is incongruity or widening of the scapholunate interval, to grade IV injuries, in which the interosseous ligament is completely detached and a 2.7-mm arthroscope can be passed freely from the midcarpal space to the radiocarpal space. This corresponds to the widened scapholunate gap seen on posteroanterior radiographs of a wrist with complete scapholunate dissociation. The number of patients with each grade of instability is presented in Table 2. Chondromalacia and fibrillation in the scapholunate joint are also indications of dynamic instability.

Patients are offered conservative treatment if the symptoms can be tolerated in day-to-day living, if grip strength is 80% of the other hand and if the symptoms are controlled with occasional oral analgesics.

Table 1—Demographic data for all responders

	<i>Dynamic SL instability</i>	<i>Reducible static SL instability</i>
Number of operations	72	45
Mean age (SD) – years	37.9 (10.6)	38.2 (9.5)
Age range – years	22–63	20–56
Mean follow-up (range) – years	4.1 (0.9–8.2)	3.7 (0.9–8.4)

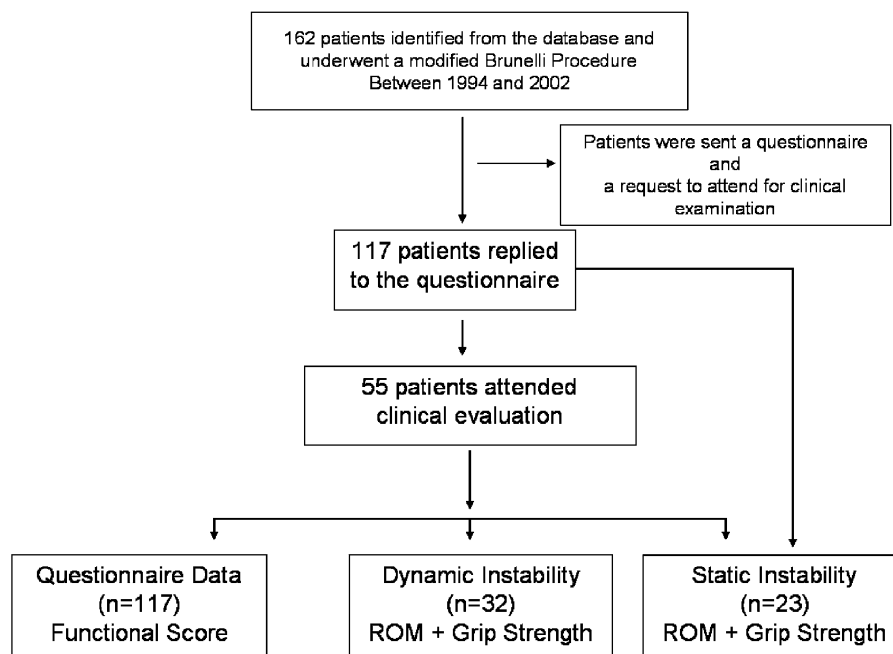


Fig 1 Flowchart showing patients included in this study.

Table 2—Geissler grade

Grade	Dynamic (n = 32)	Static (n = 23)
Grade 1 Attenuation of ligament, no incongruity	2	—
Grade 2 Slight step, with gap less than width of probe	12	—
Grade 3 Incongruity, probe can be passed through gap	18	7
Grade 4 Incongruity, 2.4 mm scope can be passed through gap	—	16

Current operative technique and rehabilitation

All operations were performed or supervised by a senior author (MJH, JHS, IAT and JKS). A dorsal 5 cm transverse incision is made at the level of the scapho-lunate joint. The scapho–trapezio–trapezoidal (STT) and the scapholunate joint are then exposed by elevating a flap which is based on the radiolunotriquetral and transverse intercarpal ligaments (Berger et al., 1995). Scar tissue is excised from both joints and the scapholunate joint is inspected to confirm the diagnosis and exclude any arthritis. The distal pole of the scaphoid and the sheath of the FCR tendon are exposed through a palmar incision over the scaphoid tubercle. After incising the sheath, a tendon grasping forceps is passed about 10 cm proximally along the FCR within the sheath. A second proximal incision is made over the grasping forceps and a strip of one-third of the FCR tendon is detached from the main body of the tendon on its anterior surface and stripped from proximal to distal, delivering the tendon strip into the distal tubercle incision. If necessary, any rotary subluxation of the scaphoid is reduced through the dorsal incision by the technique of “joy-sticking”, using temporary K-wires in the scaphoid and the lunate, to manipulate the bones into a reduced position. A custom-made jig is applied to the proximal pole of the scaphoid just proximal to the tubercle and used as an aiming device for a K-wire, which is drilled from the front of the scaphoid tubercle to the posterior bare area. A cannulated AO drill (3.2 mm for males/2.9 mm for females) is then passed over the K-wire from palmar to dorsal, emerging at the proximal pole. Check radiographs may be taken to ensure accurate placement of the K-wire. Next, the FCR tendon slip is passed through this tunnel (Fig 2). The slip is tightened to ensure that the scaphoid is reduced. The distal end of the dorsal radiolunotriquetral (RLT) ligament is then localized and, near its insertion on the triquetrum, a slit is created through which the FCR

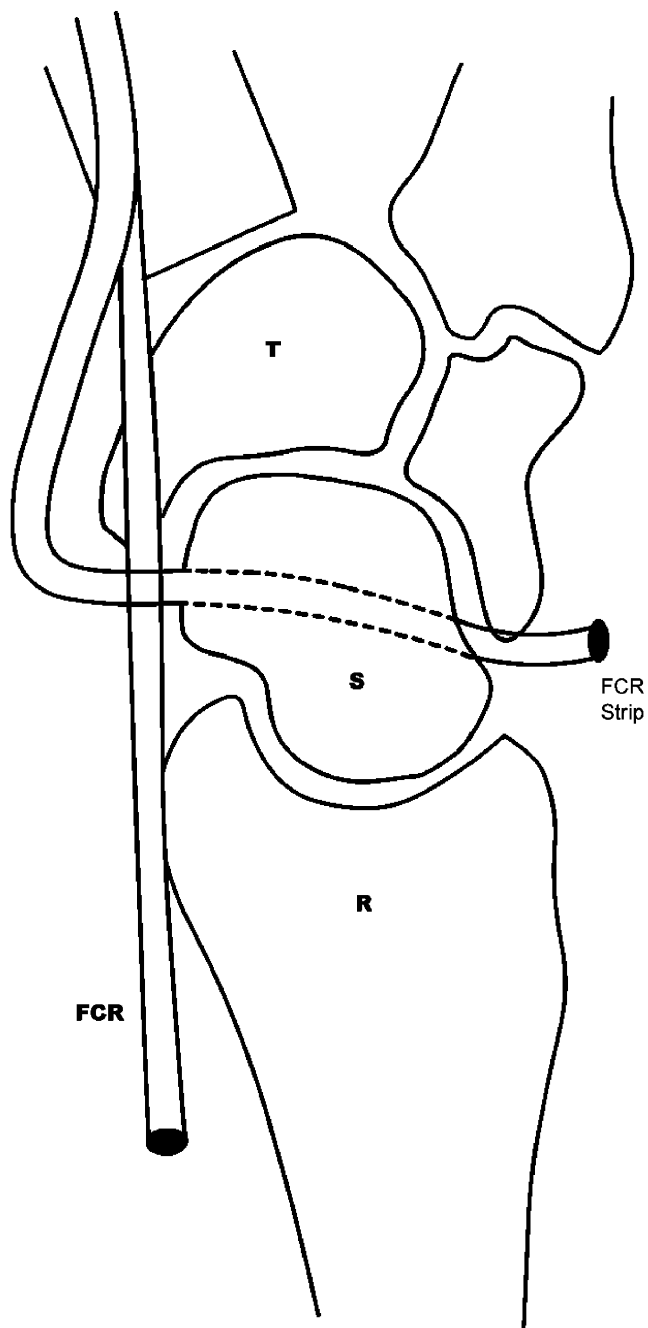


Fig 2 Diagrammatic lateral view of the wrist showing the flexor carpi radialis strip pulled through the distal pole of the scaphoid. FCR, flexor carpi radialis; R, radius; S, scaphoid; T, trapezium.

tendon strip is passed. This ligament is used as a pulley to tension the FCR slip. The tendon slip, after adequate tension has been achieved, is sutured back on itself using 3–0 non-absorbable sutures (Fig 3), and onto the lunate by one of the authors (IAT). The posterior interosseous nerve is routinely excised and the capsular flap is

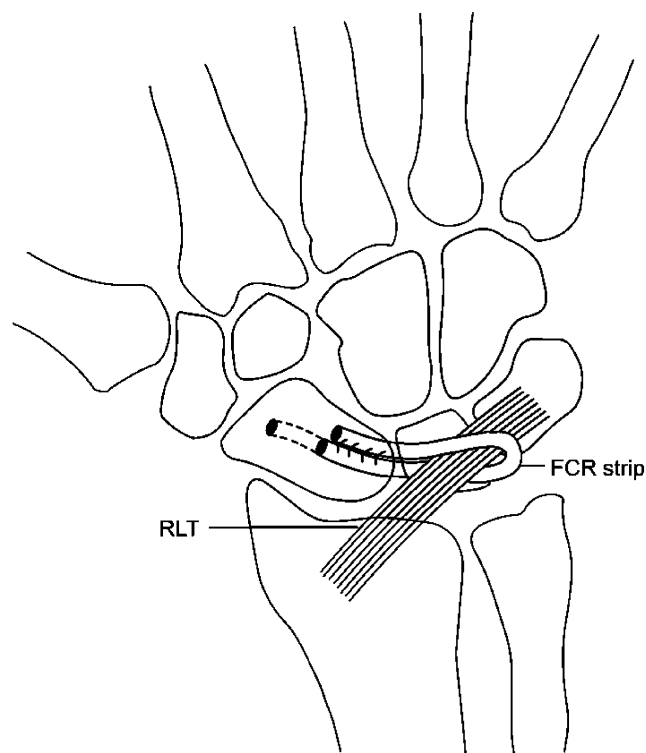


Fig 3 Diagrammatic posterior view showing the flexor carpi radialis strip pulled under the radiolunotriquetral ligament and sutured to itself. RLT, radiolunotriquetral ligament; FCR, flexor carpi radialis.

reattached with absorbable sutures. Skin closure is with a subcuticular 3/0 prolene suture. The limb is, initially, immobilized in a palmar plaster of Paris slab including the thumb. An above elbow, sugar-tong cast is applied next day. The stitches are removed 2 weeks post-operatively and another sugar-tong cast is applied for a period of 4 weeks. At 6 weeks, gentle range of motion exercises are commenced and, at 12 weeks, grip strengthening exercises are started.

Case notes, operative records and radiographs were used to determine whether the instability was static or dynamic. A note was also made of any ongoing legal claims. Some patients were also assessed at personal interviews, during which they were examined by one of the researchers.

The severity of pain present at the time of review was determined from a visual analogue scale (0 – no pain; 10 – severe pain). The pain scale was then categorized as either no pain (0–1), mild (2–4), moderate (5–7) or severe pain (>7).

The active and passive ranges of radial and ulnar deviation, flexion and extension at the wrist were measured and recorded using a standard goniometer and compared with the contralateral side.

Grip strength was recorded as the average of three attempts with a JAMAR dynamometer (Fabrication

Table 3—Wrightington activity of daily living, assessment for wrist function

Activity

- Can use the back pocket of the trousers
- Personal care
- Can use a screwdriver
- Can place the hand flat to the face
- Can take up coins offered as change
- Can lift object with hand gripping
- Can use the hand to rise from a chair
- Can do usual work

Activities are graded for function

1 = normal, 2 = with difficulty, 3 = aid needed, 4 = unable to complete

Best score possible = 8

Worst score possible = 32 (Cannot complete any of the activities)

Ent., Inc. NY, New York) at position 2 (3.8 cm). The strength of the operated side was compared with that of the contralateral, uninjured wrist.

Functional assessment was performed using the Wrightington Hospital evaluation form (Table 3). A visual analogue scale for problem solving (10 – completely cured; 0 – surgery not beneficial) was used to assess how useful the procedure was in terms of solving the original problem.

Patients in both groups were asked if they had felt improvement in the wrist and if they would undergo the same procedure again.

Analysis for statistical significance was conducted using the paired 2 sample for means Student's *t*-test. A *P* value of ≤ 0.05 was considered significant.

RESULTS

Pain assessment in the postoperative period showed that 77 (62%) of the 117 patients had no to mild pain, 33 patients had moderate pain, while 7 (6%) patients had severe pain. The mean pain score, using the visual analogue scale, was 3.7 (SD = 2.5) in all responders ($n = 117$).

There was a 33° (26%) loss of flexion–extension and 13° (12%) loss in radial–ulnar deviation when compared with the non-operated side. The results for range of motion are shown in Table 4. The loss in the arc of flexion–extension was due to a reduced range of flexion (mean loss 31%). Eighty per cent of extension was maintained compared with the contralateral side.

The mean grip strength on the operated side was 80% of the non-operated side and there was no demonstrable difference between patients having dynamic or static instability or between those involved, or not, in legal claims (Table 5).

Table 4—Range of motion

	Range of motion (°)	Dynamic n = 32	Static n = 23	P-value
Operated side	Palmar flexion	46 (10–80)	45 (10–70)	>0.05
	Dorsiflexion	54 (20–90)	57 (20–90)	>0.05
	Radial deviation	19 (5–35)	16 (5–35)	>0.05
	Ulnar deviation	28 (0–50)	30 (15–45)	>0.05
Non-operated side	Flexion	68 (30–90)	67 (40–90)	
	Extension	68 (50–100)	69 (50–90)	
	Radial deviation	23 (5–40)	21 (10–60)	
	Ulnar deviation	37 (15–55)	38 (26–60)	

	Range of motion (°)	Claims n = 18	Non-claims n = 37	P-value
Operated side	Flexion	48 (10–80)	45 (10–75)	>0.05
	Extension	50 (20–80)	57 (20–90)	>0.05
	Radial deviation	18 (5–35)	18 (5–35)	>0.05
	Ulnar deviation	27 (15–40)	30 (0–50)	>0.05
Non-operated side	Flexion	67 (30–90)	68 (40–90)	
	Extension	66 (50–85)	70 (50–100)	
	Radial deviation	23 (10–60)	22 (5–35)	
	Ulnar deviation	35 (15–60)	38 (20–55)	

Table 5—Grip strengths in kg force: Mean (range)

	Operated side	Non-operated side
Dynamic (n = 32)	22.6 (4–68)	30.8 (6–72)
Static (n = 23)	29.9 (8–68)	33.6 (15–72)
No legal claim (n = 37)	24.46 (4–68)	31.3 (6–72)
Legal claim (n = 18)	28.1 (8–62)	33.4 (15–58)

The legal claims group appeared to score poorly using the visual analogue scale for problem solving and the Wrightington wrist score. The group with no legal claims performed better (Figs 4,5 and Table 6). However, the difference between the two groups was not statistically significant ($P > 0.05$).

On subjective evaluation, 92 (79%) patients who responded were satisfied with the result of the surgery (Good to Excellent). Twenty-two (18%) patients were unsatisfied with the surgery, while three patients found that the surgery had made no difference. Twenty-one (34%) of the patients reviewed were taking part in heavy or light manual labour, while 4% were unemployed. Twenty-four patients (43%) had changed their occupation to lighter duties.

Four patients had persistently tender scars as a result of the palmar incision near the base of the thumb. This required exploration and neuroma excision in three patients. Four patients had persistent mechanical pain. Two of these patients subsequently underwent scapho-capitate fusion, while the other two underwent wrist fusions. Two patients developed persistent ulnar-sided symptoms which were treated by ulnar shortening. One patient developed CRPS Type 1 (reflex sympathetic dystrophy) which needed further management by the pain clinic and hand therapists.

DISCUSSION

Whilst of great importance, the scapholunate ligaments can only be partially responsible for scapholunate dissociation. Through anatomic observations, Brunelli et al. (Brunelli and Brunelli, 1995a,b) concluded that the STT ligaments, particularly the palmar ligament complex comprising the floor of the sheath of the FCR is the most important element in preventing rotary subluxation of the scaphoid.

The Brunelli procedure has been used in our institution since 1995 for the management of scapholunate dissociation, as our results with alternative procedures, particularly the Blatt procedure (Deshmukh et al., 1999), did not compare favourably with those of other published reports (Blatt, 1987; Wintman et al., 1995).

Brunelli and Brunelli (1995a,b), in their preliminary findings on 13 patients with a follow-up of 6 months to 2

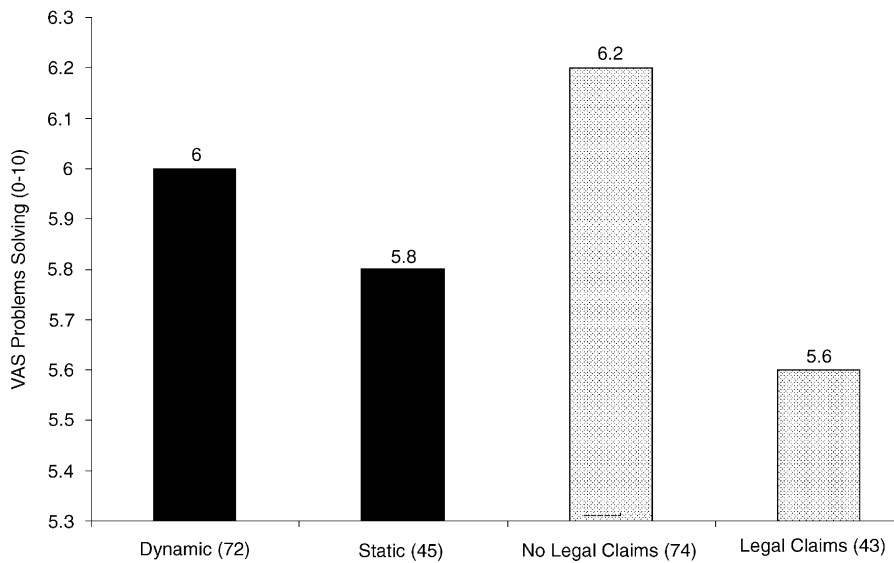


Fig 4 Visual analogue scale for problem solving (0–10).

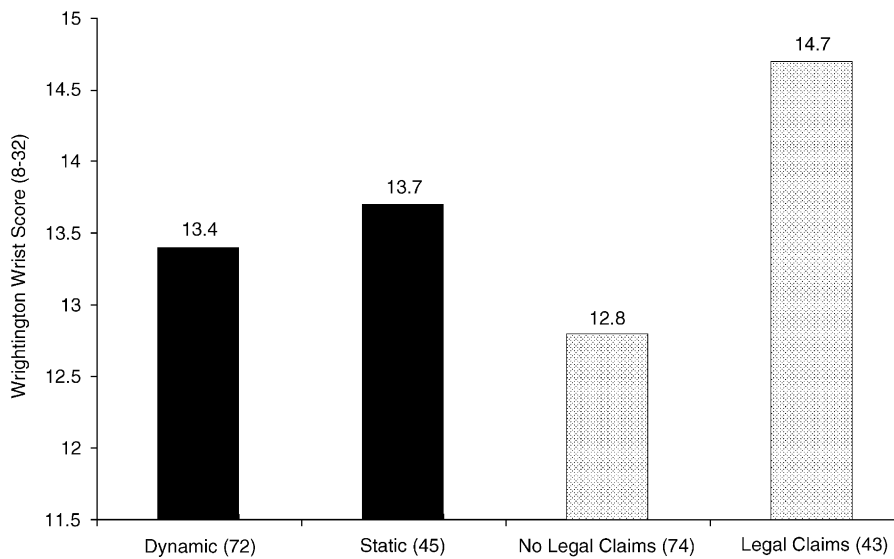


Fig 5 Wrightington wrist score (8–32).

Table 6—Function

	Wrightington score Mean (SD)	VAS (problem solving) Mean (SD)
No legal claim (n = 74)	12.8 (4.5)	6.2 (2.1)
Legal claim (n = 43)	14.7 (5)	5.6 (3)

years, reported a reduction ranging from 30% to 60% in range of motion relative to the contralateral wrist. The grip strength was found to be 35% less than that of the

opposite hand, but with an average improvement of 50% over the pre-operative range. They reported a high rate of patient satisfaction with all patients returning to work after an average period of 100 days.

Szabo et al. (2002) have reported on a dorsal intercarpal ligament capsulodesis for chronic static scapholunate dissociation in 20 patients with a follow-up of 1–4 years. Although the reduction in range of motion using this method is less than that in other reported series, the authors were disappointed that only just over 50% of patients had a Mayo wrist score considered excellent or good. They also found that a

large proportion of patients with workers compensation insurance had fair to poor results, a finding mirrored in our preliminary series (Van Den Abbeele et al., 1998).

Weiss (1998) reported the results of a scapholunate ligament reconstruction procedure using a bone–retinaculum–bone autograft. He compared the results of this procedure in patients with static and dynamic instability and found that the procedure had encouraging results in the management of dynamic scapholunate instability. Patients with static instability did not do as well. The numbers in this series were low (static instability, $n = 5$) and with a short average follow-up (3.6 years). Furthermore, the orientation of the fibres in the autograft was at right angles to that which would have had the highest resistance to stretch. This led the author to question the use of this procedure in static instability and suggest the use of a stronger bone–soft tissue–bone construct.

Limited wrist arthrodeses result in loss of wrist motion. Previous studies on STT arthrodesis for the treatment of chronic scapholunate instability have reported between 16% and 45% loss of wrist flexion, 25% loss of wrist extension and 45% radial deviation (Kleinman, 1989; Watson and Hempton, 1980; Watson et al., 1986). Scaphocapitate fusion also results in a loss of wrist motion. Furthermore, it has been suggested that intercarpal arthrodeses can alter wrist kinematics, leading to different wear patterns on the joint surfaces and leading to premature arthritis (Garcia-Elias et al., 1989).

In this series, we found that the loss in the arc of flexion–extension was due to a reduced range of flexion (31%), while 80% of extension was maintained compared with the contralateral side. The grip strength on the operated side was reduced by 20% of the non-operated side. There was no statistically significant difference ($P > 0.05$) in the range of movement or the grip strength between the static and dynamic groups or the legal claims and no legal claims groups.

The significant reduction in the range of motion in our study, particularly the reduction in flexion, is a matter of concern. However, at a mean follow-up of 4 years, there was a high satisfaction rate (79%) with the procedure, with 88% of the patients reviewed willing to have the procedure again for the same problem. The complication and revision rate was low and grip strength recovery was 81% of the non-operated side.

We believe the modified Brunelli procedure has a role in the management of scapholunate dissociation in the absence of degenerative changes and in those situations in which it is possible to reduce the scapholunate dissociation at surgery. There was no statistically significant difference in the functional outcomes between patients with dynamic and static instability as regards pain scores, range of motion and grip strengths.

The authors acknowledge that this is a retrospective analysis and that the objective data represents 34% of the initial population. The poor response may be related

to the tertiary nature of the referral pattern, where a proportion of patients cannot attend because of the distances involved in returning to our unit.

Previous reports (Szabo et al., 2002; Van Den Abbeele et al., 1998) have commented on the outcomes of the study being biased by the presence or absence of medicolegal claims. Although the legal claims and no legal claims groups behaved similarly when objective criteria were considered, the legal claims group performed poorly in their responses to subjective assessment. However, this failed to reach statistical significance.

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