

Internal Fixation of Acute, Nondisplaced Scaphoid Waist Fractures Via a Limited Dorsal Approach: An Assessment of Radiographic and Functional Outcomes

Asheesh Bedi, MD, Peter J. L. Jebson, MD, Radford J. Hayden,
Jon A. Jacobson, MD, Jeffrey E. Martus, MD

From the Division of Elbow, Hand, and Microvascular Surgery, Department of Orthopaedic Surgery, University of Michigan Health System; and the Section of Musculoskeletal Radiology, Department of Radiology, University of Michigan, Ann Arbor, MI.

Purpose: To evaluate the clinical and radiographic outcomes of a consecutive series of patients who had internal fixation of an acute, nondisplaced scaphoid waist fracture via a limited dorsal approach.

Methods: Twenty consecutive patients had surgical fixation of a nondisplaced scaphoid waist (Herbert B2) fracture via a limited dorsal approach. Eighteen patients were available for follow-up evaluation at a mean duration of 98 weeks after surgery (range, 12–272 wk). Fifteen males and 3 females with a mean age of 25 years (range, 16–62 y) were examined. Wrist range of motion; grip strength; visual analog and numeric pain scores; and a Disabilities of the Arm, Shoulder, and Hand (DASH) outcomes questionnaire were assessed. Postoperative radiographs were reviewed in a blinded fashion to assess the fracture union and screw position.

Results: Seventeen of 18 fractures healed at a mean duration of 8 weeks. No case of proximal pole avascular necrosis occurred. All patients were satisfied and returned to their pre-injury level of employment. Five of 6 collegiate or professional athletes returned to play without limitations. The mean subjective and visual analog pain scores were 0.3 and 0.4 (maximum of 10 for each scale). The mean DASH score was 6.12 (out of 100), which is consistent with an excellent functional outcome. Central axis screw position was achieved on anteroposterior and lateral radiographs in 17 of 18 patients.

Conclusions: Fixation of an acute, nondisplaced scaphoid waist fracture via a limited dorsal approach is safe and effective. The limited dorsal approach allows for accurate insertion of the screw in the central scaphoid, which is biomechanically advantageous for fracture union and early restoration of function. (J Hand Surg 2007;32A:326.e1–326.e9. Copyright © 2007 by the American Society for Surgery of the Hand.)

Type of study/level of evidence: Therapeutic IV.

Key words: Scaphoid fracture, dorsal, cannulated screw.

Controversy continues to surround the treatment of acute, nondisplaced scaphoid waist fractures. The mainstay of treatment for these injuries has been cast immobilization, with an acceptable rate of union and a low rate of complications documented in the literature.^{1–4} A considerable period of immobilization often is required, however, potentially resulting in limited range of motion and delayed functional recovery. In addition, a prolonged

time to union and a high rate of incomplete healing has been reported with cast immobilization of these fractures.^{4–6}

Surgical fixation of nondisplaced, scaphoid waist fractures has been advocated increasingly over the past few years. Rigid internal fixation allows for early physiotherapy throughout the healing phase, a more rapid time to union, improved range of motion, and rapid functional recovery.^{7–20} Several studies

have reported a high rate of union and excellent clinical outcome with minimal morbidity using percutaneous techniques^{7–20}; however, the benefits and risks of surgery for a nondisplaced waist fracture compared with cast immobilization remain controversial.

Clinical and biomechanical studies also recently have documented the importance of screw position with fixation of scaphoid fractures.^{21,22} Central placement of the screw is advantageous biomechanically, with greater stiffness and load to failure.²¹ Trumble et al²² showed more rapid progression to union with a central screw position in patients with scaphoid nonunion. A volar approach traditionally has been used for screw insertion; however, recent studies have raised potential concerns regarding eccentric screw placement and damage to the scaphotrapezial articulation with this approach.^{12,23,24}

Our preferred technique is a limited dorsal approach with compression screw fixation of the scaphoid waist fracture.²³ The technique is simple and permits visualization of a reliable starting point for screw placement within the central axis of the scaphoid. Furthermore, the limited dorsal approach avoids potential damage to the scaphotrapezial articulation that can occur with the volar approach.¹² Our study assessed the radiographic and functional outcomes in a consecutive series of patients who had surgical fixation of an acute, nondisplaced scaphoid waist fracture through a limited dorsal approach.

Materials and Methods

This study was approved by the Institutional Review Board at our health system. From 2000 to 2005 there were 20 consecutive patients who had an internal cannulated screw fixation of a nondisplaced scaphoid waist (Herbert B2) fracture via a limited dorsal approach by a single surgeon (P.J.L.J.) at the University of Michigan Health System. The fracture was detected on plain radiographs in each patient. All proximal pole or tuberosity fractures, fractures with displacement greater than 1 mm, fractures with associated ligament injuries, fractures presenting more than 10 days after the index injury, or patients with a history of prior ipsilateral wrist injury were excluded. All patients included in the study were skeletally mature and had screw fixation via the limited dorsal approach within 2 weeks of the injury.

Wrist range of motion and grip strength were measured in both limbs at the final follow-up visit. Visual analog and numeric pain scores, presence of scar sensitivity, and the Disabilities of the Arm, Shoulder, and

Hand (DASH) outcomes questionnaire score also were obtained. The DASH is a validated outcomes instrument for upper-extremity function.²⁵ The score is calculated out of 100, with a higher score representing greater disability and less satisfaction.

Extension, flexion, radial deviation, and ulnar deviation were measured in each wrist using a goniometer by an examiner not directly involved in the patients' care. Grip strength was measured using a dynamometer (Jamar; Sammons Preston Rolyan, Bollingbrook, IL), recording the maximal grip strength. Both range of motion and grip strength parameters also were converted into a percentage of the contralateral side for each patient. The numeric pain and visual analog pain scale used are shown in [Appendix A](#) (this Appendix may be viewed at the Journal's Web site, www.jhandsurg.org).

All postoperative radiographs of the involved wrist, including anteroposterior (AP), lateral, and dedicated scaphoid views, were reviewed retrospectively in a blinded fashion by a surgeon (A.B.) and a senior musculoskeletal radiologist (J.A.J.) not directly involved in the patients' care. Criteria for radiographic union was clear bridging trabeculation with progressive disappearance of the fracture line. Central versus eccentric screw position, as based on previously established criteria by Trumble et al,²² was assessed on AP, lateral, and dedicated scaphoid views ([Fig. 1](#)).

Surgical Protocol

A general or regional anesthetic may be used. The forearm is pronated and a longitudinal skin incision that is approximately 2 cm in length is placed beginning at the proximal aspect of Lister's tubercle and extending along the axis of the third metacarpal. The extensor retinaculum of the third compartment is incised immediately distal to Lister's tubercle and the fascia overlying the extensor pollicis longus (EPL) tendon is released, permitting retraction of the EPL radially. The fascia over the extensor digitorum communis, extensor carpi radialis longus, and extensor digitorum brevis (ECRB) tendons is incised longitudinally. The extensor digitorum communis tendons are retracted ulnarly while the ECRB and extensor carpi radialis longus tendons are retracted radially with the EPL, thereby exposing the underlying radiocarpal joint capsule.²³

A limited inverted T-shaped capsulotomy is made with the transverse limb placed just distal to the dorsal rim of the radius and the longitudinal limb directly over the scapholunate articulation. The capsular flaps are elevated from the dorsal lunate, the



Figure 1. (A) Anteroposterior and (B) lateral radiographs showing the criteria for the central third screw position as defined by Trumble et al.²² The placement of the screw was assessed on the final follow-up AP radiographs taken with the wrist in the neutral position with ulnar deviation and on lateral and oblique radiographs taken with the forearm in pronation and supination. The proximal pole of the scaphoid was divided into 3 equal sections, with the middle section representing the central one third.²² The screw was considered to be placed centrally if it was located in the central one third of the proximal pole of the scaphoid. Otherwise it was considered to be placed peripherally, even if the screw extended out of the central one third on only one view. Arrows denote edges of central third region. (C) Peripherally placed screw by criteria of Trumble et al.²² Reprinted with permission from *The Journal of Bone and Joint Surgery, Inc.*, Trumble et al.²²

dorsal component of the scapholunate ligament, and the proximal pole of the scaphoid. Care is taken to avoid exposing or stripping near the dorsal ridge vessels entering at the scaphoid waist.²³

An appropriate guidewire is inserted. This is performed by fully flexing the wrist over a bolster of 3 to 4 rolled towels. The guidewire is inserted at the membranous portion of the scapholunate ligament origin and aimed down the central axis of the scaphoid toward the thumb. Intraoperative portable fluoroscopy is used to confirm accurate wire placement. A lateral view is obtained but we have found it difficult to interpret with respect to screw insertion in the central axis. We use a 30° pronated lateral view to facilitate accurate wire placement (Fig. 2). A posteroanterior view with the wrist held in ulnar deviation also is obtained, with care taken to avoid bending the guidewire. This requires some wrist flexion



Figure 2. Intraoperative fluoroscopy showing the 30° pronated oblique view used to confirm central axis guidewire placement.

during imaging. The wire is advanced up to, but not into, the scaphotrapezial joint.²³

We use the Acutrak or mini-Acutrak screw system (Accumed, Beaverton, OR), but any cannulated screw system that permits screw insertion beneath the articular surface can be used. We prefer to use the larger Acutrak screw if possible; however, the mini-Acutrak system may be necessary in those patients with a small scaphoid or irregular shape such that insertion of an Acutrak screw may result in inadvertent propagation of the fracture to the insertion site with fragmentation of the proximal scaphoid.

We subtract 4 mm from the measured length to allow burial of the proximal screw beneath the articular surface. Once the screw length has been determined, the wire is driven into the trapezium to avoid loss of position during reaming. The cannulated reamer then is used, followed by manual insertion of the screw. The guidewire is removed and the screw position is assessed via fluoroscopy (Fig. 3).

After surgery the patient is immobilized in a short-arm plaster splint and discharged home with instructions on strict arm elevation and frequent digital range-of-motion exercises. Two weeks after surgery the patient should return for suture removal. Formal occupational therapy is begun and a removable forearm-based splint is worn. The splint is discontinued at 4 to 6 weeks after surgery. Fracture healing is assessed at 2, 6, and 12 weeks after surgery with routine plain radiographs. If there is any question regarding fracture union, a computed tomography scan is obtained 3 months after surgery.

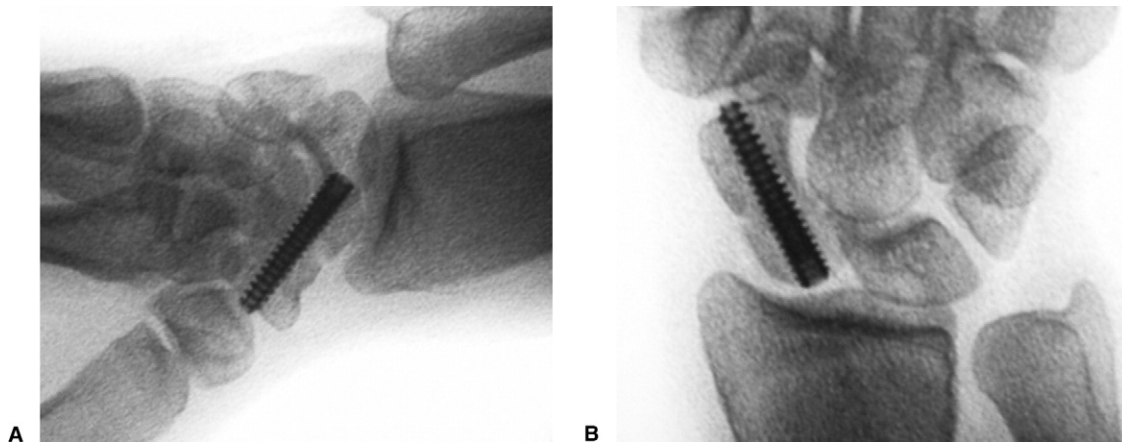


Figure 3. (A) Intraoperative AP and (B) 30° pronated oblique fluoroscopic images showing cannulated screw placement along the central axis of the scaphoid.

Results

Clinical Outcome

Eighteen patients were available for follow-up examination at a mean duration of 98 weeks after surgery (range, 12–272 wk) (Table 1). Despite an exhaustive search, the remaining 2 patients could not be contacted. One patient was homeless and had moved to an out-of-state shelter. The study population consisted of 15 males and 3 females, with a mean age of 25 years (range, 16–62 y). Six patients were collegiate or professional athletes at the time of presentation. All but 1 of the patients were nonsmokers. There were 17 right-handed and 1 left-handed pa-

tient. Sixteen of 18 fractures occurred in the dominant limb. One patient sustained an associated minimally displaced, ipsilateral radial head fracture.

One patient noted mild sensitivity of the dorsal scar at the final follow-up evaluation; however, there was no functional consequence or interference with occupational duties or activities of daily living. No cases of infection or complications requiring revision surgery occurred. All employed patients eventually returned to work without restrictions. Five of 6 collegiate or professional athletes returned to their previous level of play. All 18 patients reported that they would have the procedure again and would recom-

Table 1. Summary Data: Demographics

Patient No.	Age, y	Gender	Dominant Hand	AP	Lateral	Scaphoid View	Union	Time to Union, wk	Duration of Follow-up Evaluation, wk	Pain (Subjective)	Pain (Visual Analog)	DASH Score
1	25	M	RH	Y	Y	Y	Y	6	16	0	0	7.5
2	18	F	LH	Y	Y	Y	Y	6	26	2	2	10.3
3	21	M	RH	Y	Y	Y	Y	8	112	0	0	3.3
4	38	F	RH	Y	Y	Y	Y	12	272	0	0	0
5	21	M	RH	Y	Y	N	N	8	28	0	0	20
6	22	M	RH	Y	Y	Y	Y	6	36	0	0	0.83
7	20	M	RH	Y	Y	Y	Y	8	32	0	0	3.3
8	27	M	RH	N	N	N	Y	6	21	0	0	0
9	22	M	RH	Y	Y	Y	Y	8	172	2	2	10.8
10	24	M	RH	Y	Y	Y	Y	8	220	0	1	0.83
11	26	M	RH	Y	Y	Y	Y	8	164	0	0	0
12	25	M	RH	Y	Y	Y	Y	8	160	0	0	2.5
13	31	M	RH	Y	Y	Y	Y	8	236	2	2	30.8
14	17	M	RH	Y	Y	Y	Y	8	32	0	0	0.83
15	21	M	RH	Y	Y	Y	Y	6	40	0	0	0
16	62	F	RH	Y	Y	Y	Y	6	160	0	0	8.3
17	17	M	RH	Y	Y	Y	Y	10	12	0	0	1.72
18	16	M	RH	Y	Y	Y	Y	10	14	0	0	9.16
Mean	25							8	97	0.3	0.4	6.1
N				18	18	17	18	18	18	18	18	18
SD								2		1	1	8

RH, right-handed; LH, left-handed.

mend the surgery to a friend or relative with a similar injury.

The results of the subjective and visual analog pain scores are shown in Table 1. The mean subjective pain score at the final follow-up evaluation was 0.3 ($n = 18$, $SD = 0.8$) on a scale of 0 to 10, with 10 representing the worst possible pain. The mean visual analog pain score was 0.4 ($n = 18$, $SD = 0.8$) on a scale of 0 to 10, with 10 representing the worst possible pain (Appendix A; this Appendix may be viewed at the Journal's Web site, www.jhandsurg.org).

The results of the DASH questionnaire are shown in Table 1. The mean score was 6 of 100 ($SD = 8$, 95% confidence interval [CI], 2–10). Range-of-motion measurements and 95% CIs for the involved and contralateral wrist are shown in Table 2. The mean extension ($n = 17$) was 65° (92% of the uninjured wrist; $n = 14$). The mean palmar flexion ($n = 17$) was 52° (93% of the uninjured wrist; $n = 14$). Radial and ulnar deviation were 21° ($n = 15$) and 38° ($n = 15$), respectively (both greater than 90% of the uninjured side; $n = 13$). The mean differences and results of a paired t test analysis are shown in Table 3. No statistically significant difference in flexion ($p = .24$) or ulnar deviation ($p = .61$) was noted between the injured and uninjured wrists. A statistically significant reduction in extension ($p = .043$) was identified, with a mean difference of 6° between wrists. The reduction in radial deviation ($p = .035$) also was significant, with an average loss of 4° .

Comparisons of grip strength between the injured and contralateral wrist are shown in Table 3. The mean grip strength was 40 kg ($n = 15$) at the final follow-up evaluation, which was approximately 95% of the uninvolved wrist ($n = 14$). Paired t test analysis showed no significant difference ($p = .086$) in grip strength between the injured and uninjured extremity at the final follow-up evaluation.

Radiographic Outcomes

Seventeen of 18 patients (94%; 95% CI, 0.84–1.0) progressed to radiographic union without complication. This was defined by evidence of obliteration of the fracture line and clear bridging trabeculation as determined by a blinded review of the radiographs by an independent, senior musculoskeletal radiologist. The mean time to union was 8 weeks ($SD = 1.66$; 95% CI, 6.95–8.61). One nonunion occurred with a nondisplaced, comminuted waist fracture that failed to show bridging trabeculation on computed tomography scan evaluation at 3 months. This patient cur-

rently is being treated with an external bone stimulator. No cases of proximal pole avascular necrosis occurred. No signs of screw migration or loosening were noted in any patient.

Screw position relative to the central axis of the scaphoid as defined by Trumble et al²² was evaluated on postoperative AP, lateral, and dedicated scaphoid radiographs. Ninety-four percent (95% CI, 0.84–1.0) of patients showed a central screw position on the AP and lateral views. Eighty-eight percent (95% CI, 0.73–1.0) of patients showed a central screw position on the dedicated scaphoid view.

Discussion

Cast immobilization has been the mainstay and generally accepted treatment of an acute, nondisplaced scaphoid waist fracture. Leslie and Dickson¹ documented union rates greater than 90% with conservative treatment, and multiple other series^{2–4,26–29} have reported acceptable radiographic and functional outcomes. In recent years, however, there has been increased concern regarding the morbidity of cast immobilization. A prolonged duration of immobilization is required and can be accompanied by muscle atrophy, stiffness, reduced grip strength, and residual pain after healing.^{2–6} In addition, cast immobilization can cause major inconvenience for the patient and interference with activities of daily living.⁶ The prolonged duration of immobilization is of particular concern in the young laborer, athlete, or military personnel who requires a rapid functional recovery. In addition, an assessment of healing while the patient is in a cast is difficult, and considerable uncertainty regarding the appropriate duration of immobilization exists.² Herbert and Fisher,⁵ as well as Dias et al,⁴ also identified incomplete healing or nonunion in a sizeable number of patients treated with cast immobilization.

In an effort to avoid the morbidity associated with cast treatment, surgical techniques were developed to allow a more rapid functional recovery after a scaphoid fracture. Streli⁷ first described a percutaneous technique of nondisplaced scaphoid fracture fixation with a cannulated screw in 1970. Multiple series subsequently have documented the efficacy of a volar percutaneous approach, yielding high rates of union and rapid mobilization with minimal morbidity.^{7–20} Wozasek and Moser⁸ reported favorable outcomes in a large series of more than 200 acute scaphoid fractures treated percutaneously. Ledoux et al¹³ subsequently reported a 100% union rate and a rapid return to work in patients with acute fractures and nonunion

Table 2. Summary Data: Results

Patient No.	Grip Strength, kg	Extension°	PF°	RD°	UD°	CH Grip Strength, kg	CH: Extension°	CH:PF°	CH:RD°	CH:UD°
1	31	75	42	20	31	33	79	53	19	36
2	36	63	37	13	36	41	64	46	23	47
3	25	62	56	30	30	25	56	64		
4	32	80	60	35	35	29	80	65	35	40
5	39	61	36	14	46		62	45	19	43
6		50	30							
7	42	64	64							
8	46	85	75	30	28	47	85	70	30	25
9	49	56	32	13	51	57	82	71	18	41
10		85	70	30	35	44				
11	53	83	72	35	40	53	85	70	35	35
12										
13	50	50	39	11	26	60	71	49	19	36
14	42	54	64	15	36	42	61	42	19	34
15	40	59	53	27	41	41	74	55	21	36
16	23	45	43	11	37	19	61	37	27	40
17	37	66	71	12	43	41	59	71	14	41
18	44	65	44	21	51	46	68	47	26	31
Mean	39	65	52	21	38	41	71	56	24	37
N	15	17	17	15	15	14	14	14	13	13
SD	9	13	15	9	8	12	10	12	7	6

PF, palmar flexion; RD, radial deviation; UD, ulnar deviation; CH, contralateral hand.

managed with percutaneous screw fixation. Haddad and Goddard¹¹ reported a 100% union rate in a series of 50 consecutive patients with full restoration of wrist range of motion and grip strength by 3 months after surgery; however, concerns regarding eccentric screw placement and injury to the scaphotrapezial articulation with the volar approach have been noted recently.^{12,24}

Other studies recently have compared cast immobilization with percutaneous fixation of an acute, nondisplaced scaphoid waist fracture.^{19,26–29} Drac et al²⁶ showed a lower failure rate, favorable range of motion, and restoration of grip strength in surgically treated patients. Adolfsson et al⁹ completed a ran-

domized trial of percutaneous screw fixation versus short-arm spica cast immobilization of nondisplaced waist fractures. An improved range of motion in surgically treated patients was noted at the long-term follow-up evaluation. No differences in rate or time to union was found. Bond et al²⁷ completed a randomized, prospective comparison of cast immobilization with volar, percutaneous screw fixation of nondisplaced waist fractures in young military personnel. Although no difference in functional recovery was noted, surgery resulted in a faster progression to union. Furthermore, Dias et al²⁸ recently showed a 23% nonunion rate with cast immobilization, and inferior recovery of wrist range of motion

Table 3. Analysis of Differences Between Injured and Uninjured Wrist Grip Strength and Range of Motion

Difference	N	Mean*	SD	95% CI for Mean		Test Statistic†	p Value
				Lower	Upper		
Grip strength	14	2.21	4.46	−0.36	4.79	1.86	.0857
Extension	14	5.93	9.89	0.22	11.64	2.24	.0429
Flexion	14	4.36	13.27	−3.30	12.02	1.23	.2410
RD	13	3.69	5.59	0.32	7.07	2.38	.0346
UD	13	−1.23	8.35	−6.28	3.81	−0.53	.6047

RD, radial deviation; UD, ulnar deviation.

*Mean difference between surgery and contralateral hand.

†Paired *t* test.

and grip strength compared with percutaneous fixation at 2 months after surgery.

The main advantage of our approach, however, is the ability to reliably and safely insert the screw along the central scaphoid axis.²² Our criteria for accurate screw position was perhaps more stringent, demanding central axis placement at both the proximal pole and waist level on both the AP and lateral views. These findings are in concordance with Chan and McAdams,²⁴ who showed more accurate and reliable central axis screw placement with the dorsal versus the volar approach in a cadaveric model. This difference may be secondary to palmar displacement of the starting point at the scaphotrapezial articulation with the volar approach, resulting in eccentric screw position.²⁴ In addition, the limited dorsal approach avoids articular damage to the scaphotrapezial articulation, which frequently can be sustained during guidewire placement, drilling, and volar screw insertion.^{12,24}

Central screw position is advantageous biomechanically, with greater stiffness and load to failure in a waist osteotomy model.²¹ Dodds et al³⁰ recently showed significantly less fracture fragment motion with a longer versus a shorter screw in 4 of 6 displacement axes in a scaphoid waist fracture model. Based on these findings, the investigators advocated the use of a long screw placed down the central axis of the scaphoid deep into the subchondral bone for surgical fixation, permitting rigid fixation and immediate functional recovery.³⁰ Although the clinical benefits of central screw position in acute waist fracture fixation remain unknown, the immediate rigid fixation afforded by a long, headless compression screw inserted into the central axis of the scaphoid permits rapid limb mobilization and fracture union.³¹ Our study shows that central screw placement and the associated advantages can be achieved safely and reliably with the limited dorsal technique, and that this approach is an acceptable alternative to volar percutaneous or open fixation. Although the clinical importance of a biomechanically more stable construct may be limited with nondisplaced waist fractures, we believe the small dorsal approach may have a key role in approaching more unstable, displaced fracture patterns and we are addressing this hypothesis in future studies.

These results, however, do not provide justification for surgical fixation for all nondisplaced scaphoid waist fractures. Cast immobilization is a safe, effective, and an acceptable treatment strategy for those patients who do not desire surgical treatment;

however, we believe that the decision regarding cast immobilization versus surgical fixation for a nondisplaced scaphoid waist fracture should be made by the surgeon and patient together with an appropriate discussion of the various treatment options, inherent risks, benefits, and socioeconomic implications.

Received for publication June 13, 2006; accepted in revised form January 2, 2007.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Corresponding author: Peter J. L. Jebson, MD, Associate Professor and Chief, Division of Elbow, Hand, and Microvascular Surgery, Department of Orthopaedic Surgery, University of Michigan Health System, Ann Arbor, MI 48105; e-mail: pjebsen@med.umich.edu.

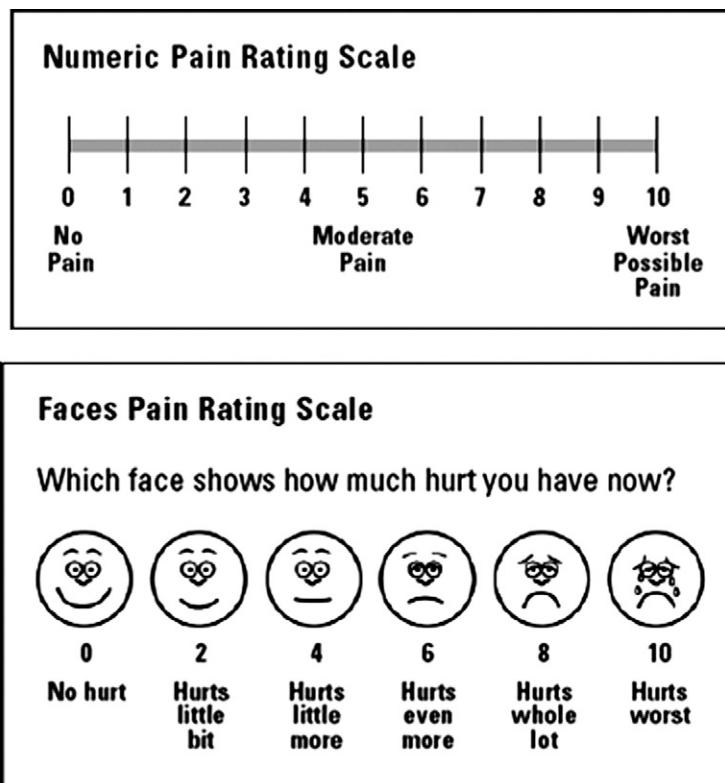
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doi:10.1016/j.jhsa.2007.01.002

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Appendix A. (Top) Subjective numeric pain rating. **(Bottom)** Visual analog FACES pain rating score used at the University of Michigan Health System.
