■ WRIST & HAND

Radiological outcome of early surgical fixation versus cast immobilization for adults with a scaphoid waist fracture: five-year follow-up of the Scaphoid Waist Internal Fixation for Fractures Trial

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Aims

In the Scaphoid Waist Internal Fixation for Fractures Trial (SWIFFT), surgical fixation was compared with cast immobilization, with the primary endpoint being the outcomes at one year. The aim of the current study was to assess the radiological outcomes (union and the development of osteoarthritis (OA)) of the two forms of treatment at five years.

Methods

Patients who remained in the trial at five years after randomization were invited to have plain radiographs and a CT scan of the injured wrist, and a posterior-anterior radiograph of the contralateral wrist. This imaging was reviewed by three observers independently for union of the fracture and the distribution and severity of OA. This analysis followed a pre-specified statistical analysis plan. The relationship between OA and the Patient-Rated Wrist Evaluation (PRWE) scores at five years was assessed.

Results

Of the 439 patients who were randomized, 267 (60.8%) provided imaging at five years. Their characteristics were similar to those of the original cohort. A total of 182 patients (68.2%) (n = 92 fixation, n = 90 cast) had complete union and seven had a nonunion (2.6%; n = 3 fixation, n = 4 cast). Fractures with a minimum of 20% union at one year consolidated with the passage of time without intervention. Progression of OA in the joints around the scaphoid was seen in both groups from baseline to five years. By five years, 140 patients (52.4% of those with imaging at five years) had OA in at least one joint with similar prevalences in both groups. The prevalence of OA, the number of arthritic joints and the maximum severity of OA, was similar in the two groups. A total of 344 of the initial cohort of 439 patients (78.4%) provided a valid PRWE score at five years and the mean score was higher in those with more severe OA, indicating worse pain and function.

Conclusion

Between one and five years after randomization, union consolidated in those with > 20% bridging without intervention. The proportion of patients with full, almost full, partial, slight, and nonunion for the two forms of treatment remained similar at five years. The prevalence and severity of OA increased during the five years but was similar in both groups.

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Introduction

The Scaphoid Waist Internal Fixation for Fractures Trial (SWIFFT) was a pragmatic, parallel-group, multicentre, open-label, two-arm, randomized superiority trial involving 31 NHS hospitals in England and Wales. Patients were recruited from

Table I. A comparison of the status of union of fractures at one and five years, overall, and by group.

Variable	Patients, n	United	Almost full union	Partial union	Slight union	Nonunion	Missing
Overall							
One year, n		165	123	13	8	5	125
Five years, n (%)							
United	182	97 (58.8)	57 (46.3)	3 (23.8)	0 (0.0)	0 (0.0)	25 (20.0)
Almost full	76	22 (13.3)	32 (26.2)	8 (61.5)	1 (12.5)	1 (12.5)	12 (9.6)
Partial union	0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Slight union	2	0 (0.0)	0 (0.0)	1 (7.7)	0 (0.0)	0 (0.0)	1 (0.8)
Nonunion	7	0 (0.0)	0 (0.0)	0 (0.0)	3 (37.5)	3 (60.0)	1 (0.8)
Missing	172	46 (27.9)	34 (27.6)	1 (7.7)	4 (50.0)	1 (20.0)	86 (68.8)
Surgical fixation							
One year, n		93	64	3	3	1	55
Five years, n (%)							
United	92	49 (52.7)	26 (40.6)	1 (33.3)	0 (0.0)	0 (0.0)	16 (29.1)
Almost full	50	19 (20.4)	21 (32.8)	1 (33.3)	0 (0.0)	0 (0.0)	9 (16.4)
Partial union	0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Slight union	1	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	1 (0.5)
Nonunion	3	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	1 (100.0)	0 (0.0)
Missing	73	25 (26.9)	17(26.6)	0 (0.0)	1 (33.3)	0 (0.0)	30 (54.6)
Cast immobilization							
One year, n		72	59	10	5	4	70
Five years, n (%)							
United	90	48 (66.7)	31 (52.5)	2 (20.0)	0 (0.0)	0 (0.0)	9 (12.9)
Almost full	26	3 (4.2)	11 (18.6)	7 (70.0)	1 (20.0)	1 (25.0)	3 (4.3)
Partial union	0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Slight union	1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)
Nonunion	4	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	2 (50.0)	1 (1.4)
Missing	99	21 (29.2)	17 (28.8)	1 (10.0)	3 (60.0)	1 (25.0)	56 (80.0)

orthopaedic departments at these hospitals between July 2013 and July 2016, and initially followed up for one year after randomization.

The primary outcome measure was the total Patient-Rated Wrist Evaluation (PRWE),[1] a 15-item, patient-reported questionnaire designed to measure wrist pain and disability in activities of daily living. Secondary outcomes included the 12-Item Short-Form Health Survey questionnaire (SF-12),[2] EuroQol five-dimension three-level questionnaire (EQ-5D-3L),[3] bone union, grip strength, range of motion (ROM), return to work and recreational activities, and complications.

Patients were eligible for SWIFFT if they were aged ≥ 16 years, skeletally mature, and presented within two weeks of injury with a bicortical fracture of the waist of the scaphoid on plain radiographs and could have surgery within two weeks of presentation. Eligible patients who gave written consent were randomly assigned 1:1 to the surgery group (percutaneous or open surgical fixation), or the cast immobilization group (below-elbow cast immobilization for six to ten weeks with or without inclusion of the thumb, followed by immediate fixation if nonunion of the fracture was confirmed).

The study and all amendments were approved by the East Midlands Research Ethics Committee (13/EM/0154). The protocol was published in 2016,[4] with the planned statistical analysis as Supplementary Material. The clinical findings at one year, including the degree of union, have also been published.[5]

All patients who remained in the trial at the end of the one-year follow-up were invited to attend clinic for follow-up at five-years. This study reports the radiological outcomes for this group of patients. The five-year clinical review was prespecified in the protocol and the trial was overseen by an independent steering committee.

Methods

Follow-up data were collected from patients by post, telephone, or at clinic appointments. At five years, the PRWE scores were collected again, ROM was measured using a goniometer, and grip strength using a Jamar dynamometer. The scars from surgery were examined for tenderness and sensitivity, and their influence on daily activities was recorded. These outcomes have been recently reported.[6] The patients completed the EQ-5D-3L healthcare resource questions,[7] and questions about the impact on their job, and these results have also been reported.[7,8]

Routine radiographs of the scaphoid were obtained with posterior-anterior, lateral, semi 45° prone, semi 45° supine views, and an elongated Ziter view, as well as a CT scan. A posterior-anterior view of the contralateral wrist was also obtained.

A total of 439 patients were initially randomized (219 to fixation and 220 to cast immobilization). Of these, 423 (96.4%) were still 'active' in the trial (i.e. had not withdrawn) at one year and were approached to be reviewed at five years. A total of 344 provided hospital follow-up data at five years, and imaging data for the affected wrist was obtained for 267 patients (63.7% of those followed up, 60.8% of the initial cohort).

The five-year data were collected between September 2018 and January 2022. The baseline characteristics for those who

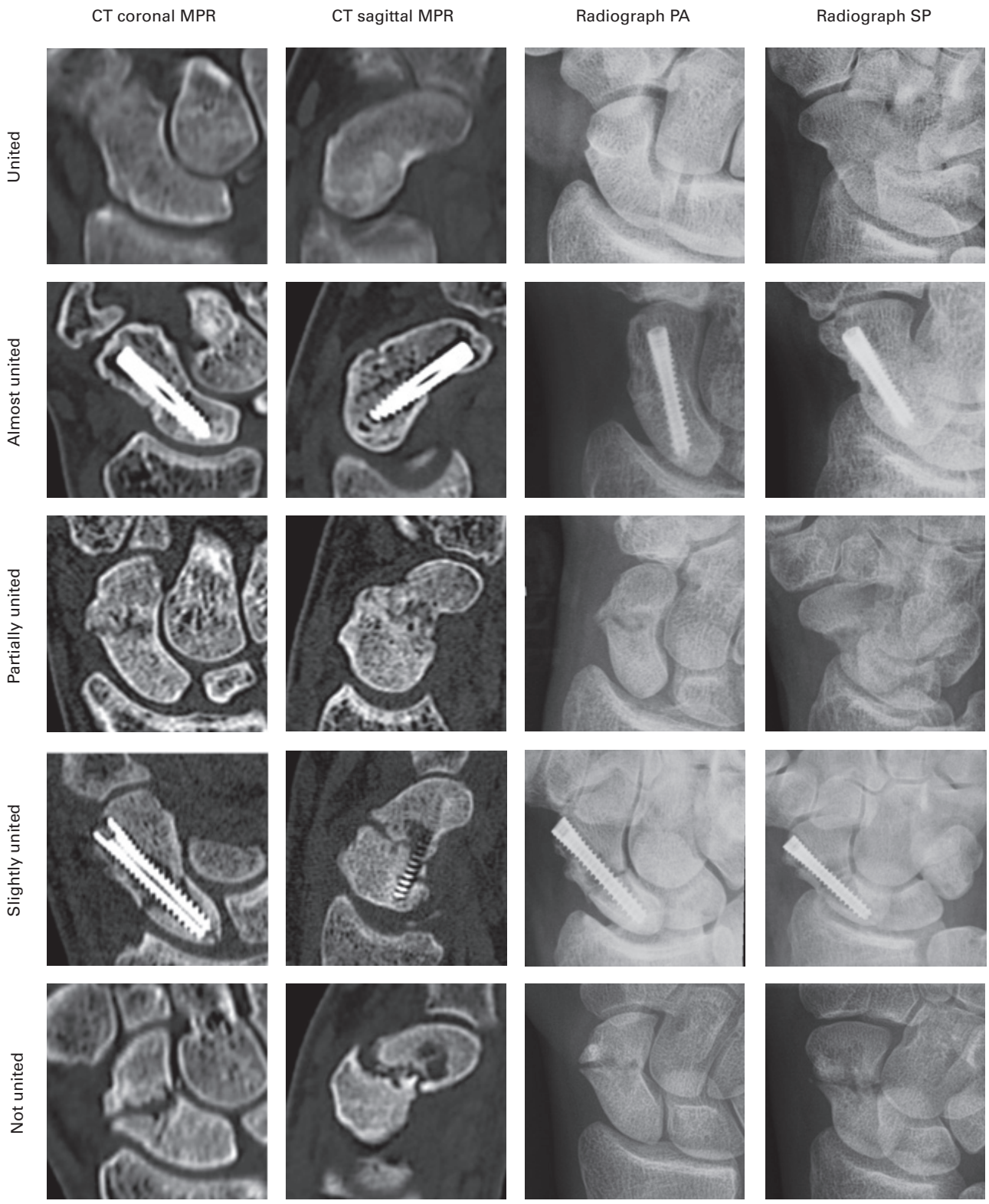

Fig. 1

CT scan-specific grading union. This figure shows the five grades of union on coronal and sagittal multiplanar reconstructions (MPR) in the scaphoid plane. Radiographs, illustrated using posterior-anterior (PA) and semi-prone (SP) views, are inconsistent with CT scan in the assessment of union.

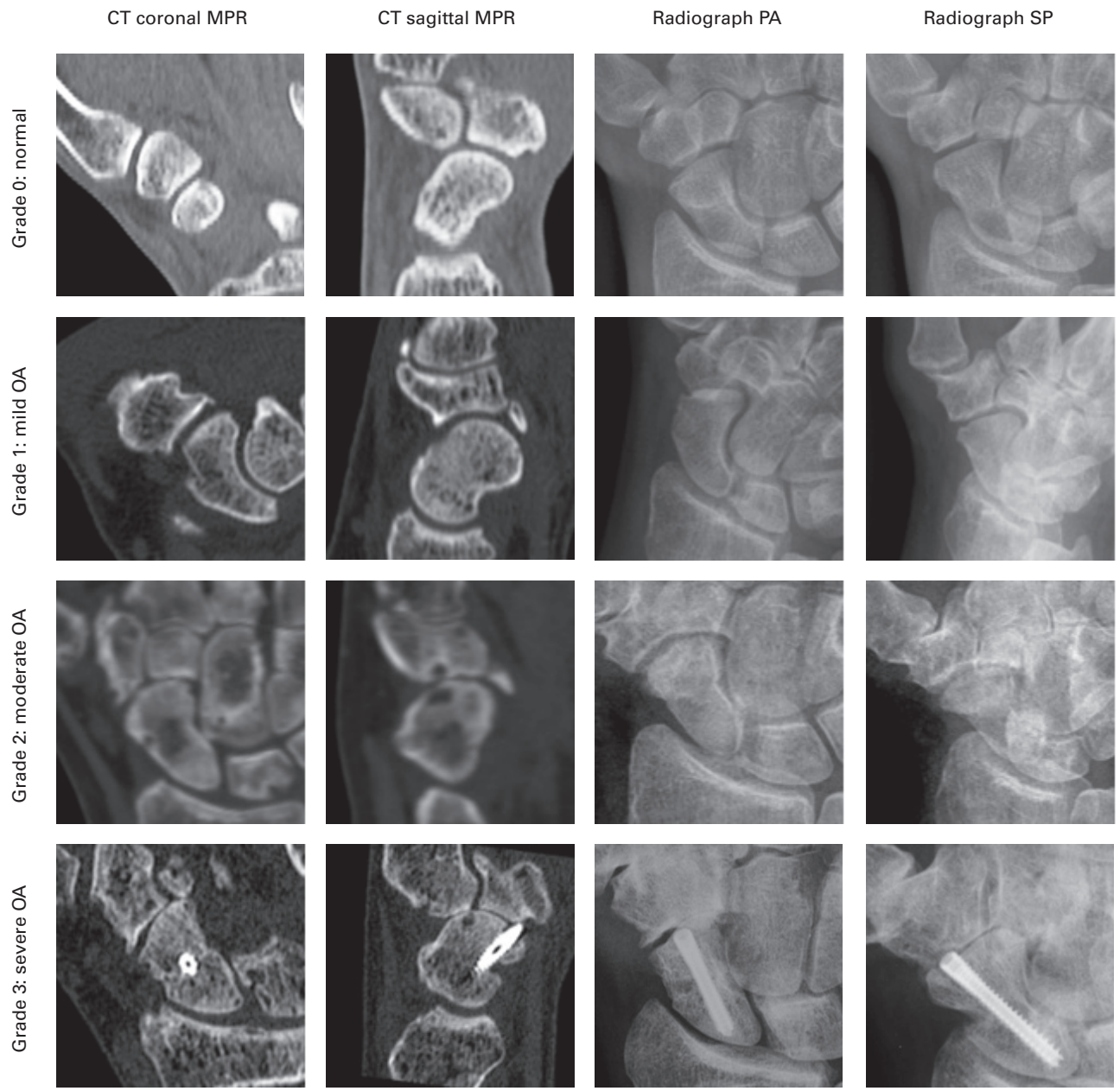

Fig. 2

Grades of osteoarthritis (OA) in the scaphotrapezium joint. This figure shows the CT scan-specific arthritis grading system using four grades of severity at the scaphotrapezium-trapezoid joint on coronal and sagittal multiplanar reconstructions in the scaphoid plane. The multiplanar reconstructions (MPR) involved the wrist rather than the scaphoid in the coronal and sagittal planes. This complements the description and classification for other joints within the wrist. Grading into four levels (normal, mild, moderate, and severe osteoarthritic changes) is based on the system described by Kellgren and Lawrence summarizing the severity of loss of joint space, subchondral sclerosis, cyst formation, and osteophytes. Radiographs, illustrated using posterior-anterior (PA) and semi-prone (SP) views, underestimate severity of arthritis.

provided imaging data at five years were similar to those of the whole cohort (Supplementary Table i).[5,6]

Union (Figure 1) was assessed on radiographs and CT scans, and the percentage of bony bridging at the fracture site calculated on scans by three independent senior observers using a classification agreed with the collaborating surgeons on the study.[9] The percentage of union was classified as nonunion (0% bony bridging at the fracture site), slight union (> 0% to 20%), partial union (> 20% to 70%), almost full union (> 70% to 95%), and full union (> 95%).[9] Conflicts were resolved at regular meetings of the three observers (JJD, SC, KJ) and their assessments have been compared in pairs using a Bland-Altman plot and the findings reported.[9]

The imaging was assessed for OA looking at the four areas around the fractured scaphoid: the radioscaphoid joint distal to the fracture; the radioscaphoid joint proximal to the fracture; the

scaphotrapezium-trapezoid joint; and the scaphocapitate joint. The capitolunate and radiolunate joints were also assessed, and any other joint showing changes suggestive of OA. The most severely affected joint was noted.[10] When a patient had several 'worst' joints, they were all classed as the 'worst', so they were not mutually exclusive. The state of the joint space, sclerosis, and the presence of osteophytes were all graded as none, mild, moderate, or marked, and cysts were graded as none, small, moderate, or marked. Using the Kellgren-Lawrence grading,[11] based on these four characteristics, the severity of OA was summarized as none, mild, moderate, or severe (complete loss of joint space) (Figure 2).[12,13]

Statistical analysis. A statistical analysis was pre-specified and strictly followed. Analysis was undertaken in Stata v. 17 (StataCorp, USA). Baseline characteristics are summarized descriptively using mean, SD, and ranges for continuous data, with median and IQR for skewed data, and counts and percentages for categorical data.

The classification of union of the fracture is reported by group and overall. This classification at five years for any fractures classified as nonunion or partial union at one year is presented. Additionally, any that were classified as full union at one year, but not at five years are detailed. The grade of severity of OA is summarized. A cross tabulation is also presented for each joint which was assessed. A summary of the PRWE scores by the maximum severity of OA is given to assess the impact of OA.

The study was not powered to undertake formal comparative analysis on the five-year imaging data between the two groups, so descriptive summaries only are provided.

Results

The number of patients who were assessed and the number with the different grades of union of the fracture at one and five years are shown in Table I. In summary, at five years 96.6% had full or almost full union (97.3% in the fixation group and 95.9% in the cast group).

Of the 13 partial unions at one year, three (23.1%) became fully united, eight (61.5%) became almost fully united, one (7.7%) had degraded to a slight union, and one (7.7%) was not assessed at five years. Of the five nonunions at one year, three (60.0%) remained as nonunion, one (20.0%) was almost fully united, and one (20.0%) was not assessed at five years (Table I). A total of 22 (13.3%) of the 165 fractures which were fully united at one year were not classified as such at five years; all were assessed to be almost fully united. The longer-term follow-up of these fractures shows that in those with > 20% of union at one year, the union continued to increase and consolidate over time (Figure 3).

At baseline, 43 patients (9.8%) had OA in one or more joints (21/219 (9.6%) fixation, 22/220 (10.0%) cast). At one year, OA was noted in 78 patients (26.7% of the 292 who had a CT scan; 42/157 (26.8%) fixation, 26/135 (26.7%) cast). At five years, 140/267 (52.4%) patients had OA in one or more joints (74/146 (50.7%) fixation, 66/121 (54.5%) cast).

At five years, OA was least common in the capitolunate joint, and most common in the scaphotrapezium-trapezoid joint (Supplementary Table ii). There were similar levels of OA (in any joint) in each group (50.7% fixation (n = 74), 54.6% cast (n = 66)), and a similar number of joints with OA (mean: 1.3 (SD 1.8) fixation, 1.5 (SD 1.8) cast). The maximum severity seen in the six joints was similar in the two groups (Supplementary Table ii).

Between baseline and one year, 62/292 patients (21.2%) had worsening of OA with similar rates in both groups (36/157 (22.9%) fixation, 26/135 (19.3%) cast). Of the 215 patients who had the OA assessed at both one and five years, the maximum severity had progressed from one year for 81 patients (37.7%) (43/115 (37.4%) fixation, 38/100 (38.0%) cast) (Supplementary Table iii, Supplementary Figure a). Overall, the OA progressed by more than one grade in 12 patients (eight fixation, four cast).

At baseline, the most commonly worst affected joint was an 'other' joint (33/43 (76.7%)). For 24/43 (55.8%), the worst affected joint was the scaphotrapezium-trapezoid joint. Neither the scaphocapitate nor radioscaphoid joint was the most affected joint in any patient. At one year, the most common worst-affected joint was the scaphotrapezium-trapezoid joint (53/78 (68.0%)). An 'other' joint was the worst affected for 35/78 patients (44.9%), the radioscaphoid joint for 14 (18.0%), and scaphocapitate joint for five (6.4%).

These percentages were similar at five years, with the scaphotrapezium-trapezoid joint being the most severely affected joint in 78/140 patients (55.7%), and an 'other' joint in 54/140 (38.6%). The radioscaphoid and scaphocapitate joints were the most severely affected in 27 (19.3%) and 25 (17.9%) patients, respectively.

At five years, OA was present in the scaphotrapezium-trapezoid joint in 64/145 patients (44.1%) in the fixation group (graded at least moderate for 16) and 43/121 (35.5%) in the cast group (graded at least moderate for seven) (Supplementary Table iv).

The rate of moderate and severe OA in joints around or influenced by the scaphoid fracture (capitolunate and radiolunate) but excluding 'other' joints was 13.0% (13/100) in the cast group and 15.7% (18/115) in the surgical group.

The mean PRWE score increased with worsening severity of OA, indicating worse pain and function (Table II).

At five years, most patients had full union (68.2%; n = 182), and/or had no OA (47.6%; n = 127) (Supplementary Table v), while 29 patients (15.9%) with full union developed moderate or severe OA, and all seven patients with nonunion developed mild to severe OA.

Imaging data for the contralateral wrist were only available for a few patients at five years, so analysis to compare the presence of OA between the two wrists could not be performed.

Discussion

There is very little information in the literature about the progress of union and the development of OA after a fracture of the waist of the scaphoid, and no prospective studies have been reported. The SWIFFT study provides this information.

Union of these fractures has exercised surgeons because of the development of OA caused by nonunion.[10] Historically, union was defined as bridging trabeculae on radiographs, but CT scans give a better assessment of bridging because of the limited number, usually four or five, of radiological views which were obtained.[14]

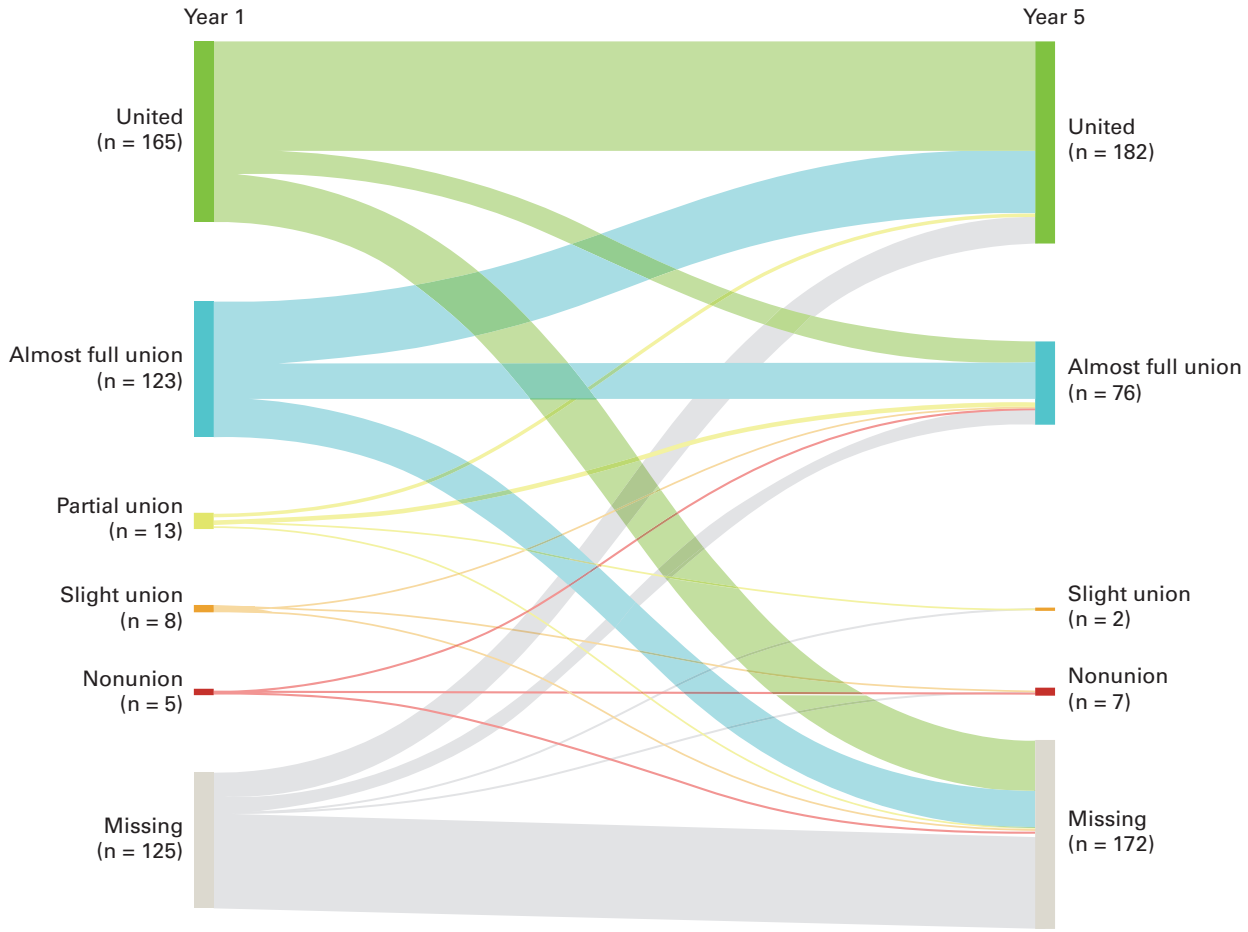

Fig. 3

A Sankey diagram showing change in the status of union between one and five years.

Table II. Patient-Rated Wrist Evaluation at five years by maximum severity of osteoarthritis.

Variable	None	Mild	Moderate	Severe
Patients, n	135	87	28	12
Mean (range; SD)	8.0 (0.0 to 78.5; 13.6)	9.3 (0.0 to 72.0; 14.9)	10.7 (0.0 to 80.4; 18.0)	12.5 (0.0 to 53.5; 17.2)
Median (IQR)	2.0 (0.0 to 11.0)	3.5 (0.0 to 12.0)	2.5 (0.0 to 10.8)	3.8 (0.0 to 21.5)

Barton,[15] in 1996, described ten patients who had a 'nonunion' of a scaphoid fracture on radiographs. The patients were explored surgically and no movement was identified at the fracture site. Four of these were classed as partial union as there was bridging on part of the surface of the fracture. Nicholl et al,[16] in 1995, used stereoscopic macroradiography and described 21 patients who had partial union of a scaphoid fracture.

Singh et al,[17] in 2005, described 52 patients, some of whom had partial union of a scaphoid fracture with follow-up. They performed CT scans at 12 to 16 weeks and obtained five coronal images, 1 mm apart, of the scaphoid and five sagittal images. They defined partial union when there was a visible gap across part of the fracture site but trabecular bridging across other parts. More than half (30/52, 57.7%) of patients had full union on CT scans. The remaining 22 had partial union but none had bridging of < 25%. For most of those with partial union (13 of 22) the union was across the ulno-palmar aspect of the fracture; in 12 of these the bridging was < 75%; nine had a further CT scan and showed progression of union.

Grewal et al,[18] in 2013 proposed definitions of union of the fracture if the proportion of bridging was between 75% and 100%, partial if bridging was between 50% and 75%, and tenuous if it was ≤ 50%. They modified the method of calculation from that described by Singh et al[17] in 2005 and reported excellent interobserver reliability with both methods of assessment. In an observational study on 219 patients, Grewal et al[19] only classified 12 as having nonunion. Nine of these had surgery and all fractures united. The authors chose 50% bridging on sagittal views of the scaphoid on a CT scan as suggesting 'sufficient' union. However, there was little explanation for use of this threshold. The natural history of partial union had not been established and they offered surgery when bridging was ≤ 50%.

Any bridging eliminates movement at the fracture site, thereby setting the environment for consolidation. The findings of the SWIFFT study have confirmed that union at one year of > 20% progresses to consolidation even when the partially united fracture is not protected. However, when union is < 20% bridging is fragile, and the bridge could fail if it is loaded; at this low level of union the clinician needs to consider further monitoring with a repeat CT scan or internal fixation, possibly with bone grafting, with a high chance that the bridging will increase. It has been reported in recent finite element analysis studies from the UK[20] and Switzerland[21] that fractures with 30% bridging can withstand the loads of activities of daily living, so the patient can be advised to resume these activities without external support.

While it has been established in observational studies that OA in the radiocarpal and midcarpal joints is common after the mechanics of the proximal carpal row are disrupted by an ununited scaphoid fracture, less information is available about the proportion of patients who develop OA after the fracture has healed. The injury causing the fracture can damage the articular cartilage and lead to OA. In the past, OA was observed on radiographs obtained 30 years later in about 15% of healed fractures (7/47, one moderate in the radioscaphoid joint and six mild) compared with a rate of 7% in the contralateral wrist.[22] A much higher rate of OA in the joints around the scaphoid was identified in the SWIFFT study at one year on CT scans. The five-year review identified progression in the rate of OA, continuing even after the fracture united. The prevalence of OA at five years was 52.4% with little difference between the two treatment groups, although the most common maximum severity of OA remained mild.

The scaphotrapezium-trapezoid joint had the highest proportion of OA and the rate was higher and more severe in the fixation group. This proportion is much greater than that previously reported, probably reflecting assessment on CT scans rather than radiographs. Vinnars et al,[23] in 2008, reported OA in the scaphotrapezium-trapezoid at ten years in 1/35 (2.8%) treated in a cast compared with 11/40 (27.5%) in those who had early surgical fixation. This may suggest a consequence of screw fixation. They observed that surgery can cause more complications and perhaps is associated with a higher risk of scaphotrapezial OA. Dias et al,[24] also in 2008, reported a 13.6% rate of OA at a mean follow-up of 93 months and concluded that there was no difference in the prevalence of scaphotrapezium trapezoid OA between the two groups having surgical fixation or cast immobilization.

Lindström and Nyström[25] had previously, in 1990, described the outcomes in 229 healed scaphoid fractures over a period of seven years. One patient had radioscaphoid OA before injury, and this worsened to grade 3 by seven years. Two had mild radioscaphoid OA by the time treatment was completed; after seven years, 11 (4.8%) had mild radiocarpal OA, one (0.4%) had moderate and one (0.4%) had grade 3 OA. They observed that OA was always located between the distal pole of the scaphoid and the tip of the radial styloid. They considered that ligamentous injury was unlikely to explain the OA and speculated that it was more likely to be a consequence of malunion. A prevalence of radioscaphoid OA of 17.6% (47/267) distal to the fracture and 16.1% (43/267) proximal to the fracture at five years on CT scans was found in the SWIFFT study. These findings suggest that the OA may reflect injury to articular cartilage, but it is usually mild at five years.

There may be a correlation between the severity of OA and the PRWE score, as patients with more severe OA report higher levels of pain and reduced function. However, the difference between the mean PRWE scores for patients with the highest and lowest levels of the severity of OA is less than the minimal clinically important difference (MCID) for the PRWE score and only a few patients had moderate or severe OA, so the confidence of this conclusion is reduced.

The pragmatic design of the SWIFFT trial ensured that the results were relevant to a wide range of settings and was the largest prospective study which has been undertaken comparing surgery with cast immobilization in these patients. The collection of imaging data included radiographs and CT scans, with decision-making based on a consensus of three expert observers from both surgical and radiological specialties. Thus, this study was more rigorously designed than previous studies and provided long-term evidence.[16–22,24,25]

Imaging data were collected for 267 patients at five years, representing 60.8% of the initial cohort. This was achieved despite half of the follow-up occurring during the COVID-19 pandemic. There were no significant differences between the characteristics of the patients at baseline and at five years, suggesting that it is unlikely that bias was introduced. However, the study was not powered to perform formal analysis of the five-year imaging data, so the analyses were restricted to descriptive summaries.

In conclusion, the five-year SWIFFT imaging data confirmed that bony bridging at the site of a scaphoid fracture site of ≥ 20% at one year almost always leads to consolidation without intervention. The prevalence of OA was greater than has been reported in the past and increased with the passage of time. OA was observed even after fracture healing was complete, but is usually mild. Overall, the imaging findings in the two treatment groups remained similar at five years.

Take home message

- This longer-term evidence confirms consolidation of the proportion of bony bridging, and the increasing arthritis impact of injury on joints.
- Radiological features of union and arthritis between the two treatment groups were similar at one and five years.

Social media

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Supplementary material

Tables and figures displaying additional data.

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