Similar 1-year subjective outcome after a distal radius fracture during the 10-year-period 2003–2012

A longitudinal register-based study involving 3,666 patients

Marcus LANDGREN [1], Antonio ABRAMO [2], Mats GEIJER [3], Philippe KOPYLOV [1], and Magnus TÄGIL [1,2]

[1] Department of Orthopedics, Clinical Sciences, Lund University and Skåne University Hospital, Lund; [2] Department of Hand Surgery Malmö, Skåne University Hospital, Malmö; [3] Department of Clinical Sciences, Lund University, and Faculty of Medicine and Health, Örebro University, Örebro, Sweden.
Correspondence: marcus.landgren@med.lu.se
Submitted 2016-10-31. Accepted 2017-02-13.

Background and purpose — During the last decades, treatment of distal radius fractures (DRFs) has changed, with surgical intervention being more common and with new techniques. We investigated whether this change has influenced the subjective outcome. Here we report, year by year, the 1-year score after a DRF over a 10-year-period, using a patient-reported outcome measure.

Patients and methods — Patients aged 18 years or more with a DRF between 2003 and 2012 were prospectively and consecutively registered in a longitudinal outcome database. 1 year after the fracture, all the patients were sent a validated subjective outcome questionnaire, the Disabilities of the Arm, Shoulder, and Hand (DASH). The lower the score (0–100), the better the outcome.

Results — Between 2003 and 2012, 3,666 patients (2,833 of them women; mean age 62 (18–98) years) were included. 22% were operated and the rate remained constant over the years. The surgical methods shifted from external fixators (42%) and fragment-specific plates (45%) in 2003, to mainly volar locking plates (65%) in 2012. 70% of the patients responded to the 1-year DASH questionnaire. The median DASH score was 9 (IQR: 2–25) for the cohort, both in surgically treated patients (9 (IQR: 3–25)) and in non-surgically treated patients (9 (IQR 2–27)). Subgroup analysis showed a higher median DASH score for women than for men; for patients with AO type C fractures rather than type B or type A fractures; for patients with external fixation or fragment-specific fixation than for those who underwent surgery using volar locking plates; and for patients who were operated by a general orthopedic surgeon rather than a hand surgeon.

Interpretation — The shift in surgical treatment had no influence on the subjective outcome for the cohort.

The distal radius fracture (DRF) is the most common fracture in adults, representing one-sixth of all fractures in the emergency room (Court-Brown and Caesar 2006). The annual incidence in Sweden in recent years was calculated to be 25–28 fractures per 10,000 person-years (Brogren et al. 2007, Mellstrand-Navarro et al. 2014).

During the last decades, the treatment of DRFs has changed, with increasingly more surgery (Chung et al. 2009, Mattila et al. 2011). In Sweden, the rate of surgical treatment increased from 16% of fractures in 2005 to 20% in 2010 (Mellstrand-Navarro et al. 2014). New methods of surgical intervention have been introduced, and the volar locking plate has replaced external fixators (Mellstrand-Navarro et al. 2014). No solid evidence of improved outcome has supported this shift, but recent meta-analyses have found a tendency regarding better outcome with newer implants (Cui et al. 2011, Wei et al. 2012, Esposito et al. 2013, Xie et al. 2013, Wang et al. 2013, Walenkamp et al. 2013, Li-hai et al. 2015). No longitudinal registry studies have evaluated the subjective outcome of DRF during this change of practice. In this study, using the 1-year Disabilities of the Arm, Shoulder, and Hand (DASH) score after DRF, we attempted to determine whether the shift in surgical techniques changed the outcome for DRF patients over a 10-year period.

Patients and methods

The Lund wrist fracture register

At the start of the study in 2003, the Department of Orthopedics, Skåne University Hospital, Lund had a primary catchment area of 227,182 inhabitants aged 18 years or more, which

DOI 10.1080/17453674.2017.1303601

increased to 255,621 in 2012 (Statistical Database, Statistics Sweden). During this time, approximately 450 adult patients were treated for DRF annually (hospital reimbursement data). In 2001, a wrist fracture register was initiated to evaluate the subjective outcome of the treatment in a larger cohort, as a complement to smaller-sized, randomized studies (Kopylov et al. 1999, Abramo et al. 2009, Landgren et al. 2017). On a weekly basis, a secretary scrutinized the medical records from the emergency department for wrist fractures. The DRF patients were prospectively and consecutively included in the register, and a patient-reported outcome measure (DASH) was distributed and collected 3 and 12 months after the fracture by regular mail. Patients included in 2 published randomized studies (Abramo et al. 2009, Landgren et al. 2017) were not excluded. Non-responders received a reminder 2 weeks later. Results from the first 2 years (September 2001 through August 2003) have been reported previously (Abramo et al. 2008a).

Treatment protocol

Non-displaced fractures were treated in a forearm cast for 4–5 weeks; displaced fractures were reduced and cast. If impossible to reduce primarily, or if secondary loss of reduction occurred at the 7- to 10-day follow-up, surgical treatment was recommended (Abramo et al. 2008a). The type of surgical treatment changed over the study period. At the start, primarily bridging external fixators were used for dorsally displaced fractures and a volar non-locking plate was used for volarly displaced fractures. The fragment-specific wrist fixation system (Konrath and Bahler 2002) was introduced at our institution in 1996. It was used routinely from 2001, and was compared with the external fixator in a randomized study on 50 patients between May 2002 and December 2005 (Abramo et al. 2009). The fragment-specific wrist system gave better forearm rotation and grip strength at 12 months after surgery and replaced the external fixator. The volar locking plate was introduced at our institution in 2004, and has been in routine use since 2006. A second randomized study on 50 patients between December 2010 and December 2012 compared the fragment-specific system with the volar plate system (Landgren et al. 2017). Both implants had good and similar clinical outcomes, but the fragment-specific fixation had a higher complication rate. During the entire period, a group of 4 dedicated hand surgeons with both orthopedic and hand surgery training performed the majority of the DRF operations (62%).

The current report

Here we report registry data from a 10-year period (January 2003 to December 2012). All medical records were analyzed retrospectively to verify the diagnosis, the type of treatment, and the classification according to the International Classification of Diseases (ICD) 10 system for distal radius fractures (S52.50, S52.51, S52.60, and S52.61). The surgically treated patients were also analyzed retrospectively for AO fracture type, high- or low-energy injury, and time from fracture to surgery. Of 3,855 patients in total (Figure 1), 44 had a new DRF during the 10-year period and were excluded. 105 patients were excluded for incorrect coding with distortions, fractures, or dislocations of other parts of the arm. Patients with persistent pain from older fractures (n = 5), those operated at other hospitals (n = 10), and those incorrectly registered twice (n = 25) were excluded. Thus, 3,666 patients with a DRF were included in the register during the 10-year period.

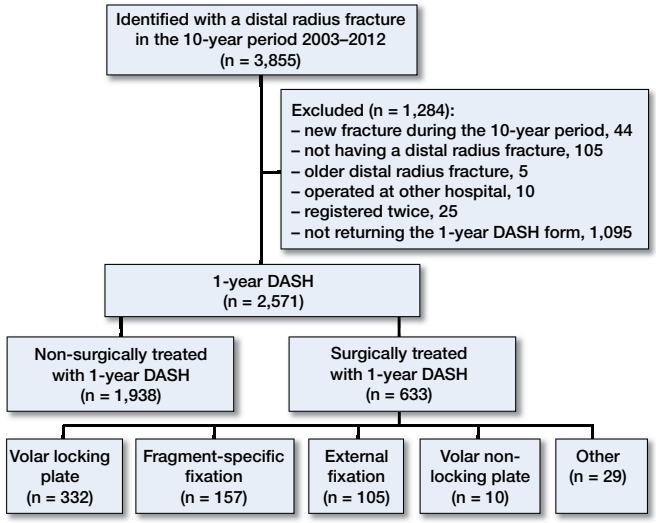

Figure 1. Flow chart of the study.

Outcome questionnaire

The DASH questionnaire is a patient-reported outcome measure, which has been validated in Swedish (Atroshi et al. 2000). The DASH evaluates disability and symptoms of the upper extremity. The original DASH questionnaire has a 30-item scale evaluating function, pain, and symptoms of the upper extremity during the preceding week. A final score is calculated, ranging from 0 (meaning no disability) to 100 (most severe disability). In 2005, a short version—the Quick-DASH with only 11 questions—was developed (Beaton et al. 2005), translated to Swedish, validated, and correlated to the DASH (Gummesson et al. 2006). At our center, the Quick-DASH replaced the original DASH questionnaire from February 2008, and a strong correlation was found between the full 30-question version and the shorter 11-question version (r_s = 0.97; $p < 0.001$) (Abramo et al. 2008a).

Radiography

In surgically treated patients, the DRF was assessed on postero-anterior and lateral radiographs taken at presentation, and classified as A, B, or C according to the AO classification (Müller et al. 1990) by 1 of 2 of the authors (ML or MG). Radiographs from 100 patients were scored by both observers to assess inter-observer reliability.

Table 1. Demographic data showing the DASH scores 1 year after fracture of the distal radius

	n	1-year DASH score median (IQR) [a]	mean (95% CI)	p-value [b]
Sex				
Female [c]	2,051	11 (2–27)	18 (17–19)	
Male [c]	520	5 (0–18)	13 (11–14)	< 0.001
Age (years)				
18–64	1,323	7 (1–20)	14 (13–15)	
≥65	1,248	14 (3–32)	20 (19–21)	< 0.001
Treatment group				
Surgical	633	9 (3–25)	17 (15–18)	
Non-surgical	1,938	9 (2–27)	17 (16–18)	0.5

[a] Interquartile range
[b] Independent samples Wilcoxon rank sum test for between group comparisons
[c] Female mean age 64 and male mean age 53

Table 2. Types of implant in relation to DASH at 1 year

	n	1-year DASH score median (IQR) [a]	mean (95% CI)	p-value [b]
Volar locking plate	322	8 (2–20)	14 (13–16)	
Fragment-specific	157	12 (5–27)	19 (16–22)	0.004
External fixation	105	13 (3–30)	19 (15–23)	

[a] Interquartile range
[b] Independent samples Kruskal-Wallis test for multiple group comparisons (volar locking plate, fragment-specific, and external fixation)

Statistics

DASH outcome data are ordinal with a skewed distribution, so non-parametric tests were used with median and interquartile range (IQR) to report the central tendency and variation. In the tables, mean and 95% confidence interval (CI) are presented to enable comparisons with previously published studies. For between-group comparisons, the Wilcoxon rank-sum test was used, and for multiple group comparisons the Kruskal-Wallis test was used. The chi-square test was used for group comparisons of responders and non-responders. A 2-sided p-value < 0.05 was considered to be statistically significant. Cutoff values for the DASH score were arbitrarily set and the patients were divided into 3 groups to reflect the severity of residual symptoms: minor (0–10), moderate (11–35), and major (36–100). Inter-observer reliability of AO type classification was assessed with Cohen's kappa (unweighted). Spearman's rank-order correlation was used to determine the relationship between age and DASH score.

Ethics

The regional ethics committee approved the study (ETIK 2009/318), and waived the need for informed consent.

Funding and potential conflicts of interests

Funding was received from Government Funding of Clinical Research within the National Health Service (ALF), the Swedish Research Council (project 2031), Regional Research Support (Region Skåne), the Maggie Stephens Foundation, the Erik and Angelika Sparre Foundation, the Greta Kock Foundation, the Alfred Österlund Foundation, the Thure Carlsson Foundation, and the Faculty of Medicine, Lund University, Sweden.

No competing interests declared.

Results

3,666 patients (2,833 of them women), mean age 62 (18–98) years, were included in the register during 2003–2012 (Figure 1). 2,861 patients (78%) were treated non-surgically and 805 patients (22%) were treated surgically. 2,571 patients (70%) returned the 1-year DASH questionnaire. Of the 2,861 non-surgically treated patients, 1,938 (68%) returned the 1-year DASH questionnaire. Of the 805 surgically treated patients, 633 (79%) returned the questionaire. 235 of the surgically treated patients were classified as AO fracture type A, 44 type B, and 519 type C. Primary radiographs from 7 patients were missing, and these fractures could not be classified. Inter-observer agreement was substantial (Landis and Koch 1977) with k = 0.66 (95% CI: 0.51–0.82). The shift in 2008—replacing the 30-item DASH with the 11-item QuickDASH—increased the response rate from 66% to 73%.

Median DASH score at 1 year was 9 (IQR: 2–25) for the whole cohort; women had a higher (worse) median DASH score than men (11 and 5, respectively; p < 0.001) (Table 1). A weak correlation was found between age at fracture and the 1-year DASH score (rs = 0.24; p < 0.001). 1,248 older patients, 65–98 years old, had a higher median DASH score of 14, as compared to 7 in 1,323 patients aged 18–64 years (p < 0.001) (Table 1). Non-surgically and surgically treated patients had similar median DASH scores (9, IQR: 2–27 and 3–25, respectively) (Table 1). No change in the 1-year DASH score was seen during the study period, in either the non-surgically treated patients (p = 0.8) or the surgically treated patients (p = 0.1). Patients operated with a volar locking plate had a better median DASH score (8, IQR: 2–20) than those with fragment-specific fixation or external fixator (12, IQR: 5–27; and 13, IQR: 3–30; p < 0.004) (Table 2). In the surgically treated group, a higher median DASH score was found for patients with AO type C fractures (n = 188) (11, IQR: 4–27) than for those with AO type B (n = 36) (5, IQR: 0–13) or AO type A (n = 405) (7, IQR: 2–18) (p < 0.001). A subgroup with substantially worse outcome was found post-hoc in 48 patients operated for distal radius-ulna fractures (20, IQR: 5–40) than for 585 patients who were operated for an isolated DRF (9, IQR: 2–25; p = 0.005). Similarly, 39 patients treated non-surgically for a distal radius-ulna fracture had worse outcome (25, IQR:

Table 3. Data showing responders vs. non-responders in the cohort 1 year after fracture

	Responders n = 2,571 n (%)	Non-responders n = 1,095 n (%)	p-value [a]
Sex			
Female	2,051 (72)	782 (28)	
Male	520 (62)	313 (38)	< 0.001
Age			
< 40	281 (56)	225 (44)	
40–80	1,962 (77)	582 (23)	< 0.001
> 80	328 (53)	288 (47)	
Treatment			
Surgical	633 (79)	172 (21)	
Non-surgical	1,938 (68)	923 (32)	< 0.001

[a] Chi-squared test for between group comparisons

9–43) than 1,899 patients treated non-surgically for an isolated DRF (9, IQR 2–25; p = 0.003).

Median DASH was similar for high-energy fractures (n = 471) (9, IQR: 3–23) and low-energy fractures (n = 135) (9, IQR: 2–25; p = 0.9). The 1-year DASH score was similar whether patients were operated < 7 days after the injury (n = 350) (9, IQR: 3–23) or ≥ 7 days after the injury (n = 283) (11, IQR: 2–25; p = 0.3). 500 of the 805 surgically treated patients (62%) were operated by the dedicated group of 4 hand surgeons. Of the 633 patients who responded to the 1-year DASH questionnaire, the median DASH score was 8 (IQR: 2–23) for the 403 patients who were operated by the 4 hand surgeons, 13 (IQR: 5–34) for the 164 patients who were operated by 25 general orthopedic surgeons, and 13 (IQR: 3–32) for the 66 patients who were operated by 17 orthopedic residents (p = 0.007).

1,338 of 2,571 non-surgically treated patients (52%) had no or minor residual symptoms (DASH 0–10), 788 (31%) had moderate residual symptoms (DASH 11–35), and 445 (17%) had major disabilities (DASH 36–100). Similarly, 334 of 633 surgically treated patients (53%) had no or minor residual symptoms, 194 (30%) had moderate residual symptoms, and 105 (17%) had major disabilities.

Analysis of non-responders

1,095 patients (30%) did not return—or failed to correctly fill out—the DASH questionnaire 1 year after fracture. When the patients were divided into 3 age groups (< 40, 40–80, and > 80 years) (Table 3), a higher proportion of non-responders was found in the younger age group (44%) and the older age group (47%) than in the middle-aged group (23%). The male cohort had more non-responders (38%) than the female cohort (28%), and the non-surgically treated cohort had more non-responders (32%) than the surgically treated cohort (21%). Similar response rates were found in the surgically treated patients regarding AO type, but there was a higher proportion of non-responders in patients with high-energy fractures (29%) than in patients with low-energy fractures (19%).

Discussion

A low DASH score, equivalent to a limited degree of pain and disability, is the goal for the cohort as well as for the individual. We found a median DASH score of 9 (IQR: 2–25) (mean 17 (SD 20)) as an endpoint 1 year after a DRF in 2,571 patients. In the first report of the presently used hospital-based DRF register (Abramo et al. 2008a), the median DASH score in 360 patients 1 year after fracture was 7.5 (IQR: 1.7–25) (mean 16), which was compared with a median DASH score of 2.5 (IQR: 0–9.2) (mean 8) in an unfractured age- and sex-matched reference group of 71 healthy individuals (Abramo et al. 2008a). In a US general population, the DASH score in 1,706 patients > 18 years of age was median 4 (IQR: 1–13) and mean 10 (SD 15) (Hunsaker et al. 2002). A score between 0 and 10 can be considered to be a very good result, and means a return to pre-fracture function. In the present study, half of the patients had DASH scores between 0 and 10.

A full return to pre-fracture function within the first year after fracture is unlikely in every patient, regardless of treatment. Thus, thresholds for acceptable or unacceptable final subjective results are of value when evaluating a cohort. The initiator of the DASH score suggested rough cutoff values (DASH/QuickDASH e-Bulletin, Summer 2013). DASH scores of between 10 and 29 were described as patients being aware of their limitations but not considering them to be a problem, and patients with a DASH score ranging from 40 to 69 were patients experiencing much difficulty. We used cutoff values for DASH with a score of 0–10 representing minor disability, 11–35 moderate disability, and 36–100 major disability. The cutoff value for the major disability level was based on 2 previous studies of radius osteotomies due to malunion after a fracture. Patients scheduled for radial osteotomy due to malunion had median preoperative DASH scores of 39 (range: 2–63) (Abramo et al. 2008b) and 35 (range: 22–61) (Abramo et al. 2010), suggesting that a level of > 35 indicated substantial problems. So, even though a full return to pre-fracture function cannot be achieved in all patients, a reasonable goal would be to prevent major disability. We found 17% in the major disability group after 1 year. Similarly, in a Canadian DRF cohort study, 21% had moderate to severe disability when evaluated with the patient-reported wrist evaluation (PRWE) (MacDermid et al. 2003). The outcome of a DRF may not be as benign and foreseeable as is usually believed.

To our knowledge, this is the largest and longest prospective register study to analyze the subjective outcome in patients with DRF. The results show a radical shift in the choice of surgical methods at our department, from external fixation to internal fixation (Figure 2), which is similar to trends reported for Sweden (Mellstrand-Navarro et al. 2014) and internationally (Mattila et al. 2011). There was, however, no trend regarding an increased proportion of surgical treatment (Figures 3 and 4). No improvement in the median DASH score over the years was apparent, both for the whole group of patients

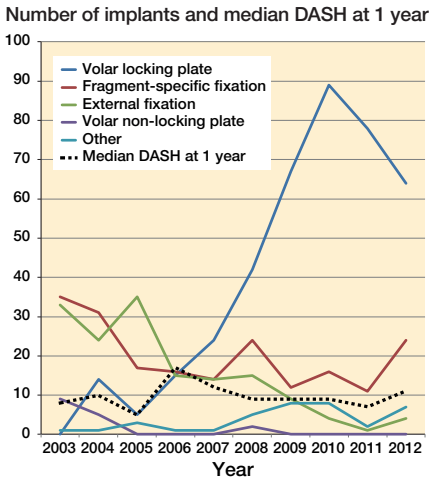

Figure 2. Types of implant used during the study period (n = 805). A randomized study comparing external fixator and fragment-specific fixation was conducted in 2002–2005 and a randomized study comparing fragment-specific fixation and volar locking plate was conducted in 2010–2012.

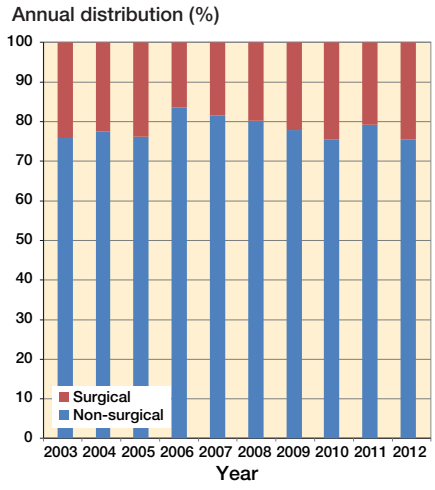

Figure 3. Relative proportions of non-surgical treatment (n = 2,861) and surgical treatment (n = 805) in the period 2003–2012. A proportion of surgical treatment of approximately 22% was observed throughout the decade.

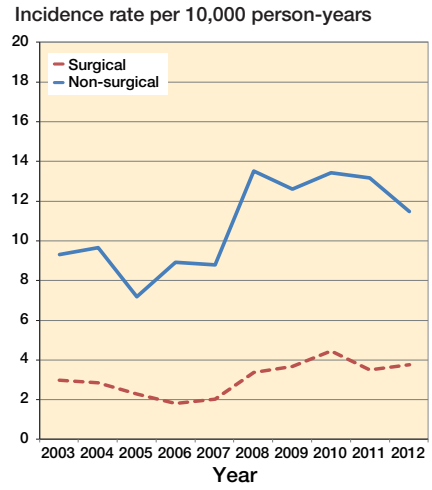

Figure 4. The incidence rate between 2003 and 2012, showing the fluctuations over the years and the rates of non-surgical and surgical treatment.

(which was perhaps to be expected, with only one-fifth being operated) and for the operated cohort.

There may be several explanations for the more advanced surgical techniques not improving the DASH score. Firstly, DASH was originally designed to evaluate effects over time, as after a fracture or an operation (Kennedy 2011). DASH was not intended for analysis of small differences between 2 types of treatment, and may simply be too blunt. Secondly, most DRF patients achieved good DASH scores at year, many even approaching the DASH score of an unfractured population (Abramo et al. 2008a). In our study, half had DASH scores ≤ 10, i.e. scores equivalent to the median value of the unfractured population (Hunsaker et al. 2002). Thirdly, by reporting the median value, which we consider correct for skewed and non-continuous scale data such as DASH, an improvement may be difficult to detect. Substantial improvements are necessary to lower the median value of the outcome after DRF when it approaches the median value in the population. By reporting the mean value of the population, which is less correct statistically (but common in previous studies), things are different. The addition of just a few patients with very high scores influences the mean value dramatically, unlike the median value. Finally, the choice of implant may be of minor importance for the outcome of a DRF, at least at the group level.

Limitations

As in any registry, the response rate is critical, and a higher rate would be desirable. With no upper age limit in our register, it is probably difficult to achieve a better response rate. Over a 10-year period, changes in hospital organization and staff may alter the conditions for a register-based study. No analysis was done of why the non-responding patients did not return the questionnaire.

In summary, there was no trend in the whole cohort of the median DASH values improving over time, or in the proportion of patients with high DASH scores decreasing during the study period. Despite a change in implants for DRF over the 10-year period, no improvement in median DASH score at 1 year after surgery was found. We believe that DASH is not the best tool to evaluate a change between groups in treatment over a number of years, but rather it is a tool to identify patients with suboptimal outcome. We have previously used grip strength in our randomized studies for between-treatment group evaluations (Kopylov et al. 1999, Abramo et al. 2009, Landgren et al. 2017) and believe that patient-reported outcome scores such as DASH may be less sensitive than when using objective outcomes. Perhaps the goal of an improved treatment should be to minimize the proportion of patients with very high DASH scores rather than to try to lower the median value for the whole cohort? Future studies are necessary to define the group with a high DASH score, which constituted one-sixth of the patients in our study. The causes of the high values are probably multifaceted and consist of a mixture of the following: surgical shortcomings leading to malunion, ulnar ligament injury with DRUJ instability, patients missed in the rehabilitation chain, and patients with musculoskeletal pain already at the time of the fracture. It would be preferable if interventions could be initiated to treat or prevent these conditions early after fracture, before they become manifest.

ML: project setup, data collection, interpretation of data, statistics, and writing of the manuscript. AA: extraction of the original data and revision of the manuscript. MG: analysis of radiographs and revision of the manuscript. PK: revision of the manuscript. MT: project setup, interpretation of data, and revision of the manuscript.

We thank secretary Monica Persson for administrative assistance in handling the DASH questionnaires.

Abramo A, Kopylov P, Tägil M. Evaluation of a treatment protocol in distal radius fractures. Acta Orthop 2008a; 79 (3): 376-85.

Abramo A, Tägil M, Geijer M, Kopylov P. Osteotomy of dorsally displaced malunited fractures of the distal radius: no loss of radiographic correction during healing with a minimally invasive fixation technique and an injectable bone substitute. Acta Orthop 2008b; 79 (2): 262-8.

Abramo A, Kopylov P, Geijer M, Tägil M. Open reduction and internal fixation compared to closed reduction and external fixation in distal radial fractures: a randomized study of 50 patients. Acta Orthop 2009; 80 (4): 478-85.

Abramo A, Geijer M, Kopylov P, Tägil M. Osteotomy of distal radius fracture malunion using a fast remodeling bone substitute consisting of calcium sulphate and calcium phosphate. J Biomed Mater Res B: Appl Biomater 2010; 92 (1): 281-6.

Atroshi I, Gummesson C, Andersson B, Dahlgren E, Johansson A. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: reliability and validity of the Swedish version evaluated in 176 patients. Acta Orthop 2000; 71 (6): 613-8.

Beaton D E, Wright J G, Katz J N. Development of the QuickDASH: comparison of three item-reduction approaches. J Bone Joint Surg (Am) 2005; 87 (5): 1038-46.

Brogren E, Petranek M, Atroshi I. Incidence and characteristics of distal radius fractures in a southern Swedish region. BMC Musculoskelet Disord 2007; 8 (1): 48.

Chung K C, Shauver M J, Birkmeyer J D. Trends in the United States in the treatment of distal radial fractures in the elderly. J Bone Joint Surg (Am) 2009; 91 (8): 1868-73.

Court-Brown C M, Caesar B. Epidemiology of adult fractures: a review. Injury 2006; 37 (8): 691-7.

Cui Z, Pan J, Yu B, Zhang K, Xiong X. Internal versus external fixation for unstable distal radius fractures: an up-to-date meta-analysis. Int Orthop 2011; 35 (9): 1333-41.

Esposito J, Schemitsch E H, Saccone M, Sternheim A, Kuzyk P R. External fixation versus open reduction with plate fixation for distal radius fractures: a meta-analysis of randomised controlled trials. Injury 2013; 44 (4): 409-16.

Gummesson C, Ward M M, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord 2006; 7 (1): 44.

Hunsaker F G, Cioffi D A, Amadio P C, Wright J G, Caughlin B. The American academy of orthopaedic surgeons outcomes instruments. J Bone Joint Surg (Am) 2002; 84 (2): 208-15.

Institute for Work & Health 481 University Ave. ST, ON Toronto, Ontario, Canada M5G 2E9. The DASH and QuickDASH - Outcome measures e-bulletin summer 2013.

Kennedy C A. The DASH and QuickDASH outcome measure user's manual 2011.

Konrath G A, Bahler S. Open reduction and internal fixation of unstable distal radius fractures: results using the trimed fixation system. J Orthop Trauma 2002; 16 (8): 578-85.

Kopylov P, Runnqvist K, Jonsson K, Aspenberg P. Norian SRS versus external fixation in redisplaced distal radial fractures: a randomized study in 40 patients. Acta Orthop Scand 1999; 70 (1): 1-5.

Landgren M, Abramo A, Geijer M, Kopylov P, Tägil M. Fragment-specific fixation versus volar locking plates in primarily nonreducible or secondarily redisplaced distal radius fractures: a randomized controlled study. J Hand Surg Am 2017; 42 (3): 156-65.

Landis J R, Koch G G. The measurement of observer agreement for categorical data. Biometrics 1977; 33(1): 159-74.

Li-hai Z, Ya-nan W, Zhi M, Li-cheng Z, Hong-da L, Huan Y, et al. Volar locking plate versus external fixation for the treatment of unstable distal radial fractures: a meta-analysis of randomized controlled trials. J Surg Res 2015; 193 (1): 324-33.

MacDermid J C, Roth J H, Richards R S. Pain and disability reported in the year following a distal radius fracture: a cohort study. BMC Musculoskelet Disord 2003; 4: 24.

Mattila V M, Huttunen T T, Sillanpää P, Niemi S, Pihlajamäki H, Kannus P. Significant change in the surgical treatment of distal radius fractures: a nationwide study between 1998 and 2008 in Finland. J Trauma Acute Care Surg 2011; 71 (4): 939-43.

Mellstrand-Navarro C, Pettersson H, Tornqvist H, Ponzer S. The operative treatment of fractures of the distal radius is increasing: results from a nationwide Swedish study. Bone Joint J 2014; 96 (7): 963-9.

Müller M E, Koch P, Nazarian S, Schatzker J. The comprehensive classification of fractures of long bones. Springer Science & Business Media 1990.

The Swedish National Council for Statistics (Statistical Database, Statistics Sweden, Statistiska centralbyrån), www.scb.se (accessed 14 September 2016).

Walenkamp M M, Bentohami A, Beerekamp M S H, Peters R W, van der Heiden R, Goslings J C, et al. Functional outcome in patients with unstable distal radius fractures, volar locking plate versus external fixation: a meta-analysis. Strategies Trauma Limb Reconstr 2013; 8 (2): 67-75.

Wang J, Yang Y, Ma J, Xing D, Zhu S, Ma B, et al. Open reduction and internal fixation versus external fixation for unstable distal radial fractures: A meta-analysis. Orthop Traumatol Surg 2013; 99 (3): 321-31.

Xie X, Xie X, Qin H, Shen L, Zhang C. Comparison of internal and external fixation of distal radius fractures: A meta-analysis of randomized controlled trials. Acta Orthop 2013; 84 (3): 286-91.