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Fractures of the distal radius:

Epidemiology, treatment and outcome assessment

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To my family

Contents

Abstract

This thesis aims to increase scientific knowledge of the most common fracture, namely the distal radius. Our understanding of this fracture is still limited, but every year in Sweden over 20,000 patients suffer from this injury. The fracture may cause persistent pain and disability for the patients, not to mention substantial costs to society. Improvement in treatment will benefit a large group of patients. Specifically, the incidence and trends in surgical treatment were investigated, outcome measurements were evaluated and the most common surgical treatment techniques were compared.

In Paper I, patient-rated outcome after a fracture of the distal radius was investigated in relation to radiological results, grip strength and range of movement (ROM). A retrospective assessment was conducted in 78 patients with a healed fracture of the distal radius. The Disability of the Arm, Shoulder and Hand (DASH) questionnaire was used to measure self-reported disability. Radiological malunion, reduced grip strength and wrist extension were each associated with a worse self-rated outcome.

To obtain a wrist-specific patient rating questionnaire in Swedish, a translation of the Patient Rated Wrist Evaluation (PRWE) questionnaire was done in Paper II. The Swedish PRWE score was validated in 99 patients recovering from a fracture of the distal radius. The Swedish version of the PRWE questionnaire was valid, reliable and responsive to change.

Paper III presents a comparison between open reduction and volar locked plating versus closed reduction and external fixation. 63 patients, 20-70 years of age, with a dorsally displaced extra-articular or non-comminuted intra-articular fracture were randomized to either method and followed during 1 year for patient-rated outcome, grip strength, ROM and radiology. Recovery was faster in the volar plate group but after 1 year outcome was similar in the two groups.

In Paper IV, surgical treatment methods and incidence for fractures of the distal radius were investigated between 2004 and 2010 in a registry analysis of 42,583 patients in Stockholm County. The overall incidence rate was 31 per 10,000 person-years and showed a bimodal distribution. We found that the incidence rate in postmenopausal women has decreased during the past few decades and that a shift in surgical treatment from external fixation to plate fixation has occurred.

In conclusion: Malunion results in poorer patient-rated outcome. The Swedish PRWE outcome questionnaire proved to be a valid instrument. Wrist function recovers more rapidly after volar plating than after external fixation. The use of plating has increased substantially at the expense of external fixation. The incidence rate of distal radius fractures has decreased in postmenopausal women.

List of publications

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Patient-perceived outcome after displaced distal radius fractures. A comparison between radiological parameters, objective physical variables, and the DASH score. Wilcke M, Abbaszadegan H, Adolphson PY. J Hand Ther 2007; 20 (4): 290-8.

II. Evaluation of a Swedish version of the patient-rated wrist evaluation outcome questionnaire: good responsiveness, validity, and reliability in 99 patients recovering from a fracture of the distal radius. Wilcke M, Abbaszadegan H, Adolphson PY. Scand J Plast Reconstr Surg Hand Surg 2009; 43 (2): 94-101.

III. Wrist function recovers more rapidly after volar locked plating than after external fixation but the outcomes are similar after 1 year. Wilcke M, Abbaszadegan H, Adolphson PY. Acta Orthop 2011; 82 (1): 76-81.

IV. Epidemiology and changed surgical treatment methods for fractures of the distal radius. A registry analysis of 42,583 patients in Stockholm County, Sweden, 2004-2010. Wilcke M, Hammarberg H, Adolphson PY. Acta Orthop. In press.

Abbreviations and definitions

AO: Arbeitsgemeinschaft für Osteosynthesfragen. A medically guided nonprofit organization led by an international group of surgeons specialized in the treatment of trauma and disorders of the musculoskeletal system.

BMD: Bone mineral density.

Content validity: Relevance and adequacy of the items in a patient rating scale.

Construct validity: The extent to which a patient rating instrument behaves as anticipated, supporting the underlying construct.

Criterion validity: A patient-rating instrument's correlation with a ''gold standard'' instrument on the same theme.

CPRS: Complex regional pain syndrome (formerly reflex sympathetic dystrophy).

DASH: Disability of the Arm, Shoulder and Hand. A regional outcome questionnaire that measures pain and disability in the upper extremities.

Effect size (ES): A measure of responsiveness. Calculated as the mean change divided by the standard deviation (SD) of the initial scores.

Kendall's W coefficient: A measurement of concordance based on ordinal data. A Kendall's W coefficient of 1 indicates complete agreement between baseline and a re-test (0 = no agreement).

Locked plate: A plate where some or all of the screw heads lock into the plate.

Malunion: When a fracture heals with an anatomic deformity.

Pyr: Person-years. The product of the number of years and the number of members of a population.

PRWE: Patient Rated Wrist Evaluation. A wrist-specific outcome questionnaire.

Reduction: The manipulation of a displaced fracture to a more anatomical position.

Reliability: The internal consistency and reproducibility of an instrument.

Responsiveness: An instrument's responsiveness to clinical change.

ROM: Range of movement.

SRM: Standard response mean. A measure of responsiveness. Calculated as the mean change in score between the first and second questionnaire divided by the SD of the change in score.

Validity: The extent to which an instrument measures what it is supposed to measure. There are three dimensions of validity: content, construct and criterion validity.

Ulnar variance = Axial shortening: The loss of length of the distal radius after a fracture.

Thesis at a glance

I. Patient-rated outcome in relation to objective measurements after a fracture of the distal radius

Is there a correlation between the patient rated outcome and radiological results, grip strength and ROM after a fracture of the distal radius?

Patients: 78 patients with a healed fracture of the distal radius.

Method: Retrospective assessment 1 year after the fracture. The patients completed the patient-rating DASH questionnaire, radiographs were obtained and grip strength and ROM were measured.

Conclusion: Radiological malunion, reduced grip strength and wrist extension were each associated with a worse patient rated outcome.

II. Translation and validation of a wrist-specific outcome questionnaire.

Is our Swedish version of the PRWE questionnaire valid for evaluating patients after a fracture of the distal radius?

Patients: 99 patients recovering from a fracture of the distal radius.

Method: Translation forward and backward. 99 patients completed the PRWE at 6 weeks and 4 or 6 months after the fracture. In addition, 50 of the patients completed the DASH questionnaire at 6 weeks and 6 months. 49 patients did a test-retest of the PRWE at 4 months.

Conclusion: This Swedish version of the PRWE questionnaire is valid, reliable and responsive.

III. Volar locked plating versus external fixation.

Is volar locked plating superior to external fixation?

Patients: 63 patients, 20-70 years of age, with a dorsally displaced extra-articular or non-comminuted intra-articular fracture.

Method: Randomization to open reduction and fixation with a volar locked plate or closed reduction and bridging external fixation.

Conclusion: The recovery was faster in the volar plate group but outcome was similar after 1 year.

IV. Epidemiology and changed surgical treatment methods for fractures of the distal radius.

What is the present incidence of fractures of the distal radius and how are different surgical methods for fixation of this injury used?

Patients: Patients with a recorded fracture of the distal radius from 2004-2010 in Stockholm County, Sweden.

Method: A registry analysis of 42,583 patients in the VAL database 2004-2010.

Conclusion: The overall incidence rate was 31 per 10,000 pyr. The incidence rate in postmenopausal women seems to have decreased the past few decades. A shift in surgical treatment from external fixation to plate fixation has occurred.

Background

Fractures of the distal radius are the most common fractures of the human body (Court-Brown and Caesar 2006). Much has been written about this topic, but still many questions remain, including major controversies regarding outcome and optimal treatment.

This fracture is especially frequent in children and the elderly. The metaphyseal widening of the distal radius is a zone predisposed to fractures because of a lower amount of strong cortical bone and higher amount of weaker cancellous bone. The major risk factors are low bone mineral density (BMD) and a tendency to fall (Vogt et al. 2002, Oyen et al. 2010). Consequently, a fracture of the distal radius is typically the result of a fall on the outstretched arm in a postmenopausal woman (Figure 1). The wrist fracture, which is often an early manifestation of osteoporosis, usually occurs while the patient is active and functionally independent. A wrist fracture predicts later hip fracture (Owen et al. 1982, Bengnér and Johnell 1985).

In Sweden, more than 20,000 patients are expected to suffer from a fracture of the distal radius every year (Brogren et al. 2007) and the mean fracture-related cost the year after an osteoporotic wrist fracture has been estimated to be 2,147€ (Borgström et al. 2006).

The aging population grows rapidly and thus the societal burden of this injury will probably increase in the future. In light of this, it is important to increase knowledge of the epidemiology of fractures of the distal radius and to optimize treatment, both from the perspective of patients and society.

Figure 1. A fracture of the distal radius with a typical clinical deformity in a postmenopausal woman.

Epidemiology

Age-related aspects

Fractures of the distal radius occur in all ages and the anatomical fracture patterns are similar. However, the frequency, gender distribution and the basic conditions of the patients vary greatly between different ages.

Overall incidence rates about 24-27 per 10,000 pyr have been presented in recent reports (Brogren et al. 2007, Flinkkilä et al. 2011, Sigurdadottir et al. 2011). There is a female dominance in the occurrence of fractures of the distal radius. This injury represents 28% of all fractures in adult women and 13% in men (Van Staa et al. 2001, Court-Brown and Caesar 2006). The female-male ratio is about 3:1 (Schmalholz 1988, Mallmin and Ljunghall 1992, Brogren et al. 2007).

The incidence has a bimodal distribution with the first peak in childhood (Bengnér and Johnell 1985, Oskam et al. 1998) and the second peak in old age. In childhood, fractures of the distal radius are very common with reported crude incidence rates from 48-59 per 10,000 pyr (Kramhøft and Bødtker 1988, Tiderius et al. 1999, Hedström et al. 2010). Fractures of the distal radius represent up to 30% of all fractures in children (Hedström et al. 2010). This injury is more common in boys and is often sport-related (Khosla et al. 2003, DePutter et al. 2011).

In young adults, fractures of the distal radius are often caused by a high-energy trauma. These patients may have additional ligament injuries (Lindau et al. 1997). There is no gender predominance under the age of 40 years (Brogren et al. 2007) and incidence rates of about 10-15 per 10,000 pyr have been reported (Brogren et al. 2007, Flinkkilä et al. 2011, Sigurdadottir et al. 2011).

After the age of 40 years, the incidence rate increases rapidly in women who then outnumber men. At the age of 50 years, women have a life-time risk of 17% compared with only 3% in men (Van Staa et al. 2001). In men, the incidence rate has been reported to rise first after the age of 60-70 years (Brogren et al. 2007. Flinkkilä et al. 2011, Sigurdadottir et al. 2011). More than 40% of women and men >60 years of age with a fracture of the distal radius have osteoporosis (Atroshi et al. 2009, Øyen et al. 2010). Recent reports suggest that the incidence in postmenopausal women has decreased in the past few decades (Brogren et al. 2007, Lofthus et al. 2008, Sigurdardottir et al. 2011).

The second incidence peak occurs in old age in both genders. Some authors report a leveling off in the incidence rate in elderly women (Owen et al. 1982, Falch 1983, Solgaard and Petersen 1985, Schmalholz 1988), whereas other report a continuous rise in the incidence of fractures of the distal radius up to over 80 years (Mallmin and Ljunghall

1992, Thompson et al. 2004, Brogren et al. 2007, Lofthus et al. 2008, Sigurdardottir et al. 2011). The reason for this discrepancy is unclear.

In addition to low BMD and a tendency to fall, poor cognitive status is an important risk factor in older women that almost doubles the risk for a wrist fracture (Vogt el al. 2002).

Because the incidence seems to change and because reports are not consistent, increased knowledge of the current epidemiology of fractures of the distal radius is valuable.

Geographical aspects

The incidence rates of fractures of the distal radius are reported to be higher in Scandinavian countries than in other European countries (Cummings and Melton 2002). The incidence in Europe is in turn higher than in Japan and Australia (Hagino et al. 1999, Sanders et al. 1999). These geographic variations are probably multi-factorial. Interestingly, the BMD among the Japanese is similar to Caucasians but the prevalence of falls is considerably lower among the Japanese (Hagino et al. 1999). The incidence of distal forearm fractures in Oslo is among the highest in the world. This can be somewhat explained by the weather conditions but because the summer incidence in Oslo is still among the highest demonstrated, other factors must be involved (Lofthus et al. 2008).

The icy weather during the winter influences the incidence in Scandinavia where fractures of the distal radius are most common during the winter months (December to March), i.e. the percentage can be more than double that of the summer months (Schmalholz 1988, Mallmin and Ljunghall 1992, Flinkkilä et al. 2011). This seasonal variation seems to apply primarily to women, whereas in men, the number of fractures is more evenly distributed throughout the year (Solgaard and Petersen 1985).

Classifications

Fractures of the distal radius are often classified according to the direction of the displacement of the distal fragment. The most common fracture type is the dorsally angulated fracture often referred to as the Colles' fracture (Colles 1972). The typical fork-like displacement is the result of a trauma against a dorsally extended wrist, typically by a fall on the outstretched hand. Such a fracture type represents up to 97% of all fractures of the distal radius (Schmalholz 1988). This thesis primarily concerns Colles' fractures.

Figure 2. Radiographs of a displaced Colles' fracture, first recognized by Abraham Colles (1773-1843), professor at the Royal College of Surgeons in Ireland.

Two other common eponyms used to describe fractures of the distal radius are the Smith and Barton fractures. A Smith fracture (Peltier 1959) is a reversed Colles fracture in which the distal fragment is volarly angulated and displaced. This injury is often the result of a higher energy trauma on the volar flexed wrist. A Barton fracture (Barton 1938) is a shear type fracture of the articular surface of the distal radius in which the articular fragment has displaced volarly or dorsally along with the carpus.

For clinical purposes, fractures of the distal radius can roughly be classified as displaced or not displaced and extra- or intra-articular. Undisplaced fractures are more stable and usually require no fixation other than for pain relief (Abbaszadegan et al. 1989a). A displaced fracture is more unstable and commonly requires reduction and plaster cast immobilization or rigid surgical fixation. Extra-articular fractures are most common and constitute approximately 70% of distal radius fractures (Vogt et al. 2002, Brogren et al. 2007). Displaced and intra-articular fractures are more frequent among the elderly

(Brogren et al. 2007). Diabetics are particularly likely to sustain more complex and intra-articular fractures (Vogt et al. 2002).

There are several detailed classification systems for fractures of the distal radius. The inter- and intra-observer reliability for these fracture classification systems has been shown to be poor (Anderson et al. 1996) and their clinical usefulness questioned (Diaz-Garcia and Chung 2012). However, for the purpose of research it can be important to describe the sample in terms of fracture types.

The AO classification (www.aofoundation.org) is perhaps the most commonly used classification today. It describes three main categories: extra-articular (A), partial articular (B) and intra-articular (C). The main categories are subdivided into 27 subclasses on the basis of fracture severity. Restricted to the three main categories, the inter-observer agreement for the AO classification is good (Kreder et al. 1996a). The Fernandez classification (Fernandez and Jupiter 1996) describes the fractures according to the mechanism of injury. Multiple other classifications systems exist that emphasize different aspects of fractures of the distal radius, for example: the Frykman, Lidström, Melone and Older classifications (Ilyas and Jupiter 2007). These systems are seldom used today but may be of interest when comparing recent with previous studies.

Treatment of fractures of the distal radius

The aim of treatment for a fracture of the distal radius is to restore grip strength and motion so that the patient can return to former activities within reasonable time and to minimize the risk for future degenerative changes in the wrist joint. The orthopedic surgeon has an arsenal of different methods to choose from to achieve this end. Despite that fractures of the distal radius are so common, there is no real consensus on their management and there remains a lack of clinical-based evidence in the literature.

Conservative treatment

Undisplaced fractures are usually stable and require no fixation (Abbaszadegan et al. 1989a). A plaster cast or elastic bandage can be used for pain relief.

Displaced factures, caused by low-energy trauma, that can be reduced to an acceptable anatomical position (approximately, axial shortening <2 mm or <10° dorsal angulation) can be immobilized in a short arm cast for about 5 weeks (Abramo et al. 2008). Closed reduction followed by plaster cast is still the most common treatment for fractures of the distal radius. There are several techniques both for reduction and casting but no method has been found to be superior (Handoll and Madhok 2003a, 2003b). If an unacceptable redisplacement occurs, re-reduction and surgical fixation may be necessary. The risk for redisplacement increases with age over 60 years, dorsal angulation >20°, dorsal communition, an associated ulna fracture and intra-articular involvement (Gehrman et al. 2008).

Closed surgical treatment

In highly unstable fractures, operative fixation is required to maintain a satisfactory anatomical position. There are several techniques for surgical fixation. Reduction of the fracture can be closed, minimally invasive or open.

Closed reduction followed by bridging (joint spanning) external fixation for 4-6 weeks is a well proven treatment that has been used for several decades (Cooney et al. 1979). Bridging external fixation relies on ligamentotaxis to reduce and to keep the fracture in alignment. Some fracture redisplacement often occurs after the fixation device has been removed (Dicpinigaitis et al. 2004). Complications after external fixation include pin site infection, radial nerve lesions, pin loosening, iatrogenic fracture, redisplacement and complex regional pain syndrome (CRPS), (Pennig and Gausepohl 1996).

Non-bridging external fixation allows wrist mobilization during the fixation which is advantageous for the rehabilitation (McQueen 1998). This method requires a sizable distal fracture fragment and has not really come to general use. A Cochrane review concluded that there is insufficient evidence to determine the relative effects of the different methods of external fixation (Handoll et al. 2008).

Figure 3. Radiographs of bridging external fixation and percutaneous pinning.

Closed reduction followed by fixation of the fracture with percutaneous pins and cast, is another widely used method. The pins may be inserted by a variety of methods; across-fracture fixation or with the intrafocal Kampandji technique (Kampandji 1987, Harley et al. 2004). Percutaneous pinning is best suited for extra-articular fractures without substantial communition. Percutaneous pinning is associated with similar complications as external fixation. Both methods require about 5 weeks' of immobilization, which often results in temporary wrist joint stiffness.

External fixation and percutaneous pinning are often combined. The percutaneous pins provide additional stability (Dunning et al. 1999), especially in intra-articular fractures where the pins also help to correct intra-articular displacement (Trumble et al. 1998).

Open reduction and plating

In later years, open reduction followed by internal fixation with a volar locked plate has gained popularity in the management of unstable, dorsally displaced, fractures of the distal radius. Good results in patients of different ages have been consistently reported (Orbay and Fernandez 2004, Chung et al. 2006, Jupiter et al. 2009). Volar plating is more invasive and expensive than external fixation or percutaneous pinning. An advantage of plating is that exact reduction of fracture fragments is facilitated and immediate functional wrist loading is allowed. Today, there is an abundance of different volar plates on the market. Reported complications include flexor and extensor tendon irritations and ruptures, carpal tunnel syndrome, fracture redisplacement, screw loosening and CRPS (Arora et al. 2007).

Figure 4. Radiographs of a volar plate of the type (Königsee, Swemac, Sweden) used in Paper III.

Dorsal (buttress) plating has become more infrequent since the introduction of the volar locked plates. Good results have been reported for comminuted fractures (Rozental et al. 2003) but there is a substantial risk for extensor tendon complications (Grewal et al. 2005). Fragment specific systems with low profile plates and wire forms have been evaluated by some authors (Konrath and Bahler 2002, Abramo et al. 2009). Intramedullar distal radius fixation devices using subchondral screws that lock to a stem are available and encouraging results have been reported (Nishiwaki et al. 2011).

Bone grafts may be used, especially in osteoporotic bone, to fill the bony defect dorsally, which often results from the fracture. Bone grafting may improve anatomical results but it is not clear if it improves the final functional results (Tosti and Ilyas 2010).

Evidence-based treatment?

Several studies have compared dorsal plating (Grewal et al. 2005, Kateros et al. 2010), fragment specific systems (Abramo et al. 2009), or a mixture of dorsal and volar plating techniques (Kreder et al. 2005, Leung et al. 2008) with external fixation, however, these studies have not shown substantial evidence to support the use of internal fixation instead of external fixation (Margaliot et al. 2005).

Studies that compare volar locked plating with external fixation, have not given evidence for either method to be superior to the other method (Wright et al. 2005, Egol et al. 2008, Rizzo et al. 2008, Wei et al. 2009). Results after comparisons of volar locked plating and percutaneous pinning are diverse. Volar locked plating has been reported to be superior (Oshegie et al. 2007, McFayden et al. 2011), advantageous in the short term (Rozenthal et al. 2009) and similar compared with percutaneous pinning (Santiago et al. 2008a).

Despite the lack of consensus, a change from closed surgical treatment to open reduction and plating has occurred in the past decade (Koval et al. 2008, Chung et al. 2009, Mattila et al. 2011).

Outcome after fractures of the distal radius

Assessment of outcome

Traditionally, the outcome after fractures of the distal radius has been assessed by radiological parameters and objective physical variables (grip strength and ROM). The correlation between radiological parameters and objective physical variables is questionable (Young et al. 2003, Karnezis et al. 2005). However, the most important outcome variable ought to be how the patients perceive the result. In the past decade, there has been growing interest in patient-rated outcome questionnaires that aim to quantify the patient's perceived disability after an injury. Validated patient-rating scales have been shown to be highly sensitive in detecting variation in outcome (MacDermid et al. 2000, Bialocerkowski et al. 2003). Patient rating scales are increasingly being used to assess the result after fractures of the distal radius. There are several self-administered questionnaires available to evaluate patient-rated outcome after a fracture of the distal radius.

The Disability of the Arm, Shoulder and Hand questionnaire (DASH) is a region-specific upper-extremity instrument (Hudak et al. 1996) that measures functional status, symptoms, and quality of life (QoL) status. It can be used to evaluate any joint or illness of the upper extremity. The DASH score consists of 30 questions that render a score from 0 (no disability) to 100 points (most severe disability). The DASH score regards the upper extremities as a single unit and does not consider whether the patient uses the injured or the uninjured wrist to do a specific task.

The Patient-Rated Wrist Evaluation (PRWE) is a wrist-specific 15-item questionnaire that is designed to measure wrist pain and disabilities in activities of daily living (MacDermid et al. 1998). It rates wrist-related pain and disability equally in functional activities and yields a score from 0 (no disability or pain) to 100 points.

The Patient Evaluation Measure (PEM) questionnaire for hand surgery and the Michigan Hand Outcomes Questionnaire (MHQ) (Forward et al. 2007, Kotsis et al. 2007) are also used but not as commonly as the DASH and the PRWE scores.

The use of a limited number of validated questionnaires facilitates comparisons of results and translations of scores are therefore valuable. Translation of a questionnaire requires not only a linguistic translation. In some cases, a cross-cultural adaptation is needed. A test of the responsiveness, validity, and reliability of the translated version according to proposed guidelines and international standards (Guillemin et al. 1993) should be performed.

Results after fractures of the distal radius

In children, the outcome after a fracture of the distal radius is generally good because of the remodeling ability of the growing bone and that children are not as prone as adults to develop stiffness after immobilization.

The metaphyseal bone in the distal radius has a natural ability to heal after the fracture and thus non-union is seldom a problem. However, the fracture and the associated soft-tissue injuries together with the immobilization required during the initial healing causes impairment in terms of pain, stiffness and reduced grip strength. Consequently, the rehabilitation after a fracture of the distal radius takes time. Most patients have an almost normalized wrist function after 1 year (Abramo et al. 2008) but improvement occurs up to 2-4 years after the fracture and is slower in malunited cases (Brogren et al. 2011a). Sometimes, fractures of the distal radius result in permanent pain and impairment (Cooney et al. 1980, Tsukazaki et al. 1993).

Malunion to a varying degree is common after fractures of the distal radius. The correlation between resulting bony deformity (measured by radiological parameters) and objective physical variables (grip strength and ROM) is controversial (Young et al. 2003, Karnezis et al. 2005). It is unclear if and how these traditional objective measurements and the patient-rated outcomes are associated (Kopylov et al. 1993, Tomaino et al. 1994, Fuji et al. 2002, Kumar et al. 2008). Similarly, there is no certain relationship between articular integrity and patient-rated outcomes (Goldfarb et al. 2006). Intriguingly, after a fracture of the distal radius, some patients may be asymptomatic despite obvious deformities whereas others experience substantial disability despite a good anatomical position.

Because we do not know which patient will develop a symptomatic malunion and which patient will not, the challenge is to treat all individuals on an appropriate level. Treatment must be ambitious enough but overtreatment should be avoided.

Aims of the thesis

I. To investigate the relation between patient-perceived outcome, versus radiological parameters and objective physical variables, after a fracture of the distal radius.

II. To make a wrist-specific tool accessible in Swedish to evaluate the patient-perceived outcome after a fracture of the distal radius.

III. To compare the two most common surgical methods for fixation of unstable fractures of the distal radius (bridging external fixation versus open reduction and volar locked plating) using objective and patient self-rated outcome measures.

IV. To perform a population-based analysis of the epidemiology and methods for surgical fixation of fractures of the distal radius.

Patients and methods

Recruitment and randomization

The studies were performed at the Department of Orthopedics, Danderyd Hospital, Stockholm, Sweden, which serves a region of approximately 450,000 inhabitants.

In Paper I, the inclusion criterion was a unilateral fracture of the distal radius that had undergone reduction in patients ≥20 years. Patients were detected by scanning all radiological wrist examinations between November 1, 2001 and December 31, 2002. The exclusion criteria were a previous fracture of the wrist, the presence of other fractures, or concurrent disorders affecting either of the upper extremities. The reason for these strict exclusion criteria was that there were no baseline data because of the study's retrospective design. Patients with impaired cognitive ability (e.g. dementia) were also excluded because the patient-rated outcome was assessed with a self-administered questionnaire. The potential patients were sent a letter that explained the study and invited them to an appointment in the outpatient clinic.

In Paper II, the patient lists at the emergency ward were scanned and all patients >15 years of age with a fracture of the distal radius were invited by letter to participate. Returning the first questionnaire was considered consent. There were no exclusion criteria.

In Paper III, the inclusion criteria were an acute unilateral dorsally displaced fracture of the distal radius (extra-articular AO class A fractures and C1 fractures with only one intra-articular fracture line), an axial shortening of ≥4 mm, or a dorsal angulation of ≥20°) in patients aged 20–70 years with no previous fracture of either wrist. Exclusion criteria were a concurrent fracture of the upper extremities, warfarin medication, unable to cooperate with follow-up examinations (dementia, substance abuse, etc.), open fracture or a fracture that was not amenable to both methods. The patients were informed of the study and asked to participate during the visit at the emergency ward or by telephone on the following day. Randomization was conducted by a sealed envelope procedure by a physician engaged in the study. All patients were informed of the randomized operation method immediately. Randomization was conducted in blocks of 20 with age stratification (over or under 50 years of age).

In paper IV, registry data from the Stockholm County Council's database for health care - the VAL database - was extracted for the period 2004-2010. The patients were selected by the ICD-10 diagnoses (WHO 2007) for distal radius fractures (S52.50, S52.51, S52.60 and S52.61). The first time an individual was reported with the diagnosis during the study period was noted, to avoid the risk of multiple counting. The population was defined as all individuals domiciled in the Stockholm County during 2004-2010. Non-inhabitants who had received health care for a wrist fracture were excluded.

Definitions of a fracture of the distal radius

Papers I and III concern dorsally angulated fractures of the distal radius (Colles') while Papers II and IV could comprise other types of fracture displacement, such as Smith and Barton fractures. The ICD-10 diagnoses used in paper IV (S52.50, S52.51, S52.60 and S52.61) do not distinguish between different types of fractures of the distal radius.

Definitions of fracture displacement

In Paper I, a displaced fracture was defined as a fracture that had undergone reduction (Bengnér and Johnell 1985).

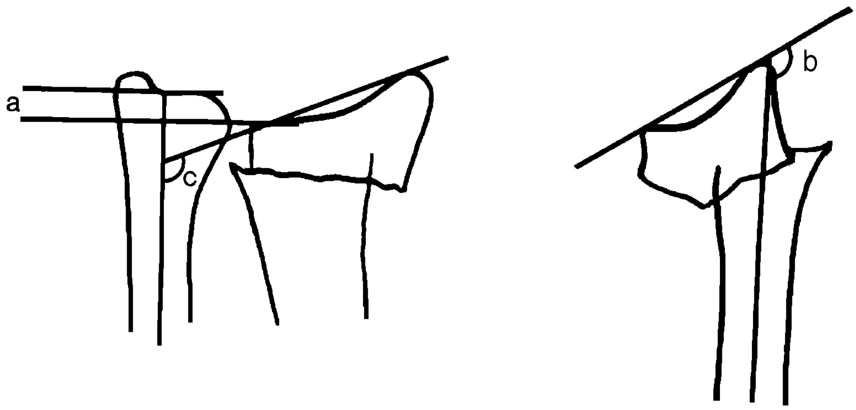
In Paper III one inclusion criterion was a substantial displacement and this was defined as an axial shortening of ≥4 mm or dorsal angulation ≥20° from a line perpendicular to the long axis of the radius. An axial shortening ≥4 mm and dorsal angulation ≥20° have been found to be strong prognostic indicators of fracture instability (Cooney et al. 1979, Abbaszadegan et al. 1989b).

Radiological assessment

In Paper I, radiographs were taken at the clinical assessment. In Paper III, radiographs were taken directly after surgery, after 5 weeks, and after 12 months. Standard anteroposterior and lateral radiographs with the wrist in neutral rotation were used. The two perpendicular projections of the forearm are accomplished by rotating the x-ray tube or the patient's shoulder. This is essential because rotating the wrist will give two perpendicular projections of the radius but not of the ulna, which affects the ulnar variance (axial shortening).

The radiological measurements in Papers I and II were performed according to Figure 5. The axial shortening (a), dorsal angulation (b) and radial angulation were measured (c). The uninjured wrist was used as a reference. This is important in that there is interindividual variation (Friberg and Lundström 1975, Medoff 2005). Radial shortening is expressed in millimeters while dorsal and radial angulation is expressed in degrees. Values are presented as the difference between the injured and the uninjured wrist. The radiological measurements were performed by the author of this thesis (MW).

Figure 5. Radiological parameters.



There are several sources of measurement errors in the radiological assessment starting with the transcription of the three-dimensional anatomy of the distal radius to a two-dimensional radiograph. This step might be affected by the position of the wrist. For example, rotation of the wrist may produce up to 6° change in measured dorsal angulation (Johnson and Szabo 1993). The accuracy of the x-ray equipment and the imaging software might hypothetically vary. In addition, there is intra- and inter-observer variability. Axial shortening and dorsal angulation (palmar tilt) have shown high intra- and interrater agreement, whereas the size of intra-articular steps and gaps in a healed fracture are inconsistently measured. Agreement is always higher within than between observers; hence it is important that a single observer make the measurements (Kreder et al. 1996b).

In Paper I, the fractures were classified radiologically according to Lidström, Older and Frykman by one of the senior authors (HA) (Lidström 1959, Older et al. 1965, Frykman 1967). In Paper III the fractures were classified by (MW) according to the AO classification system.

Objective physical measurements

In Papers I and III, the objective physical variables, including grip strength and ROM (extension, flexion, pronation, supination, radial deviation and ulnar deviation) were assessed in both wrists by a physiotherapist blinded to the radiological results. Group assignment could not be blinded because of different scar formation in Paper III. In Paper I, grip strength was measured with a balloon dynamometer (Martin Vigorimeter®, Martin Medizin-Technik, Tuttlingen, Germany). In Paper II, grip strength was measured with a dynamometer (Grippit; AB Detector, Sweden). ROM was measured with a standard goniometer in Papers I and III. The uninjured wrist was used as control. Grip strength and ROM are expressed as a percentage of the value of the uninjured wrist. Ten percent less grip strength was allowed for the non-dominant side (Crosby et al. 1994). In Paper III, objective physical variables were assessed at 3, 6 and 12 months postoperatively.

Assessment of patient-rated outcome

In Papers I and III, the Swedish version of the DASH score (Hudak et al. 1996, Atroshi et al. 2000) (Appendix 1) was used to assess the patient-rated outcome. In Paper III, the DASH score and the PRWE outcome questionnaire (MacDermid et al. 1998) (Appendices 2 and 3) were used. Both questionnaires yield a score from 0-100, where higher scores represent more disability. Scores are presented with the baseline scores subtracted in Paper III.

In Paper I, the DASH questionnaire was completed before the clinical assessment and in Paper III, the DASH and PRWE questionnaires were completed at baseline (representing the status before the injury) and at 3, 6 and 12 months after the injury.

The validation process

The original PRWE score was translated forwards and backwards by the authors. The responsiveness, validity and reliability of the Swedish version were tested in 99 patients who were recovering from a fracture of the distal radius. The patients completed the PRWE questionnaire 7 weeks and 4-6 months after the injury.

The instrument's **responsiveness** to clinical change was assessed by the standard response mean (SRM) and effect size (ES). A SRM and an ES >0.8 were considered large (Kazis et al. 1989).

Content validity was evaluated by assessing the distribution of scores and the proportions of best and worst possible scores (ceiling and floor effects). Large proportions of best and worst possible scores indicate a lack of sensitivity of the instrument for the experienced disability.

Construct validity was assessed by testing the underlying construct that the PRWE score measures pain and disability in the wrist and hence the score should decrease with time from the fracture. The score was expected to be larger in patients with a fracture of greater severity. Construct validity was assessed with the Wilcoxon signed rank test (paired data) and the Wilcoxon rank sum test (unpaired data).

Criterion validity was assessed by comparison with the validated Swedish version of the DASH score (Hudak et al. 1996, Atroshi et al. 2000) using Spearman's rank correlation coefficient.

Reliability was assessed with a test-retest in the 49 patients that answered the PRWE questionnaire the second time 4 months after the injury, a time when the patients were assumed to still have substantial symptoms but the clinical state would be relatively stable from day to day. Kendall's W coefficient and Spearman's rank correlation coefficient were used to analyze intra-observer reliability.
Internal consistency (the homogeneity of the questions) was assessed by Cronbach's alpha which was calculated in the two groups separately and from the total population. An alpha value of 0.8 indicates good internal consistency and 0.9 excellent internal consistency (Feinstein 1987).

Treatment decision (Paper I) and surgical interventions (Paper III).

In Paper I, the treatment of choice had been determined by the attending physician at the emergency department. 53 (of 78) fractures were reduced during local or intravenous regional anesthesia and immobilized in a dorsal below-elbow plaster splint for 4-5 weeks. 5 patients had an unacceptable redislocation at the 10-day radiological control and therefore underwent secondary surgery with bridging external fixation. 25 patients were treated with primary bridging external fixation for 5 weeks. At the termination of immobilization, all patients received the same mobilization instructions, consisting of a basic exercise program as demonstrated by a physiotherapist.

In Paper III, primary reduction was performed and a temporary plaster cast was applied at the emergency ward. After recruitment and randomization, day surgery was performed in plexus anesthesia after a mean of 4 (range 1–9) days. In plate-fixated patients, a volar flexor carpi radialis approach was used and a volar locked plate, with four optional distal locked screws, was applied (Königsee, Swemac, Sweden). A dorsal below-elbow plaster cast was applied for 10–12 days and thereafter active wrist mobilization began supervised by a physiotherapist. A Hoffmann device (Stryker, NJ, USA) was used for external fixation. Supplementary K-wires were not used routinely but at the surgeon's discretion. External fixation was removed after 5 weeks and then wrist mobilization began supervised by a physiotherapist.

Assessment of register data, definitions of subgroups and surgical interventions (Paper IV).

Data were extracted from the VAL database for the period 2004-2010. The VAL database is a population-based register that contains information on all individuals in the Stockholm County Council (2 million inhabitants) that have received health care. Reporting to the database is mandatory and the Council pays the health care providers according to their performance as reported in the database which ensures the quality of the data. The VAL database is anonymous but information (e.g. gender, age and area of living) is linked to each individual.
Population data were obtained from the database of Statistics Sweden (www.scb.se). The incidence rates were calculated from the number of reported first time fractures.

The surgical interventions were defined as classified by the NOMESCO Classification of Surgical Procedures (NCSP), (NOMESCO 2008). External fixation was searched as NCJ29 and NDJ29, percutaneous pinning as NCJ49 and NDJ49 and plating as NCJ69 and NDJ69.

The data were stratified in five age classes (I-V) to achieve large subgroups. The classes were based on certain characteristics of wrist fractures:

I. < 18 years of age, i.e. when patients were still regarded as children.
II. 18-39 years, representing young adults when the fracture is often a result of a trauma of higher energy or sport.
III. 40-64 years because an increase in fractures of the distal radius in females starting as early as 40 years of age has been reported (Mallmin and Ljunghall 1992, Lofthus et al. 2008).
IV. 65-79 years, with the rationale that an increase in incidence rate in men has been shown after age 65 years (Bengnér and Johnell 1985, Thomson et al. 2004, Lofthus et al. 2008). Further, this is the normal age for retirement in Sweden.
V. ≥80 years representing elderly patients and expected peaks in fractu incidence rates for both genders (Mallmin and Ljunghall 1992, Brogren et al. 2007, Flinkkilä et al. 2011).

In addition, the incidence rate for women 50-79 years of age was calculated because a changed epidemiology has been reported in this group in a recent Scandinavian study (Brogren et al. 2007).

Statistical analyses

In Papers I and III, Wilcoxon's rank sum test was used for comparison of parametric data (e.g. DASH and PRWE scores) between groups. The Chi-square test was used to compare bimodal data (such as sex and hand dominance) in Papers I and III and for comparison of proportions in Paper IV. Pearson's product moment test was used to describe linear correlations between DASH scores and radiological and objective physical measurements in Paper I. The unpaired Student t-test was used to compare groups on objective physical and radiographic measurements in Paper III.

In Paper I, values for radiological malunion, grip strength and ROM were dichotomized when correlated with the DASH scores. Cutoff values were chosen to cause a significant difference, equal or close to a clinically important change, in DASH scores between the groups. This has been estimated to 10 points (Gummesson et al. 2003).

The statistical tests used in Paper II are declared in the description of the validation process in the Methods section (page 28).

In Paper IV, incidence rates were calculated from the mid-year population size and expressed per 10,000 pyr. Mid-year population size was estimated by taking the geometric mean of year-end population sizes of consecutive years. The 95% confidence intervals (CIs) for all incidence rates were calculated using the Poisson exact method. Yearly changes in incidence rates and in number of surgical interventions during the study period were assessed with Poisson regression analysis.

In papers I, II and III, statistical analyses were performed with the statistical package JMP (SAS Institute Inc., NC, USA). In paper IV, the SAS System (SAS Institute Inc., Cary, NC, USA) and the R system, version 2.15.2 (R Foundation for Statistical Computing, Vienna, Austria) were used.

In all papers, differences were considered significant at p-values <0.05.

Results

Paper I

78 patients (57 females, 21 males) were assessed after a mean of 22 (range 10-31) months after their injury with the DASH questionnaire and a radiological and clinical follow-up. The median age of the patients was 59 (range, 22-95) years. The mean DASH score was 13 (95% CI 9-16) points. 20% of the patients reported no disability at all (0 points). Weakness was the most common symptom, followed by activity-related pain.

A final radial shortening ≥2 mm, dorsal angulation >15°, and radial angulation >10° were each significantly associated with a poorer DASH score. Grip strength <80% of the uninjured side was associated with a poorer DASH score. Extension <85% and ulnar deviation <80% of the uninjured side also correlated with a significantly poorer DASH score (Table 1).

Table 1. Final radiological parameters and objective physical variables significantly associated with the DASH scores.

		n	DASH score	CI
Radial shortening	≥2 mm	53	16	12-20
	<2 mm	25	6	2-9
			p<0.01	
Dorsal angulation	>15°	34	18	13-24
	≤15°	44	8	5-12
			p<0.01	
Radial angulation	>10°	10	24	10-37
	≤10°	68	11	8-14
			p=0.03	
Grip strength	<80%	27	19	12-25
	≥80%	51	9	6-13
			p<0.01	
Extension	<85%	13	22	13-32
	≥85%	65	11	8-14
			p=0.02	
Ulnar deviation	<80%	26	18	12-24
	≥80%	52	10	6-14
			p<0.01	

Radiological values are presented as the mean difference between the injured and uninjured wrist. Physical values are presented as a percentage of the uninjured wrist. The DASH scores are presented as mean values.

Paper II

Translations were made without problems and no discrepancy was found between the forward and backward translations. One item “turn a door knob” was modified to “open a tight or new jar” becasue door knobs are rare in Sweden.

50 patients completed both the PRWE and the DASH questionnaires at a mean of 7 weeks and about 6 months after the injury. Another 49 patients completed the PRWE questionnaire once at 7 weeks and again at about 4 months after the injury on two occasions with an interval of 1-14 (median 5) days.

The responsiveness was excellent with high SRM and ES (SRM 1.4-1.7, ES 1.3) which reflects the large expected clinical change in a group of patients who are recovering from an acute condition.

Concerning content validity, no extreme effects to indicate lack of sensitivity were found during the early rehabilitation phase, but there was a small proportion of best possible scores at 4-6 months. Completeness of responses to items was good, all items being answered by 78-84% of the patients. In support of construct validity, the PRWE score improved (decreased) with time after the injury and patients with more severe fractures reported worse scores than patients with less severe fractures at the group level (Table 2). The strong correlation with the DASH score (Spearman’s rank coefficient 0.86) implied good criterion validity. Intra-observer reliability of the test-retest (Kendall W coefficient 0.79) and internal consistency (Cronbach’s alpha 0.94-0.97) was good, implying good reliability.

Table 2. Construct validity.

	PRWE 1	PRWE 2	
All patients	48 (1-89)	15 (0-89)	$p<0.01$[a]
Older type 1-2 (less severe fractures)	46 (1-78)	8,5(0-60)	
Older type 3-4 (more severe fractures)	52 (9-89)	18 (0-89)	
	$p=0.04$[b]	$p=0.02$[b]	

PRWE1 = first questionnaire (7 weeks); PRWE 2 = second questionnaire (4-6 months). Values are given as median (range). [a]Wilcoxon signed rank test; [b]Wilcoxon rank sum test.

Paper III

33 patients were randomized to volar plating and 30 to external fixation. The groups were similar in gender, age and fracture type. Most fractures were extra-articular. External fixation, in comparison to volar plating, was more often performed by less experienced surgeons.

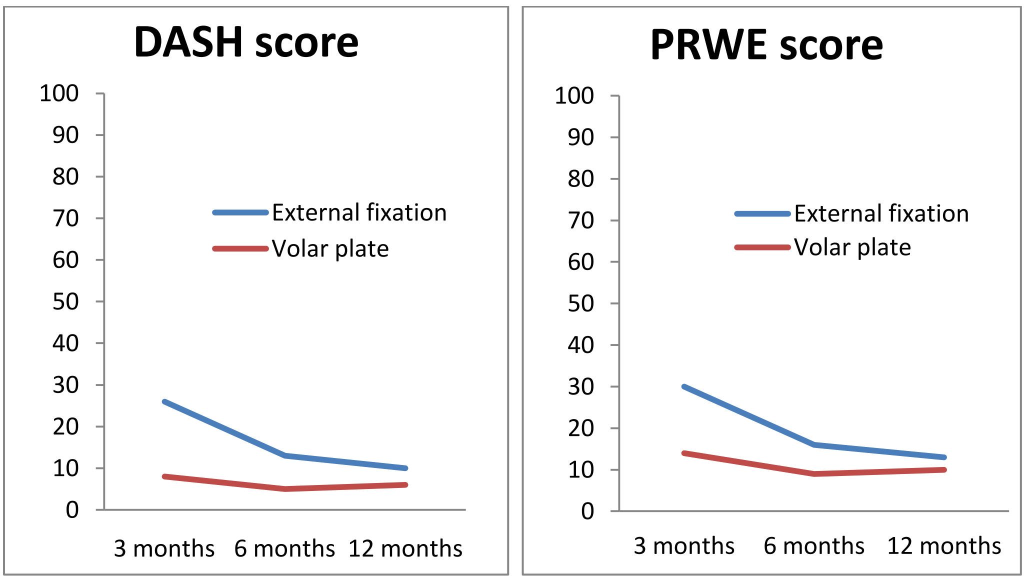
Patient-perceived outcome: The patients in the volar plate group reported significantly better DASH and PRWE scores than the patients in the external fixation group at 3 and 6 months. However, after 12 months, the differences had diminished and were no longer significant (Figure 6).

Objective function: Grip strength and ROM were better in the volar plate group but the differences diminished with time.

Radiographical results: The patients in the volar plate group had less axial shortening and dorsal angulation of the distal radius than the patients in the external fixation group at final follow-up.

Complications: One plate-fixated patient suffered from a flexor pollicis tendon rupture and there were two cases of fracture collapse with malunion in the external fixation group. This study could not demonstrate a clear advantage with either treatment for complications.

Figure 6. The patient-rated outcome (mean DASH and PRWE scores) after external fixation and volar plating.



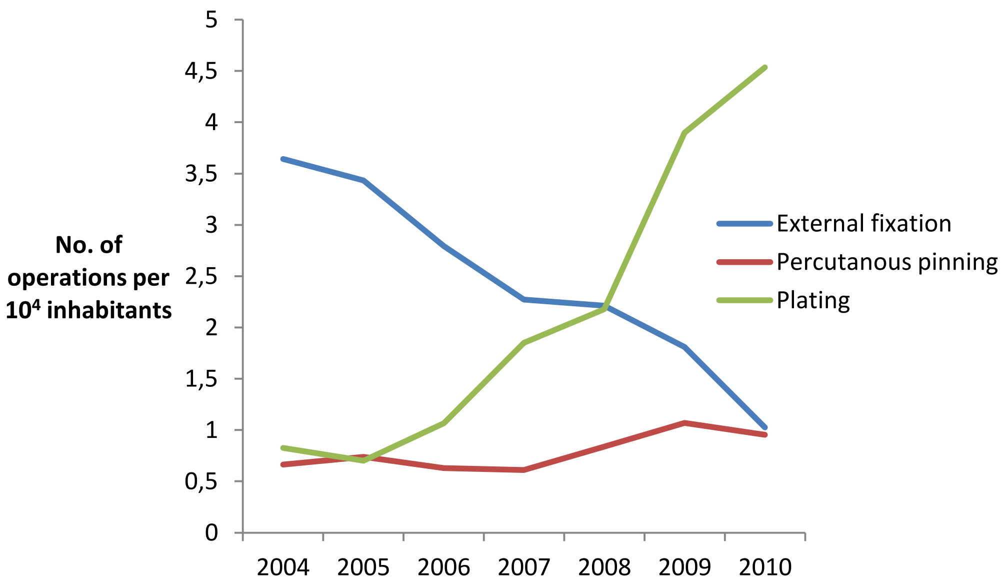
Paper IV

The study included 42,583 patients with a recorded diagnosis of a fracture of the distal radius during 2004-2010. The crude incidence rate was 31 (95% CI 31-31) per 10,000 pyr. The mean age was 42 (range, 0-106, SD 29) years for all patients during the study period: mean age 51 (SD 28) years in women and 27 (SD 24) in men.

In adults (≥18 years), the incidence rate was 25 per 10,000 pyr (CI 25-25). In women ≥18 years, the incidence rate was 36 (95% CI 35-37) and in men 14 (95% CI 13-14) per 10,000 pyr, resulting in a female: male incidence ratio of 2.7:1 (95% CI 2.6-2.7). The age-related incidence rate was bimodal with the first peak at the age of 11 years in girls (incidence rate 111 per 10,000 pyr, 95% CI 103-118) and 13 years in boys (incidence rate 148 per 10,000 pyr, 95% CI 140-157). After the age of 45 years, the incidence rate in women increased sharply and leveled off first at a very high age. The incidence rate in postmenopausal women was lower than the figures reported about 2 decades ago. In men, the incidence was low and it increased slowly until the age of 80 years, when it amounted to 31 per 10,000 pyr.

The number of surgical procedures increased with 40% despite a decreased incidence rate. In adults, the proportion of fractures treated with plating increased from 16-70% while external fixation decreased from 71-16% during this period (Figure 7). This change occurred in all age groups and in both genders. For children and adolescents (<18 years), percutaneous pinning was the predominant method of fixation.

Figure 7. Changing surgical methods for fractures of the distal radius in patients ≥18 years in Stockholm, Sweden 2004-2010.



General discussion

Because of the high incidence and an increasing elderly population, fractures of the distal radius are an important public health issue. It is essential to manage this common injury correctly and cost effectively. Remarkably, there is still insufficient evidence and lack of consensus with regard to the management of this frequent fracture.
The studies in this thesis aim to increase our knowledge about how to effectively assess the result after a fracture of the distal radius, to compare the most common surgical treatment methods and to investigate the current epidemiology and trends in surgical treatment.

Do the radiological results correlate with patient-perceived outcome?

Abraham Colles concluded in 1814 that despite remaining deformity of the wrist "...the limb will at some remote period again enjoy perfect freedom in all its motions, and be completely free from pain" (Colles 1972). This statement still applies to many patients in that malunion after a fracture of the distal radius can be asymptomatic. However, today we are well aware that many patients suffer from disability and pain after a fracture of the distal radius. The proportion of patients with remaining disability is small, but due to the high incidence, the number is considerable.

In the past decade, outcome assessment has increasingly focused on patient-perceived disability with concomitant less emphasis on radiological and objective physical measurements. In Paper I, we examined the correlation between patient-rated disability and radiological parameters after a fracture of the distal radius. We found that malunion was associated with greater patient-rated disability as measured by the DASH score. This finding has been supported by several other investigations. In a prospective study of 216 patients, Grewal and MacDermid (2007) demonstrated a strong link between poor outcome (based on PRWE and DASH scores) and the presence of a malunion of the distal radius in patients <65 years. In a recent study, Brogren et al. (2011b) reported that dorsal angulation over 10° and positive ulnar variance were associated with higher patient-reported disability (DASH). Karnezis et al. (2005) and Kumar et al. (2008) also reported positive correlations between radiological and patient-rated results (DASH and PRWE score, respectively).

In older patients, satisfactory patient-rated results (DASH score) despite malunion, have been described (Jaremko et al. 2007, Kumar et al. 2008). Conversely, Brogren et al. (2011b) found a correlation between worse radiological result and poorer patient-rated result regardless of age. Grewal and MacDermid (2007) suggest that the relationship between malunion and patient-rated outcome should not be considered as an all-or-none phenomenon but rather as a decreasing gradient of risk for disability with increasing age, with the most significant change occurring after patients reach 65 years of age.

To date, there is no consensus regarding which radiological parameter that best predicts the outcome (Mason 1953, Villar et al. 1987, Gliatis 2000). We found that all three radiological parameters correlated with the DASH score. Reasonably, all three parameters have a bearing because they are coherent and reflect the effect of the forces (axial load and dorsal extension) on the distal radius at the time of the injury. The result is an axial shortening of the distal radius, a dorsal angulation of the articular surface and a radial compression that "shortens" the radius styloid. Experimental studies have explained how malunion gives symptoms by causing a carpal malalignment that alters the dynamics and loading patterns of the wrist joint (Pogue et al. 1990, Kihara et al. 1996, Park et al. 2002). Pogue et al. (1990) found that normal wrist mechanics were maintained if axial shortening was <2 mm, volar tilt changed by <20°, and radial inclination was maintained at >10°. These findings are in accordance with ours.

Altered load over the wrist as well as articular incongruity predisposes the development of posttraumatic osteoarthritis of the wrist (Goldfarb et al. 2006, Forward et al. 2008). However, radiological osteoarthritis can be clinically asymptomatic and the clinical relevance of radiological degenerative changes in the wrist has been debated (Downing and Karantana 2008). We could not draw any conclusions for the effect of articular incongruity on the patient-rated outcome in Paper I, because the follow-up was too short and the sample was too small for this type of analysis.

The potential measurement error in the radiological assessment awakes the question of whether it is meaningful to relate the degree of radiological deformity to the outcome. Despite a confirmed high-rater agreement, the intra-observer tolerance limits (the expected margin of error) have been estimated to ±3 mm for axial shortening and ±10° for dorsal angulation (Kreder et al. 1996b). Rather than dismissing the existing scientific evidence that involves radiological measurements, we suggest that one should be careful to set rigorous thresholds or postulate conclusions on precise radiological measurements. A reasonable interpretation of the results in Paper I is that malunion results in more patient-rated disability but it would be imprudent to conclude that 2 mm is the crucial limit of allowed axial shorteing. However, it is not unlikely that the radiological measurement error partially can explain the discrepancy in the literature, at least regarding intra-articular fractures in which, the low rater agreement for measuring size of steps and gaps in healed fractures renders difficulties for valid comparisons of results (Kreder et al. 1996b).

Objective physical parameters versus patient-rated outcome

It is plausible that poor grip strength affects the patient-rated disability negatively, as observed in Paper I. This observation is supported by others (Karnezis et al. 2002, Swart el al. 2012). To correlate ROM with the patient-rated result is more problematic because of the inherent overcapacity in ROM (Nelson 1997). Moreover, patients' demands and expectations on wrist function differ and the extent to which various ROM variables relate to the overall function of the wrist may vary between individuals. This might explain why a correlation between specific ROM variables and the patient-perceived result after fractures of the distal radius had not been demonstrated previously (Karnezis et al. 2002). We found that reduced extension and ulnar deviation correlated with a poorer DASH score. This observation is supported by the findings that extension and ulnar deviation have been found to be the most important movements in wrist activities (Palmer et al. 1985, Ryu et al. 1991). Swart el al. (2012) recently reported that supination appears to be an important determinant of the patient-rated outcome (DASH). The reason why we could not demonstrate a correlation between supination or pronation and DASH score in Paper I, is probably because most patients had a full prosupination arc at follow-up.

To measure patient-rated outcome – quantifying subjective perception.

During the work with paper I, we identified a need for a wrist-specific patient rating tool in the Swedish language. The DASH score conceptualizes the upper extremity as a single functional unit. The advantage with such a region-specific instrument is that it can be used for a large number of conditions and allows comparisons of the patient-rated disability between various upper-extremity conditions. However, the items are not specific to the wrist. Furthermore, the DASH score does not take into account whether the patient uses the injured or the uninjured wrist to do a specific task, which could affect the disability after a wrist fracture. Handedness is another concern in the sense that an injury to the non-dominant wrist probably will affect the score to a lesser degree. In patients with fractures of the distal radius, the PRWE has been shown to be more responsive to clinical change than the DASH (MacDermid et al. 2000). Self-esteem issues are a dimension of the outcome that is addressed in the DASH but not in the PRWE. In Paper III we used both questionnaires for completeness and for the possibility to compare with other studies that might have used either score.

To assess the patient-rated disability and health-related QoL have become a trend the past decade. Patient-rated outcome scores have been developed with the aim to quantify subjective perceptions. It is important to remember that the score is calculated from purely subjective ratings. When the subjective rating is assigned a numeral, it is perceived as objective and accurate and it may be tempting to use and to interpret this categorized subjectivity as an exact measurement.

Subjective factors that are not related to the injury, such as education level and injury compensatory status, have been shown to be influential predictors of the perceived disability (measured with the PRWE score) 6 months after a fracture of the distal radius. Patients with injury compensation reported more than twice the pain and disability as did the remainder of the study population (MacDermid et al. 2002).

Considering the variability in the perception of disability and the highly subjective nature of patient rating scales, rather large differences are needed when comparing patient-rated results between groups. The relevance of differences in patient-rated results must be interpreted with caution, bearing in mind that the smallest worthwhile effect may vary significantly among patients. Patient rating instruments are valuable complements in the outcome assessment. For a complete picture, however, subjective data should be used as the soul means of evaluation but must be related to objective variables (grip strength, ROM, radiology).

Volar plating or external fixation?

In Paper III, we reported that volar plating was more advantageous for rehabilitation than bridging external fixation. A more rapid return of function to regain functional independence and ability to perform daily activities of living, work and hobbies is beneficial to both individuals and society. The advantage of volar plating was reduced over time, however, and after 1 year the patient self-rated scores were comparable. Other trials that compare volar plating with external fixation (Egol et al. 2008, Wei et al. 2009) or percutaneous pinning (Rozental et al. 2009), described the same tendency. A reasonable explanation to the faster rehabilitation after volar plating is the earlier mobilization allowed.

On the other hand, Lozano-Calderon et al. (2008) found that early mobilization (at 2 weeks) did not improve grip strength, ROM, pain or the DASH score at 3 and 6 months after the injury compared with late mobilization (at 6 weeks) after volar plating of fractures of the distal radius. Correspondingly, Atroshi et al. (2006) found that the functional and patient-rated results were similar over time after bridging and non-bridging external fixation of fractures of the distal radius. This inconsistency suggests that, in addition to the differences in the timing of mobilization, there may be factors inherent in the method of volar plating that contribute to the advantage in early rehabilitation. By speculation, a more rigid fixation of the fracture may cause less pain, which would favor a more effective rehabilitation. Not having to wear an inconvenient external fixation device could make rehabilitation easier. Occasionally, external fixation holds the wrist in a dysfunctional posture that causes additional digital tightness and capsular stiffness.

Gradl et al. (2013) compared non-bridging external fixation with multiplanar K-wires (early mobilization) versus volar plating and found that at 8 weeks ROM was similar but grip strength was better after volar plating whereas patients treated with non-bridging external fixation reported less pain. At 6 and 12 months results were comparable. Patient-rated wrist or upper-extremity disability was not assessed.

Is the absence of differences in patient-rated results in the longer term in Paper III and other reports due to underpowered studies? We did note a small advantage in objective variables (grip strength and ROM) at 1 year. Accordingly, one might question whether there would have been a statistically significant difference in DASH and PRWE scores as well if the patient groups had been larger. Nevertheless, a statistically significant difference between two methods does not necessarily mean a clinically meaningful difference. The difference must be relevant to be valuable. The reported difference in DASH and PRWE scores at 1 year was 4 points which is most likely too small to be relevant. A recent meta-analysis of randomized controlled trials comparing external fixation and open reduction and volar plating (Esposito et al. 2013) showed that although no individual trial found a significant difference in the DASH score at 1 year, when data were pooled, a significant difference in favor of volar plating was found. However, the difference of 7 points is probably clinically insignificant. It would translate to a change in one level (i.e. from ‘’no difficulty’’ to ‘’mild difficulty’’) in 6 of the 30 domains of the DASH score. The meta-analysis found no differences in grip strength or ROM between external fixation and volar plating after 1 year. Overall the authors concluded that there was very little clinical difference between external fixation and volar plating.

Open reduction and internal fixation with a volar plate facilitate reduction and fixation of articular fracture fragments which theoretically is an advantage in intra-articular fractures. Only extra-articular and non-comminuted AO type C1 fractures were included in Paper III and because of small sample and too short follow-up, we could not draw any conclusions on any advantages in intra-articular fractures. There is still little evidence in the literature that volar plating is better than external fixation for intra-articular fractures (Wright et al. 2005, Rizzo et al. 2008) and the presence of post-traumatic arthritis does not necessarily correlate with a poor outcome (Kopylov et al. 1993, Catalano et al. 1997).

A relevant question is whether the advantage of a faster rehabilitation after volar plating rationalizes a change of surgical methods if increased costs and potential unknown complications are taken into account. Because the patient-rated outcomes in the long-term appear similar, the complications of each method are important outcome variables. Paper III could not demonstrate any differences in complications after either treatment. However, the study was not designed to investigate this aspect and the sample was too small to compare complications as outcome variables. The meta-analysis of Esposito et al. (2013) could not show any significant differences in the relative risk for complications overall, nor specific complications (e.g. malunion, nerve deficit or tendon ruptures). The risk for infections was higher after external fixation but this was due to minor pin tract infections. The different nature of the complications after external fixation and volar plating makes comparisons difficult. It is not meaningful to simply compare the overall number of recorded complications: the severity of the complications must be taken into account as well. With external fixation, the complications can be expected to present during the treatment whereas after volar plating, complications can present late because of the remaining hardware. With respect to volar plating, reported high rates of tendon ruptures after volar plating and cases of fracture collapses and screws penetrating into the radiocarpal joint (Rozental and Blazar 2006, Arora et al. 2007, Knight et al. 2010) probably reflect the learning curve.

The cost of each method is not irrelevant. External fixation is less expensive than volar plating and, with the exception of the pins, the fixation device can be reused. In addition, external fixation generally requires less costly time in the operation theatre. On the other hand, if patients regain wrist function sooner after volar plating, the costs in term of sick leave and social services will decrease.

In Paper III, we suggested that volar plating should be considered when rapid recovery of wrist function is important. When choosing the appropriate treatment for a patient, one must use current knowledge and take into account the patient’s assumptions, age, bone quality and anticipated functional loading of the wrist (according to function level, handedness, profession, hobbies and social situation). The patient should be well informed and engaged in the decision-making process. An elderly patient may tolerate malunion well and might prefer conservative treatment. In a younger patient, the ambition should be to restore anatomy, which could be achieved in several ways according to current medical evidence. A general treatment scheme that allocates every patient category to the proper surgical treatment would be convenient. However, such a scheme is not yet achievable based on available medical evidence.

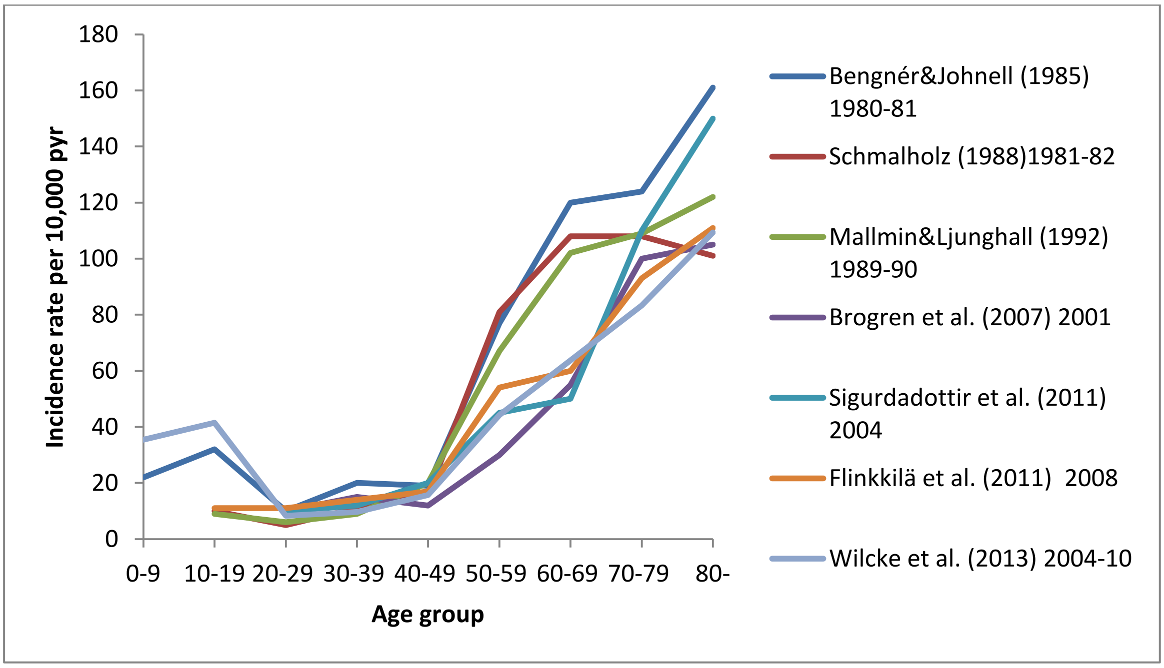
A consequence of the shift in surgical treatment from external fixation to plate fixation that has occurred in the past decade (as shown in Paper IV) is that it might be difficult to perform randomized investigations that include external fixation, because this method seems to have become out of date, despite no medical evidence of its inferiority.

A changing epidemiology

In Paper IV, we reported that the incidence rate of fractures of the distal radius in postmenopausal women was lower than reports from 2-3 decades ago (Schmalholz 1988, Mallmin and Ljunghall 1992). Other recent Scandinavian investigations reported the same tendency (Brogren et al. 2007, Lofthus et al. 2008, Sigurdardottir et al. 2011). Figure 8 shows approximate incidence curves from reports of the past decades. As the figure indicates, there is a noticeable difference in postmenopausal women, with higher incidence rates in previous studies and lower incidence rates in more recent studies.

Our interpretation is that from the 1950s, possibly due to a more active lifestyle and increased life expectancy, the incidence rate of fractures of the distal radius increased until the 1990s when it began to decrease, probably because of effective treatment of osteoporosis.

Figure 8. Reproduced approximately incidence rate curves from earlier and recent studies.



We could not find a difference in incidence rates between earlier and recent reports in men, which suggests a more stable incidence. However, in Paper IV, we noted a decrease in incidence rate in men 65-79 years during the study period of 7 years. Whether this is a continuing trend or a passing phase needs to be investigated in the future.

There have been unanimous reports regarding the presence of a leveling off in the incidence rate from the age of about 60 years in women (Falch 1983, Miller 1985, Bengér and Johnell 1985, Schmalholz 1988, Mallmin and Ljunghall 1992, O'Neill et al. 2001, Thomson et al. 2004, Brogren et al. 2007, Flinkkilä et al. 2011). It is reasonable that the incidence rate levels off in older age due to a lower level of activity. In Paper IV we found a leveling off of the incidence rate in women but at a higher age than previously reported. At the present time, this leveling seems to take place about two decades later compared with before the treatment of osteoporosis. The leveling off is probably difficult to detect in small populations which partly explains the diverse findings on this issue. Most studies that report no leveling include relatively small numbers of fractures in patients >80 years of age, which can make the incidence rates somewhat unreliable. In some studies, patients >80 years were analyzed as one category so any leveling after this age could not be detected.

Reports on the incidence of fractures of the distal radius in childhood are scare. A report from New Zealand (Jones et al. 2000) shows a substantially higher incidence rate (104 per 10,000 pyr, 3-5 years) than we found in our population (53 per 10,000 pyr <18 years of age). Two Scandinavian studies reported incidence rates about 43-49 per 10,000 pyr (Kramhøft et al. 1988, Tiderius et al. 1999), which is more in line with our findings. The incidence rate of fractures of the distal radius in children in a recent Scandinavian report (59 per 10,000 pyr <20 years) (Hedström et al. 2010) is in accordance with our findings. However, whereas Hedström et al. (2010) reported a 13% increase in overall children fractures from 1993-2007, we found a decline in the incidence rate of fractures of the distal radius in boys and girls <18 years of age from 2004-2010. A more sedentary lifestyle in children might be the cause for this change.

A shift in surgical treatment

In Paper III, we suggested that, apart from a slower return of wrist function, external fixation is still a viable alternative for many unstable fractures of the distal radius. Nevertheless, external fixation seems to have become out of date. Paper IV showed that a drastic shift in surgical treatment from external fixation to open reduction and plating has occurred rapidly and a similar trend has been shown in the USA and Finland (Koval et al. 2008, Chung et al 2009, Mattila et al. 2011). What is most remarkable about this changed treatment regime is perhaps the lack of supporting medical evidence. Few studies have reported that plating is superior to external fixation other than in the short-term (Egol et al. 2009, Rozental et al. 2009, Wei et al. 2009).

The lack of convincing medical evidence does not necessarily mean that a relevant difference does not exist. The widespread opinion of clinicians that volar plating is the preferable method must not be underestimated. However, to justify such a drastic change with associated increased costs and an unknown load of long-term complications more substantial medical evidence is desirable. The results in Paper III could not be used as a justification for such a paradigm shift. Rather, the results suggest that external fixation is a good alternative in the long term.

Chung et al. (2009) observed from 1996-2005 in the USA a shift towards an increased use of more aggressive treatments of distal radius fractures in elderly patients, including internal fixation. This observation is noteworthy in light of reports showing that malunion seems to be better tolerated in patients >65 years of age (Grewal and MacDermid 2007, Diaz-Garcia et al. 2011). Conservative treatment with acceptance of malunion (Figure 9) seems to result in a similar outcome as volar plating in patients over this age (Arora et al. 2009, 2011). In our material, the conversion from external fixation to the more invasive method of open reduction and plating occurred in all age-groups ≥18 years, including the elderly.

The number of surgical interventions for fractures of the distal radius increased substantially during the study period despite a decreasing incidence rate. More frequent surgical fixation of fractures of the distal radius indicates extended indications for surgery. This may be explained by an increased ambition to restore the anatomy of the distal radius to avoid malunion. With volar locked plating, safe fixation is possible even in very osteoporotic bone which may have contributed to the overall increase in surgical fixation as well as the shift in surgical methods. The increase in surgical interventions was more modest in the elderly, suggesting a less aggressive attitude in surgical fixations in the oldest.

Figure 9. A lateral radiograph of a malunited fracture of the distal radius.

Strengths and weaknesses of the studies

Paper I

The major strength of Paper I is that it addresses the important question of whether there is a correlation between the objective result and the patient-rated outcome after fractures of the distal radius. An obvious shortcoming is the retrospective design that results in a lack of baseline data. Patients with disabilities of the upper extremities and former wrist fractures had to be excluded, which likely altered the population, reducing general applicability of the findings. Another limitation is that the cohort is too small and heterogenic to allow any valid subgroup analyses. For instance it would have been valuable to analyze the patients in groups according to age.

All measurements (objective functional variables and radiological) are presented compared with the uninjured side. This approach has an advantage because absolute values are less valuable due to the natural variance between individuals and inter-assessor variability. However, the potential measurement error for radiological and objective physical measurement is a weakness in Paper I. Radiological analyzes were made by a single reviewer as recommended by Kreder et al. (1996) but intra-observer and inter-observer agreement were not validated. One could question whether it is relevant to correlate radiological differences, as small as a few mm or degrees to the patient-rated outcome when studies suggest that you cannot measure radiological small differences reliably (Kreder et al. 1996). Comparing two relatively unreliable outcome variables such as radiology and patient-rated outcome can appear doubtful but these are the only available measurements.

Paper II

The strength of Paper II is that a useful instrument for evaluating patient self-reported outcome after fractures of the distal radius was made available in Swedish by an adequate validation procedure. One weakness concerns the methodology, such as the alteration of the item “turning a door knob” or the timing and length of the time interval of the test-retest. However, because these possible biases are minor, they would not likely affect the overall outcome. Another translation to Swedish has later been conducted with good validity and reliability (Mellstrand Navarro et al. 2011). The two versions are very similar, confirming the validity of both translations.

Paper III

The main strength of Paper III is the randomized controlled design. There were few losses to follow-up, which is another advantage. One limitation is the possible risk of a type-2 error due to a relatively small sample size. The execution of the study was pragmatic and adjusted to the clinic's routines which results in both strengths and limitations. The results are applicable to and reflect the clinical reality, which is an asset, but a scientifically better execution may have made the results more legitimate. For example, because the randomization was not performed in the operating theater, the possibility of surgeon bias is introduced. External fixation was more often performed by less experienced surgeons than volar plating and this may have contributed to the slightly poorer radiological result in this group and the two cases of fracture collapse.

Both extra-articular and non-comminuted intra-articular fractures were included. It can be argued that these injuries should not be mixed. However, a high percentage of fractures, classified as extra-articular by standard radiographs, are actually intra-articular fractures of the distal radius (Schneppendahl et al. 2012).

The patients' age range was from 20-70 years, and consequently, both osteoporotic and non-osteoporotic fractures were included which can be questioned. However, this circumstance reflects how surgical treatment methods for fractures of the distal radius are used. The same methods are applied for very different patients with various functional demands, as well as varying bone quality and associated soft-tissue injuries. The patients were stratified according to being older or younger than 50 years to decrease the risk for bias related to this variable. The majority (n=49) of the patients were ≥50 years of age. The group <50 years (n=14) showed the same trend in patient-rated outcome as the older patients. Thus we do not believe that including younger patients (i.e. <50 years) affected the results. However, the patients under 50 years of age expressed less disability in the early rehabilitation phase and although this was not statistically significant, it could have potentially affected the results because there were somewhat more patients <50 years of age in the volar plating group (5 vs. 9). Still, the results remained when the patients <50 years were excluded from the analyses (data not shown).

Paper IV

The main strength of Paper IV is the large population of the study. Such a large population increased the reliability of incidence rates and thus makes the results generally applicable. A benefit with a study period of several years is that the influence of annually changing weather conditions (that could have an impact in Scandinavia) is decreased. A limitation of the study is the risk for incorrect or inconsistent coding, resulting in the inclusion of patients with false positive diagnoses and misclassified patients not taking part in the study although they should. The VAL database contains the same data as the Swedish (in- and outpatient) register and, in addition, data from primary care. Neither the VAL database nor the Swedish outpatient register has been validated for the correlation of fracture diagnosis with patient case history.

To avoid multiple counting, only the first recorded fracture during the period was considered. Such a strategy increases the risk of underestimation of the incidence rate because patients with two wrist fractures during the period were only counted once. Underestimation is probably compensated to some extent because some patients possibly sustained their fractures before the study period but were coded with the diagnosis at a follow-up visit during the study period. The lack of information of the precise type of fracture or surgical procedure and inability to distinguish between primary surgery and re-operation are other shortcomings.

Conclusions

Malunion after a fracture of the distal radius results in poorer patient self-reported outcome as quantified by the DASH score.

The Swedish version of the PRWE questionnaire is valid, reliable and responsive. Further, it is easily understood and can be administered by mail.

Volar plating is advantageous compared with external fixation in the early rehabilitation phase in patients <70 years with an extra-articular or simple intra-articular Colles' fracture. After 1 year, the outcome is similar, however.

A shift in the surgical treatment of wrist fractures has occurred in the past years. Open reduction and internal fixation with plating have increased substantially at the expense of external fixation despite a lack of solid evidence suggesting that the former is a superior technique.

The incidence rate of fractures of the distal radius in postmenopausal women has decreased in the past 2-3 decades. Recent years have shown a decreasing incidence of wrist fractures in children (<18 years).

Future perspectives

Fractures of the distal radius form a heterogeneous group of patients that is treated with numerous techniques and assessed with a variety of outcome measurements. The diversity makes it difficult to come to consensus, which in part explains the lack of medical evidence. Randomized comparisons provide the highest level of medical evidence and are optimal for comparisons of specific interventions in defined patient groups but are probably not sufficient to form consensus on how to optimally treat fractures of the distal radius. Even a large number of well-powered, scientifically optimally designed studies are unlikely to give us all the answers. It is also important to realize that with large enough samples statistically significant differences probably can be demonstrated between any methods. However, the difference might not be clinically relevant and thus the study has little clinical relevance.

Large prospective cohort studies (ideally population-based registry studies) would add relevant knowledge of fractures of the distal radius. Yet no quality register for fractures is established and such register will probably be too costly and resource demanding to become reality real option any time in the near future. However, the Swedish National patient Register and local registers (e.g. the VAL database) might be useful sources for research on fractures of the distal radius because of increased and improved reporting from health care producers.

Considering the small differences in short-term outcome between surgical interventions reported by us and others, complication rate is one of the most imortant outcome variables for future comparisons. Complications such as tendon ruptures and fracture collapse are so infrequent that randomized studies are not feasible; instead registry studies will be most valuable. Additionally, taking into regard the increasing economic burden of wrist fractures on society, comparisons of direct and indirect costs for different surgical interventions will be of utmost importance.

Registry studies will also be extremely useful as a means of investigating the changing epidemiology of fractures of the distal radius. The decreasing incidence in children and older men observed in Paper IV will be worthy to monitor.

Both over- and under treatment of injuries should be avoided. A current concern is that elderly patients may be over treated. Recent reports suggest that surgical fixation of a fracture of the distal radius does not result in a better patient-rated result compared with non-operative treatment in elderly patients (Arora et al. 2009 and 2011). In considerations of this evidence it is doubtful to perform interventions that expose elderly patients for unnecessary risks. More randomized comparisons will add to our knowledge on this matter. We are currently conducting a randomized comparison between plaster immobilization and volar plating in elderly patients >75 years of age at the Orthopedic clinic in Danderyd Hospital.

Articulate incongruity after distal radius fractures predisposes for arthritis but not all patients with radiological arthritis develop symptoms (Kopylov et al. 1993, Goldfarb et al. 2006, Forward et al. 2008). Well-powered, prospective long-term follow-ups are desirable as a means to establish whether patients with restored articular congruity show better results in terms of arthritis development, patient-rated outcome and objective measurements than patients with remaining articular incongruity.

Summary in Swedish - Sammanfattning på svenska

Handledsfraktur (strålbensbrott, distal radius fraktur) är en mycket vanlig skada som drabbar tusentals personer i Sverige varje år. De största riskfaktorerna för en handledsfraktur är benskörhet och falltendens. Orsaken är oftast ett fall i samma plan där patienten har tagit emot sig med utsträckt handled för att lindra fallet. Skadan drabbar särskilt ofta kvinnor efter klimakteriet eftersom skelettet blir skörare då.

Den vanligaste behandlingen är gipsförband på underarmen under ca 5 veckor. Om det finns en felställning i frakturen försöker man korrigera den innan man anbringar gipset. Man vet att det är viktigt att frakturen läker i ett gott läge hos yngre patienter medan äldre patienter tycks mer toleranta för en viss felläkning. En del av frakturerna är så instabila att ett gott frakturläge inte kan behållas i gips utan man måste operera dem. Det finns ett flertal olika operationsmetoder.

Antalet handledsfrakturer ökar med åldrande befolkning och utgör en ökande belastning för individer, vård och samhälle. Det är viktigt att förbättra kunskapen om denna vanliga skada och hur vi effektivt ska behandla och utvärdera den.

När man har undersökt resultatet efter handledsfrakturer har man traditionellt granskat hur frakturen har läkt på röntgen och mätt vilken greppstyrka och rörlighet patienten har i handleden. De senaste åren har man dock intresserat sig mer för hur patienten upplever funktionen i handleden efter skadan och detta kan mätas med självskattningsenkäter.

I denna avhandling har vi undersökt sambandet mellan det objektiva resultatet (röntgenbild, greppstyrka, rörlighet) och det subjektiva, patientskattade resultatet (Studie I). Vi fann att felläkning och minskad kraft och rörlighet gav sämre patientskattat resultat.

Självskattningsenkäten vi använde i Studie I (DASH) skattar funktionen i bägge armarna som en enhet. Vi fann att det skulle vara värdefullt med en svensk enkät som var specifik för handleden och gjorde därför en översättning och testing av en kanadensisk handledsenkät (PRWE) som används mycket internationellt (Studie II).

I Studie III jämförde vi de 2 vanligaste kirurgiska behandlingsmetoderna för instabila handledsfrakturer: en relativt ny metod som blivit populär senaste åren där man fixerar frakturen med en metallplatta direkt på benet (volar platta) och en traditionell metod där man fixerar frakturen med en stålställning som håller handleden stilla i 5-6 veckor (externfixation). Vi fann att operation med platta gav snabbare återhämtning av greppstyrka, rörlighet och patientskattad funktion men efter ett år var det patientskattade resultatet lika trots att plattan tillät rörelseträning tidigt och gav något bättre resultat röntgenologiskt.

I den sista studien (IV) undersökte vi förekomsten av handledfrakturer i Stockholms läns landsting under åren 2004-2010. Vi fann att förekomsten var 31 handledfrakturer per 10000 personer och år. Det innebär att man kan förvänta sig att ungefär 28000 patienter bryter handleden årligen i Sverige. Jämförelser med äldre studier visade att förekomsten av handledfrakturer hos kvinnor efter klimakteriet tycks ha minskat. Det visade sig ha skett en stor förändring i den kirurgiska behandlingen av handledsfrakturer; operation med platta har ökat kraftigt på bekostnad av externfixation. Detta har skett trots att det inte finns övertygande medicinska bevis för att platta är bättre än externfixation annat än på kort sikt. Vi såg också att antalet patienter som opereras har ökat trots att förekomsten av handledsfrakturer har minskat.

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Appendices

Appendix 1 – Swedish version of the DASH questionnaire

Gradera Din förmåga att utföra följande aktiviteter under den senaste veckan genom att kryssa för ett svarsalternativ för varje fråga

	Ingen svårighet	Viss svårighet	Måttlig svårighet	Stor svårighet	Omöjligt att göra
1. Öppna en ny burk, eller hårt sittande lock					
2. Skriva					
3. Vrida om en nyckel					
4. Förbereda en måltid					
5. Öppna en tung dörr					
6. Lägga upp något på en hylla över Ditt huvud					
7. Utföra tunga hushållssysslor (t ex tvätta golv och väggar, putsa fönster, hänga tvätt)					
8. Trädgårdsarbete					
9. Bädda sängen					
10. Bära matkassar eller portfölj					
11. Bära tunga saker (över fem kilo)					
12. Byta en glödlampa ovanför Ditt huvud					
13. Tvätta eller föna håret					
14. Tvätta Din rygg					
15. Ta på en tröja					
16. Använda en kniv för att skära upp maten					
17. Fritidsaktiviteter som kräver liten ansträngning (t ex spela kort, sticka, boule)					
18. Fritidsaktiviteter som tar upp viss kraft eller stöt genom arm, axel eller hand (t ex spela golf, använda hammare, spela tennis, skytte, bowling)					
19. Fritidsaktiviteter där Du rör på armen fritt (t ex spela badminton, simma, gympa)					
20. Färdas från en plats till en annan					
21. Sexuella aktiviteter					

22. Under **de senaste sju dagarna**, i vilken utsträckning har Dina arm-, axel- eller handproblem stört Ditt vanliga umgänge med anhöriga, vänner, grannar eller andra?

☐ Inte alls ☐ Lite ☐ Måttligt ☐ Mycket ☐ Väldigt mycket

23. Under **de senaste sju dagarna**, i vilken utsträckning har Dina arm-, axel- eller handproblem stört Ditt vanliga arbete eller andra dagliga aktiviteter?

☐ Inte alls ☐ Lite ☐ Måttligt ☐ Mycket ☐ Väldigt mycket

Ange svårighetsgraden på Dina symtom **de senaste sju dagarna**:

	Ingen	Lätt	Måttlig	Svår	Mycket svår
24. Värk/smärta i arm, axel eller hand	☐	☐	☐	☐	☐
25. Värk/smärta i arm, axel eller hand i samband med aktivitet	☐	☐	☐	☐	☐
26. Stickningar (sockerdrickskänsla) i arm, axel eller hand	☐	☐	☐	☐	☐
27. Svaghet i arm, axel eller hand	☐	☐	☐	☐	☐
28. Stelhet i arm, axel eller hand	☐	☐	☐	☐	☐

29. Har Du haft svårt att sova, under **de senaste sju dagarna**, på grund av värk/smärta i arm, axel eller hand?

☐ Inte alls ☐ Viss svårighet ☐ Måttlig svårighet ☐ Stor svårighet ☐ Mycket stor svårighet

30. Jag känner mig mindre kapabel, har sämre självförtroende eller känner mig mindre behövd på grund av mina arm-, axel- eller handproblem.

☐ Instämmer absolut inte ☐ Instämmer inte ☐ Vet inte ☐ Instämmer ☐ Instämmer absolut

Appendix 2 – Swedish version of the PRWE questionnaire

PATIENTUPPLEVD HANDLEDSFUNKTION

Namn____

Datum______________

*Nedanstående frågor ska hjälpa oss att förstå hur mycket besvär du har haft från din handled den senaste veckan. Du ska ange dina genomsnittliga handledsbesvär den senaste veckan på en skala från 0 till 10. Var vänlig och besvara **ALLA** frågor. Om du inte utförde en viss aktivitet, vänligen UPPSKATTA den grad av smärta eller svårighet som Du tror hade uppstått. Om Du ALDRIG har utfört en viss aktivitet kan du lämna raden obesvarad.*

1. SMÄRTA

Ange Din genomsnittliga handledssmärta den gångna veckan och ringa in siffran som bäst motsvarar smärtan på en skala från 0 till 10. Noll (0) betyder ingen smärta och tio (10) betyder att Du har haft den värsta tänkbara smärtan eller att du inte kunde utföra aktiviteten på grund av smärta.

Exempel:	skala	0 **Ingen smärta**	1	2	3	4	5	6	7	8	9	10 **Värsta tänkbara smärta**

UPPSKATTA DIN SMÄRTA:

I vila	0	1	2	3	4	5	6	7	8	9	10
När du utför en uppgift med upprepade handledsrörelser, t ex skruva	0	1	2	3	4	5	6	7	8	9	10
När du lyfter ett tungt föremål	0	1	2	3	4	5	6	7	8	9	10
När smärtan är som värst	0	1	2	3	4	5	6	7	8	9	10

Hur ofta har du haft ont i handleden den senaste veckan?	0 **Aldrig**	1	2	3	4	5	6	7	8	9	10 **Alltid**

Var god vänd

2. FUNKTION

A. SPECIELLA AKTIVITETER

Ange graden av svårighet som Du har haft den senaste veckan att utföra nedanstående aktiviteter genom att ringa in siffran som beskriver svårigheten på en skala från 0 till 10. En nolla (0) betyder att Du inte har haft någon svårighet och tio (10) betyder att Du har haft så stor svårighet att Du inte kunde utföra aktiviteten alls.

Exempel:	skala	0	1	2	3	4	5	6	7	8	9	10
		Ingen svårighet										**omöjligt att utföra**

Öppna en ny burk, eller hårt sittande lock med den påverkade handen	0	1	2	3	4	5	6	7	8	9	10
Skära kött med kniv med den påverkade handen	0	1	2	3	4	5	6	7	8	9	10
Knäppa skjortknappar med den påverkade handen	0	1	2	3	4	5	6	7	8	9	10
Använda den påverkade handen för att skjuta ifrån och resa mig upp från en stol	0	1	2	3	4	5	6	7	8	9	10
Bära ett 5 kilos föremål med den påverkade handen	0	1	2	3	4	5	6	7	8	9	10
Använda toalettpapper med den påverkade handen	0	1	2	3	4	5	6	7	8	9	10

B. VARDAGLIGA AKTIVITETER

Uppskatta graden av svårighet du har upplevt när du har utfört vardagliga sysslor inom nedan listade områden under den gångna veckan, genom att ringa in siffran som bäst beskriver din svårighet på en skala från 0 till 10. Med vardagliga sysslor menas sysslor som du utförde innan du fick problem med handleden. En nolla (0) betyder att du inte har upplevt någon svårighet och tio (10) betyder att det har varit så svårt att du inte har kunnat utföra någon av dina vanliga sysslor inom detta område.

Personlig vård (klä på sig, tvätta sig)	0	1	2	3	4	5	6	7	8	9	10
Hushållsarbete (tvätta, diska)	0	1	2	3	4	5	6	7	8	9	10
Arbete (ditt yrke eller vardagliga sysslor)	0	1	2	3	4	5	6	7	8	9	10
Fritidsaktiviteter, hobby	0	1	2	3	4	5	6	7	8	9	10

Appendix 2 – English (original) PRWE questionnaire

PATIENT-RATED WRIST EVALUATION

Name____

Date________________

The questions below will help us understand how much difficulty you have had with your wrist in the past week. You will be describing your average wrist symptoms over the past week on a scale of 0-10. **Please provide an answer for ALL questions. If you did not perform any activity, please ESTIMATE the pain or difficulty you would expect.** *If you have* **never** *performed the activity, you may leave it blank.*

1. PAIN

Rate the average amount of pain in your wrist over the past week by circling the number that best describes your pain on a scale from 0-10. A zero (0) means that you did not have any pain and a ten (10) means that you had the worst pain you have ever experienced or that you could not do the activity because of pain.

Sample scale	0 **No Pain**	1	2	3	4	5	6	7	8	9	10 **Worst Ever**

RATE YOUR PAIN:

At rest	0	1	2	3	4	5	6	7	8	9	10
When doing a task with a repeated wrist movement	0	1	2	3	4	5	6	7	8	9	10
When lifting a heavy object	0	1	2	3	4	5	6	7	8	9	10
When it is at its worst	0	1	2	3	4	5	6	7	8	9	10

How often do you have pain?	0 **Never**	1	2	3	4	5	6	7	8	9	10 **Always**

1. FUNCTION

A. SPECIFIC ACTIVITIES

*Rate the **amount of difficulty** you experienced performing each of the items listed below – over the past week by circling the number that describes your difficulty on a scale of 0-10. A zero (0) means you did not experience any difficulty and a ten (10) means it was so difficult you were unable to do it at all.*

Sample scale	0 **No Difficulty**	1	2	3	4	5	6	7	8	9	10 **Unable To Do**
Turn a door knob using my affected hand	0	1	2	3	4	5	6	7	8	9	10
Cut meat using a knife in my affected hand	0	1	2	3	4	5	6	7	8	9	10
Fasten buttons on my shirt	0	1	2	3	4	5	6	7	8	9	10
Use my affected hand to push up from a chair	0	1	2	3	4	5	6	7	8	9	10
Carry a 10 lb object in my affected hand	0	1	2	3	4	5	6	7	8	9	10
Use bathroom tissue with my affected hand	0	1	2	3	4	5	6	7	8	9	10

B. USUAL ACTIVITIES

*Rate the **amount of difficulty** you experienced performing your usual activities in each of the areas listed below over the past week by circling the number that best describes your difficulty on a scale of 0-10. By "usual activities", we mean the activities you performed before you started having a problem with your wrist. A zero (0) means that you did not experience any difficulty and a ten (10) means it was so difficult you were unable to do any of your usual activities.*

Personal care activities (dressing, washing)	0	1	2	3	4	5	6	7	8	9	10
Household work (cleaning, maintenance)	0	1	2	3	4	5	6	7	8	9	10
Work (your job or usual everyday work)	0	1	2	3	4	5	6	7	8	9	10
Recreational activities	0	1	2	3	4	5	6	7	8	9	10

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Erratum

Paper III: page 98, line 4-8. The word “greater” should be “smaller”.