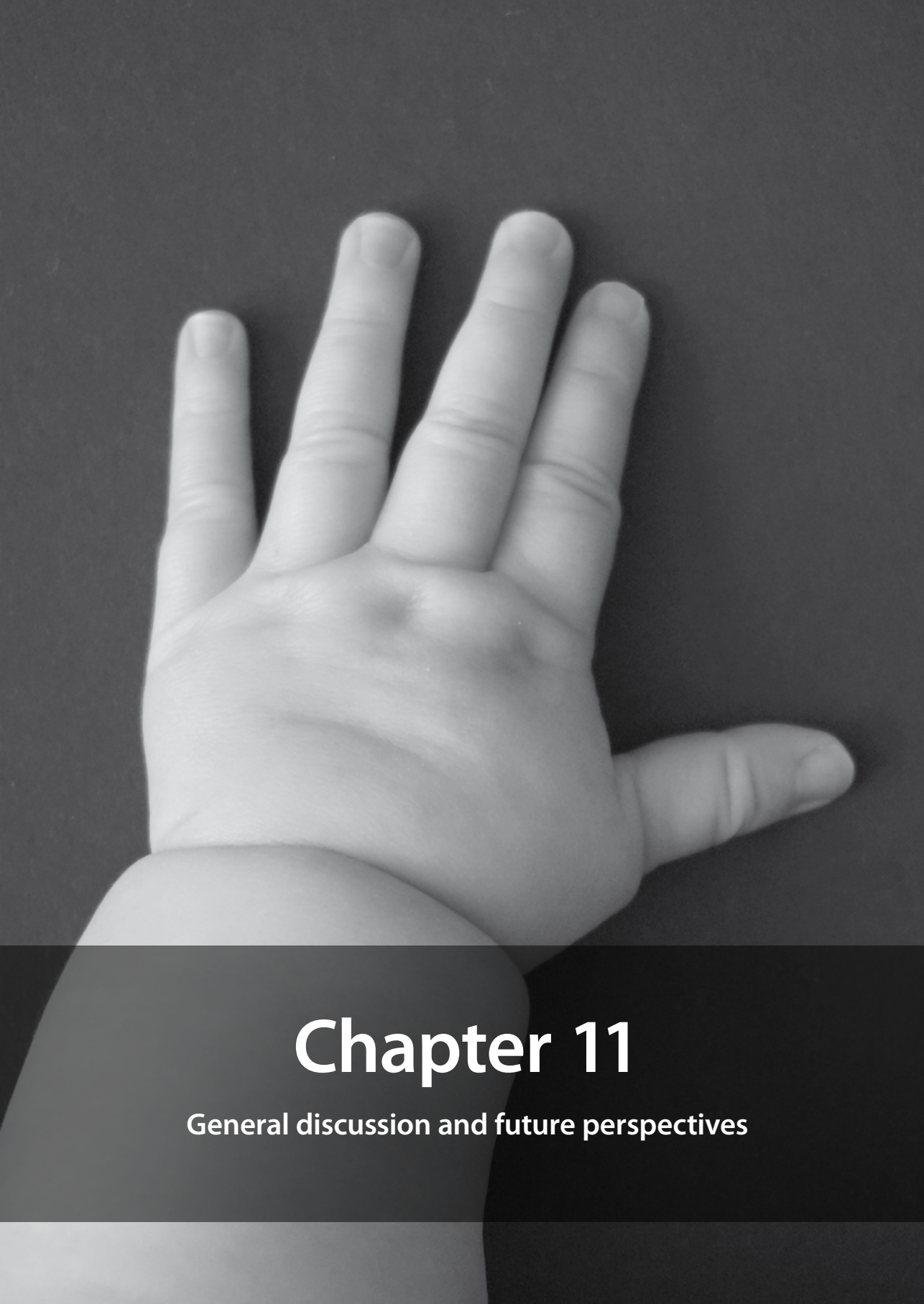
Part V

General discussion and summary



Chapter 11

General discussion and future perspectives

GENERAL DISCUSSION

Distal radius injuries are common and may be complicated by long lasting wrist pain. Distal radioulnar joint injury (DRUJ) and subsequent instability should not be overlooked in the search for the causal factors of pain. Instability results from imbalance in the complex stabilizing system around the DRUJ, caused by the injury of the wrist. Typically, these injuries concern distal radius fractures, with or without ulnar styloid process fractures. Various fracture characteristics have proven to influence the DRUJ stability. The triangular fibrocartilage complex (TFCC), with its collaborating radioulnar fibers, has been assumed to be the principal stabilizer of the DRUJ.[1-5] However, more recently, it has been suggested that the distal oblique bundle, located distally in the interosseous membrane, also fulfills an important stabilizing role.[6,7] Defining the principal DRUJ stabilizer may help in the treatment of DRUJ instability. Most of the research in this thesis relates to the principal DRUJ stabilizer: its injury results in posttraumatic joint changes and may influence clinical outcome, and its instability poses a diagnostic challenge in many ways.

CLINICAL TESTING

Although DRUJ instability seems to be a common injury, its diagnosis has proven to be a challenge. To confirm the diagnosis several clinical tests have been suggested[8-16], but their predictive values are very low and the use of these tests therefore remains a topic of discussion. Generally accepted and most used in studies is the stress test, developed to test the deep radioulnar ligaments of the TFCC. DRUJ instability is tested positive if the forced dorsopalmar translation of the radius in the injured wrist, with respect to stabilized ulna, is more than in the uninjured wrist. The radius pull test[14], developed to test the interosseous membrane, provokes longitudinal movement between ulna and radius and has a sensitivity and specificity up to 100% in cadaveric studies. A major downside of this test is the need for it to be performed under regional or general anesthesia and the lack of data on reliability in the clinical situation. The clunk test[8], the extensor carpi ulnaris (ECU) test[15] and press test[16] are described to examine DRUJ instability in non-anesthetized patients. All three have their specific shortcomings. Their reliability and predictive value have not been determined yet.

There are multiple potential explanations for the absence of a reliable and predictive clinical test to assess DRUJ instability. First, there is no gold standard for the determination of DRUJ instability, which means that the mentioned tests cannot be reliably analyzed for their predictive value. Second, DRUJ instability depends on several anatomic structures. The described clinical tests cannot be used to differentiate between

individual stabilizing structures in a symptomatic wrist. Third, great variation exists in physiological DRUJ translation in the uninjured wrist, which renders the interpretation of test findings difficult and results in varying inter-observer results.

A valid clinical test for diagnosing DRUJ stability should provide characteristics that overcome the afore mentioned shortcomings. First, in order to correct for the wide physiological range in DRUJ translation, the test results of the injured wrist should be related to those of the uninjured side. Second, the test should analyze individual stabilizing anatomical structures separately, as far as possible, which needs, if the risks can be clinically justified, local or general anesthesia. Third, the test should also be performed under the image intensifier, in order to visualize and quantify the amount of pathological ulnar translation in the longitudinal and/or volar and dorsal direction.

For daily practice this means that, the existing tests should be optimized wherever possible. DRUJ laxity is best evaluated when the currently known tests are combined and carried out under optimal circumstances: the radius pull test, the clunk test and stress test should be carried out under the image intensifier by experienced and well trained physicians. The radius pull test should be carried out with the wrist in neutral position to correct for tensioned TFCC ligaments. The clunk test should be carried out during pronation and supination to evaluate for a painful clicking movement that can be seen or felt. The stress test should be performed in various positions to test accordingly radioulnar ligaments of the TFCC. The extensor carpi ulnaris (ECU) test has to be carried out to test the sixth dorsal compartment. Although demanding and potentially requesting the support of anesthesiologists, this investigation may be of great value to the symptomatic patient recovering from a distal radius fracture with potential DRUJ instability.

This thesis shows that DRUJ instability after long term follow up, diagnosed with the nowadays commonly used tests, is found in 1 out of 3 patients with conservatively treated, consolidated distal radius fracture. With regard to wrist function (except from flexion), pain, strength and patient reported outcomes no differences were found between 17 patients with and 32 without DRUJ instability. These findings are contrary to results published by Lindau and colleagues.[10] In their study, 76 patients younger than the age at which osteoarthritis normally presents, were evaluated for DRUJ instability after a mean follow-up of 26 months. Sixty-one distal radius fracture patients had been treated conservatively and 15 patients had been operated at least once. DRUJ instability was tested by the stress test executed by one clinician. Significantly worse outcomes with regards to subjective wrist score and pain were found in the 17 patients with clinically confirmed DRUJ instability. The differences between Lindau's study and our findings are difficult to explain. The age of the investigated patients may be of principal importance. Lindau studied younger patients, median age 41 years, compared to the median age of 61 years in our study. In older patients, arthritic changes resulting in wrist pain may mask

the complaints of DRUJ instability, especially when the wrist demands are less, as can be expected in the elderly. The role of the surgically treated patients in Lindau's study remains unclear, since the results were not reported separately for the conservatively and operatively treated patients. Iatrogenic, postsurgical adhesions and scar tissue, may have influenced the outcome, although operatively treated, initially unstable distal radius fractures are found to have a similar outcome, or even better, then conservatively treated ones.[17,18] A more likely reason for the differences between the two studies is the way clinical DRUJ instability was diagnosed. Lindau used the stress test solely, whereas we used the clunk test additionally. In both studies, instability was found in about 1 out of 3 patients. In our results, in the DRUJ unstable patients, only 6 patients had positive findings for both tests. This poor agreement between tests also demonstrates the poor testing characteristics, and clearly demonstrates the risk of comparing groups defined by coincidence, rather than by a validated difference in clinical findings.

RADIOLOGICAL ASPECTS

When clinical investigations are inconclusive or unreliable, radiological investigations may aid in diagnosing DRUJ instability. Conventional radiographs of the wrist can reveal direct and indirect signs of DRUJ instability, but they have their shortcomings; obtaining true lateral views is difficult and the static radiographs do not depict the dynamic process of DRUJ movement.[19-23] Computed tomography can partially overcome the limitations of radiographs and provide more detailed information on the osseous anatomy. In part II of this thesis, the additional diagnostic value of CT-scanning in wrist injuries was evaluated. Additional CT-scan of the wrist did not improve the fair inter-observer agreement in diagnosing a coronal lunate facet fracture on radiographs. This finding suggests a limited role for additional CT-scans over standard radiographs to evaluate for fracture involvement of the DRUJ. Rozental and colleagues proved, among others, CT-scan to be superior for quantifying articular discongruencies in the lunate facet.[24,25] In general, CT-scan may be helpful in pre-operative planning, suggesting some role for CT-scan in the treatment of distal radius fractures.

Magnetic resonance imaging has greater sensitivity for soft tissue contrast compared to CT. High-resolution MRI seems to diagnose TFCC tears with high accuracy, and may therefore be useful in diagnosing DRUJ instability.[26,27] Scientific evidence is scarce, but some data suggest a discriminating role in abnormal symptomatic DRUJ geometry.[28] As in CT, the relation between MR findings and clinical relevance remains undefined.

In this thesis the reliability of wrist CT-scan, as determined by inter- and intraobserver agreement in DRUJ translation, of four DRUJ instability scoring systems was tested. The Epicenter Method showed the best reliability with a moderate interobserver agreement.

Unfortunately, the inter observer agreement does not tell us much about the accuracy of the CT for determination of DRUJ instability presence, since a good gold standard to compare the CT findings to, is lacking. In the absence of a gold standard, defining the normal physiological ranges of DRUJ translation in the uninjured wrist on CT, may help to determine guidelines for the diagnosis of DRUJ instability. Only a few studies have published on normal CT ranges of DRUJ motion in the uninjured wrist based on living subjects.[23,29,30] Nakamura et al considered volar or dorsal dislocation during rotation of less than 25% of the sigmoid notch diameter as normal and modified the radio ulnar line method, based on findings in 37 healthy wrists. Lo and colleagues present the new radioulnar ratio technique to evaluate ulnar head translation, based on normal findings in 13 healthy wrists compared to cadaveric specimens and rheumatoid arthritic patients. Park et al. based normal values on 45 uninjured wrists. Given the variety in methodology and included patients in these three studies, it is not surprising that normal values documented so far, varied widely. This reflects the need for a study with accurate representation of the trauma population, stratification for various ethnicities and ages, and with standardized scoring techniques by several observers, to obtain useful date for normal physiological ranges in DRUJ instability.

Defining normal ranges includes the risk of unintentional incorrect treatment; a wide range of normal values will lead to under-treatment, since CT-findings will be easily interpreted as normal, and thus potentially as false negative. In contrast, the establishment of a small normal range of DRUJ motion would lead to over-treatment.

The normal ranges are determined using the uninjured wrist and rely on the assumption that symmetry in DRUJ translation exists within one person. This however, has never been evaluated, but static radiological findings may differ between left and right.[31] To investigate the symmetry, a protocol should include many individuals in which DRUJ translation is evaluated in two uninjured wrists. If symmetrical DRUJ translation is present, proportional individual pathological values of instability can be defined. Additionally, such a study should evaluate the relationship between CT-findings in a wrist clinically diagnosed with DRUJ instability and the contralateral uninjured wrist, for each individual. This implies the presence of a valid test to diagnose DRUJ instability, which has proven to be consistently difficult.

TREATMENT OF DISTAL RADIUS FRACTURES

Conservative treatment of a distal radius fracture is not straightforward; follow-up should be on a regular base and (adjustments in) casting the fracture needs knowledge of the specific fracture patterns and characteristics. For example, as described in Chapter 5, distal radius fractures with an accompanying fractured ulnar styloid tend to show more

secondary dislocation compared to fractures without. To evaluate this re-dislocation of the fracture a second visit including radiographs is advocated. Dependent on patient characteristics in combination with fracture dislocation the intended conservative treatment may need change to a more invasive one focusing on reduction and stabilization. An interesting fact is that the most recent Dutch guideline for treatment of distal radius fractures (2010) did not include a follow-up schedule for distal radius fractures.[32]

Since quality of care, outcome and complication rates are hot topics in the society, in politics, for health care insurance companies and are often subject of lawsuits, dedicated wrist teams have to be formed. Treatment of distal radius fractures, and even more its complications, has shown to involve its complex soft tissues as well, therefor thorough knowledge of the complete anatomy of the wrist is needed. Chapter 3 shows that treating an increased number of distal radius fractures per timeframe and specialization in the field results in more consistency in the evaluation of fractures. Although not directly evidence based, an increased number of treated distal radius fractures per physician, may lead to better outcome. Ideally, specialized multidisciplinary teams should treat distal radius fractures. The leading physician may have the background of a trauma, orthopedic- or plastic surgeon as long as he or she treats distal radius on a regular base, in which a minimum number of wrist operations performed per surgeon per year will best be defined by consensus of the experts.[33]

The radiologist of the multi-disciplinary wrist team should be familiar with most recent imaging techniques and different modalities, especially when it comes to the evaluation of complications. Postoperative care should include physiotherapeuthical advice to diminish postoperative pain.[34]

TREATMENT OF DRUJ INSTABILITY

After consolidation of a distal radius fracture, the presence of DRUJ instability has been identified as an independent worsening factor for outcome with regard to subjective and objective wrist score and pain.[10] In patients with chronic symptomatic DRUJ instability a treatment algorithm should enclose correction of osseous malalignment.[11,35] Only when anatomical positioning of the fractured bone is achieved, the biomechanics of the collaborating stabilizing structures can be optimized. Malalignment of the sigmoid notch and ulnar fovea may result in unstable and painful discongruency of the DRUJ.[36,37] Depending on the position of the malaligned distal radius, the volar or dorsal radioulnar ligaments of the TFCC may become lax and lose their stabilizing function.[38] Residual ulnar translation of the radial shaft may introduce laxity of the distal interosseous membrane, with its distal oblique bundle[39] resulting in DRUJ laxity.[40] In Chapter 10, a new surgical approach to correct partially healed, malaligned distal radius fractures

is presented. Although not studied in DRUJ unstable patients specifically, the outcome after this extended flexor carpi radialis approach followed by volar plating, has proven to be safe and effective as a treatment method for nascent malunions of the distal radius.

If the instability persists, despite anatomic osseous reconstruction, the stabilizing soft tissues should be repaired. When primary soft tissue repair is impossible, many reconstructional techniques have been described to replace the failing stabilizers. Last resort salvage-procedures or joint replacing techniques should be carried out if invalidating DRUJ instability persists. These very specific surgical procedures, involving the anatomical structures of the wrist, again call for dedicated expertise in this field. Future treatment of DRUJ injuries may comprise of both clinical and radiological evaluation, as well as conservative or surgical treatment followed by rehabilitation, coordinated from a multidisciplinary dedicated wrist team.

WHAT CAN BE LEARNED FROM THIS THESIS

The various questions stated in Chapter 1 can now be answered, based on the results of this thesis.

- CT-scan, in addition to conventional radiographs, does not improve the interobserver agreement on diagnosing coronal articular distal radius fractures compared to just the radiographs.
- CT-scan, in addition to conventional radiographs, does not improve the interobserver agreement on the determination of fracture instability in coronal lunate facet fractures, compared to just radiographs
- The number of operatively treated distal radius fractures has a positive effect on interobserver agreement on determination of instability of a coronal lunate facet fracture. The background of observers influences the interobserver agreement on presence and instability of coronal lunate facet fractures
- The Epicenter method is the most reliable method for the determination of DRUJ instability using CT-scans of the wrist.
- Using the Epicenter method in supination, interobserver agreement is significantly better in injured wrists compared to uninjured wrists. Using the Radioulnar line method intraobserver agreement is significantly better in injured wrists compared to uninjured wrists.
- There is large normal variation in normal DRU joint movement
- In the presence of an USF secondary dislocation is more frequent in distal radius fractures with an accompanying USF compared to distal radius fractures without an accompanying USF

- Non-union of an ulnar styloid base fracture does not compromise the outcome of operatively treated distal radius fractures compared to outcome after union of the ulnar styloid base fracture in operatively treated distal radius fractures.
- No difference in outcome of distal radius fractures with or without non-union of an ulnar styloid can be found.
- Clinical DRUJ instability does not influence the clinical outcome of conservatively treated distal radius fractures after long-term follow-up, despite significantly better flexion in the DRUJ unstable patients.
- The Darrach procedure is effective in regaining forearm mobility after, amongst others, symptomatic posttraumatic DRUJ changes.
- The extended flexor carpi radialis approach followed by volar plating is a safe and effective procedure to correct partially healed malaligned fractures of the distal radius.

What can be learned from this thesis is that the anatomy around the distal radius is complex and is obviously influenced by a distal radius fracture. The ongoing discussion on the influence of ulnar styloid fractures on the outcome of distal radius fractures comes to an end. Although it seems to promote secondary dislocation, based on the highest level of evidence it can be stated that an ulnar styloid fracture should not be a surgical target since it does not influence outcome of distal radius fractures, even if it results in a non-union. One of the complicating factors after distal radius treatment is DRUJ instability. In conservatively treated fractures, the influence of DRUJ instability on outcome is limited. The ultimate question remains how to reliably and accurately diagnose DRUJ instability. Accurate clinical tests still need to be developed; CT-scan based scores seem reliable but less is known on their validity and normal values vary widely. When, despite the diagnostic dilemma, DRUJ instability is diagnosed, treatment should start with correction of osseous malalignment, in which the extended flexor carpi radialis approach has shown safe and effective. In the absence of distal radius malunion, anatomic or non-anatomic reconstruction of the DRUJ stabilizing structures can be carried out. If still unsuccessful, salvage procedures are optional.

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