Rotator cuff degeneration in the rheumatoid shoulder : 'the issue is soft tissue'

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Chapter 1

General introduction

'Movement is something I possess and will always possess. But technique is not just movement. It is about knowing how to move, when to move and why to move'

(Zinedine Zidane)

General introduction

Rheumatoid Arthritis affects 1% of the adult population and exhibits a chronic fluctuating course which often results in progressive joint destruction, deformity and disability.[1] It affects women three times more than men and is mostly diagnosed between the third and fifth decades. The disease usually begins gradually with fatigue, morning stiffness, widespread muscle aches, loss of appetite and weakness. Eventually, joint pain appears. Joint pain is often felt on both sides of the body, and can affect all synovial joints (e.g. hands, wrists, shoulders, hips, knees and the cervical spine).[2] In most joints the joint capsule is lined with synovium, which produces synovial fluid that lubricates and nourishes joint tissues (Figure 1). In rheumatoid arthritis, the synovium becomes inflamed, causing warmth, redness, swelling and pain. As the disease progresses, the inflamed synovium invades and destroys the cartilage and bone within the joint, but also causes inflammation of the surrounding tissues (Figure 2). The surrounding muscles, ligaments and tendons that support and stabilize the joint become weak and unable to work normally and joint dysfunction is likely.[3] In most joints (e.g. hip, knee) this rheumatoid involvement generally leads to joint pain and loss in range of movement, yet joint stability often is not affected. In the shoulder joint, static and dynamic glenohumeral joint stability largely depends on the soft tissues surrounding the joint capsule (Figure 3). Although the surrounding muscles of the shoulder joint (e.g. Deltoid, Pectoral, Latissimus and Teres Major muscles) are largely responsible for upper arm movement, a full range of movement is primarily dependent on intact rotator cuff function. If the rotator cuff muscles are involved in rheumatoid arthritis of the shoulder, joint stability and shoulder movement are severely compromised. Most patients (67-91%) with rheumatoid arthritis have shoulder pain, and more than one in five present moderate or severe glenohumeral joint destruction during the first 15 years from the disease onset.[4] Any of three synovial shoulder articulations can be involved, but the glenohumeral joint is the most frequently symptomatic.[3,4] Rheumatoid destruction of the shoulder is characterized also by

Figure 1. *Normal synovial joint configuration.*

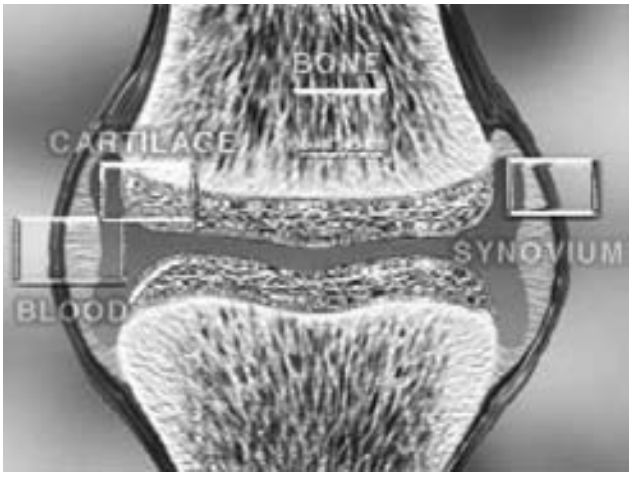
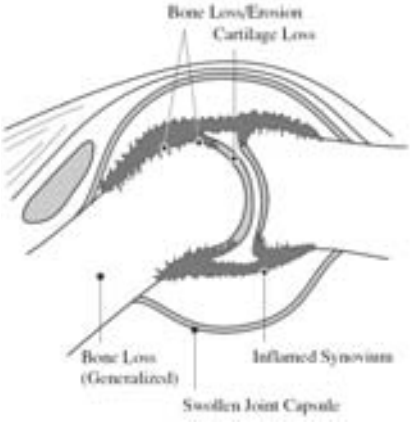


Figure 2. Joint involvement in rheumatoid arthritis.



proliferative synovitis (pannus) which causes degrading of the bone and cartilage matrix within and around the joint capsule. Therefore it not only results in cartilage destruction and bone loss but also causes soft tissue detachment and destruction (e.g. rotator cuff tendonitis and tendon tears)[5; 6] MRI based studies have reported that 24-52% of all patients over 50-years-old with rheumatoid arthritis of the shoulder joint had at least one large rotator cuff tear and/or significant fatty degeneration of the rotator cuff muscles (Figure 4).[1; 6; 7] Rotator cuff tendonitis and tears may result in muscle disuse and do not allow for isometric muscle contractions. Therefore they are associated with profound changes in the structure and function of the affected muscle.[8-10] Reflex inhibition due to pain, shoulder muscle inactivity and disuse and lack of proprioreceptive feedback due to loss of tendon tension all are thought to induce fatty degeneration of the rotator cuff muscles. In a rotator cuff tear model, vascularisation, intramuscular pressure and individual fibre composition were not markedly affected, and muscle fibres did not appear to degenerate. However muscular atrophy developed and there was a significant increase in interfascicular and intrafascicular fat: fatty degeneration. Muscle atrophy, infiltration by fat cells and an increase of interstitial connective tissue lead to impairment of the physiological properties of the muscle.[9; 11] This then may result in even more disuse and initiate a vicious cycle of shoulder joint dysfunction and pain.

Although it was found that muscle fibres do not appear to degenerate, but only atrophy, recent literature made it evident that fatty degeneration is irreversible, even after successful rotator cuff tear repair.[8; 12] Also Hirooka et al. described a rapid serious joint destruction in the presence of rotator cuff degradation.[13] This may imply a relationship between rotator cuff degeneration and joint destruction, as asymmetrical loading of the glenoid caused by shoulder muscle imbalance, can lead to progressive cartilage wear. Several authors therefore emphasized the importance of timely intervention in order to prevent advanced joint destruction and soft tissue degeneration.[1; 14-16] Several reports on shoulder surgery showed significant influence of fatty

degeneration of the rotator cuff on surgical outcome and functional improvement after surgery.[1; 14-16] They clearly demonstrated that patients with fatty degeneration of the rotator cuff muscles have a higher risk of failure after tendon repair and have inferior functional results in both tendon repair and shoulder arthroplasty. They also stated the importance of preoperative screening for fatty degeneration of the rotator cuff muscles, in order to present a reliable prognosis and facilitate optimal surgical planning. To this end Goutallier developed a five stage visual scale using CT imaging.[8] Fatty degeneration was scored as: none, few and little fatty streaks surrounded by muscle tissue followed by equal or more amounts of fat than muscle (graded from 0 to 4).This system made it possible to diagnose fatty degeneration, however it does not reliably quantify the severity of fatty degeneration, as it was moderately reproducible, provided that the observer is experienced.[17; 18] Quantitative measurement of fatty degeneration has been explored using signal intensity measurements in magnetic resonance images but produced inconsistent results and was unreliable in assessing fatty degeneration.[19] We therefore saw the need for a reliable quantitative measurement of fatty degeneration to provide patients and surgeons with a more accurate prediction of postoperative prognosis.

Furthermore a safe and simple screening method to assess the presence of rotator cuff degeneration in the course of rheumatoid disease was also lacking. Diagnostic tools for the evaluation of rotator cuff degeneration such as MRI and CT, all are relatively expensive, time consuming, depend on the radiologist's experience, or require invasive techniques, such as contrast injection or radiation. This makes them less practical in screening and follow-up studies. The use of standard shoulder radiographs in screening for rotator cuff degeneration was therefore assessed and validated.

The clinical relevance of rotator cuff degeneration is discussed in the final chapter. Swelling, stiffness, pain, a decreased strength and loss of range of motion are cited as most important clinical features.[2] When present, these features are associated with a substantially more severe rheumatoid disease status.[20] Both bony and soft tissue involvement in the rheumatoid disease process are related to increased pain and loss of

Figure 3. *The shoulder joint is surrounded by four rotator cuff muscles. Palm of hand: glenoid surface; Baseball: Humeral head; Thumb: Subscapularis muscle; Index finger: Supraspinatus muscle; third and fourth finger; Infraspinatus and Teres Minor.*

function of the shoulder joint.[2; 21-28] Interestingly if only one of these was treated (e.g. rotator cuff tear repair or shoulder arthroplasty in rheumatoid patients) shoulder pain dramatically decreased, yet functional results lacked behind.[29-31] Functional disability has been associated with pain, joint destruction and rheumatoid disease activity.[27; 28] In the early stage of rheumatoid disease functional ability is thought influenced more by disease activity than joint destruction.[32] Other reports showed a significant relation between joint destruction and functional impairment later in the disease process.[27] Both pain and function loss were measured subjectively by use of questionnaires.[28; 31] A quantitative comparison between pain, function and shoulder joint destruction was not found in recent literature. In order to asses the clinical relevance of fatty degeneration we wanted to evaluate the relation between bony and soft tissue degeneration and pain, range of movement and muscle force of the shoulder joint. The outcome of this thesis may underline the clinical, functional and surgical importance of the soft tissues surrounding the rheumatoid shoulder joint.

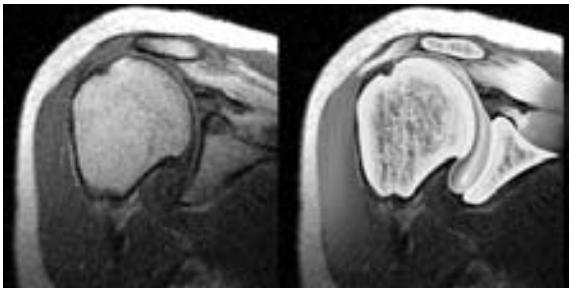
Outline

Aims of this thesis

The primary goal of this thesis was to assess and quantify rotator cuff degeneration in the rheumatoid shoulder. Furthermore we wanted to evaluate the clinical and functional implications of rotator cuff dysfunction:

First, we set out to assess the incidence and clinical relevance of rotator cuff degeneration in shoulder arthroplasty (Chapter 2). It was hypothesised that rotator cuff pathology (e.g. rotator cuff tears and fatty degeneration) played a significant role in outcome of shoulder surgery. Clinical results and complications after shoulder arthroplasty in rheumatoid and osteoarthritis patients were evaluated using a systematic review (Chapter 2.1). In Chapter 2.2 a short stemmed modular shoulder prosthesis is evaluated. Postoperative functional results are assessed and the anatomical placement of the humeral head within the rotator cuff was measured using standard radiographs. It was hypothesised that a short stemmed modular prosthesis could improve functional results and anatomical reconstruction of the shoulder joint. Finally, a salvage procedure for massive rotator cuff tears was evaluated. The expected shift of function after a transfer of the Teres Major muscle tendon was evaluated using EMG controlled force measurements.

Figure 4. *Rotator cuff tear of the Supraspinatus tendon and proximal migration of the humeral head.*



In Chapter 3.1 we validated the newly developed measure that quantifies fatty degeneration of the rotator cuff muscles. We hypothesised that a Computer Tomography (CT) based measure, making use of the difference in voxel intensity between muscle and fatty tissues, can be used to reliably quantify fatty degeneration. Subsequently we saw the need for a reliable, safe and easy to use screening method (Chapter 3.2). Simple measurement of subacromial space narrowing based on plain shoulder radiographs to determine Supraspinatus tendon ruptures has been described and the relationship between decreased subacromial space and rotator cuff abnormality has long been assumed.[13; 33-39] To this purpose a screening method using anteroposterior (AP) radiographs measuring the subacromial space was validated. We sought to determine whether measuring the subacromial space on a standard AP radiograph is a reliable measure for proximal migration of the humeral head. Several subacromial space measurements on standard AP radiographs were validated using CT images. It was hypothesised that a relative measure for the subacromial space was more reliable than the generally used absolute distance between the acromial undersurface and the most proximal art of the humeral head. In addition the assumed relation between proximal migration and rotator cuff degeneration was evaluated. It was hypothesised that fatty degeneration of the rotator cuff muscles causes a decrease of the acromiohumeral interval, more so than other patient-related factors such as age, shoulder complaints, or the presence of a rotator cuff tear. Consecutively we hypothesised that fatty infiltration of the Infraspinatus and Teres Minor muscles primarily is responsible for proximal migration of the humeral head (Chapter 4).

As assessed in the second chapter rotator cuff degeneration was related to inferior surgical and functional results after shoulder surgery.[1; 14-16] To offer patients and surgeons with a better prediction of the functional and surgical results after shoulder surgery, we evaluated the clinical implications of fatty degeneration of the rotator cuff muscles. (Chapter 5) In the aetiology of shoulder pain and dysfunction we hypothesized that pain caused by synovitis, swelling or cartilage loss leads to shoulder immobilization and disuse. This may initialize a vicious circle of fatty degeneration of the rotator cuff muscles, shoulder muscle imbalance and dysfunction and 'secondary' subacromial shoulder pain.[40; 41] Soft tissue involvement may thus play a key role in the amount of pain and loss of function in the shoulder joint.[42-44]

In order to accurately measure the dynamic range of glenohumeral movement non-invasive measurement of scapular kinematics was validated (Chapter 3.3). In the final chapter, pain, range of motion and shoulder muscle force were related to bony destruction and rotator cuff quality in the rheumatoid shoulder (e.g. cartilage loss, bone destruction, rotator cuff tears and fatty degeneration) in order to determine the dominant factors of dysfunction and pain.