SHOULDER INSTABILITY. A CLINICAL AND MRI-BASED ANALYSIS

Björn Salomonsson

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Läs ofta kartan, mina barn.
Läs den som ett kärleksbrev
med glödande försäkringar
om att världen finns.

Ingrid Arvidsson
ABSTRACT

Shoulder instability is a common but complex and challenging area of shoulder pathology, and new diagnostic methods and treatments are continuously developed. We conducted this study to evaluate the clinical outcome of shoulder instability with respect to different diagnostic possibilities and surgical treatments. We have studied the patient material from our department, consisting of atraumatic instability, posttraumatic recurrent anterior instability, and primary shoulder dislocations. This was done by following up surgical treatments. We also evaluated diagnostic enhancement by arthroscopy and MR-arthrography, as well as the use of MRI as a prognostic tool in primary dislocations. To measure the clinical outcome, we have validated a Swedish translation of a self-evaluating shoulder instability score.

Study I

27 shoulders with atraumatic shoulder instability were treated with a capsular imbrication procedure and followed up after 2 years or more. Capsular imbrication was found to be a good treatment for involuntary atraumatic shoulder instability in cases where physical rehabilitation and lifestyle adjustment have failed.

Study II

A prospective study comparing detection of lesions in recurrent instability of the shoulder on MR arthrography imaging (MRA) and arthroscopy was made in 50 patients. An assessment of agreement between MRA observers and observer repeatability show that MRA is a potentially useful tool for the detection of lesions associated with shoulder instability, and promises acceptable reliability and repeatability.

Study III

The WOSI score questionnaire is a tool designed for self-assessment of shoulder function for patients with instability problems. We retested a translation of the score into Swedish. At this retest the WOSI score had good validity, high reliability, and high responsiveness, at the same level as in the original publication.

Study IV

60 patients with primary posttraumatic shoulder dislocation were treated with closed reduction and examined by MRI within 2 weeks. Ages above 30, isolated fractures of the major tubercle, and Bony Bankart lesions were all prognostic factors for a good functional result and a stable shoulder at 8-year follow-up after a primary dislocation.

Study V

This randomised study compares an anatomical repair (Bankart suture) with a less anatomical method (Putti-Platt procedure). The Putti-Platt procedure was found to be quicker and less demanding. After assessment of pain and general shoulder function, only a small difference was found between the two surgical methods, with a slightly better outcome (in terms of pain and ROM) with a Bankart suture compared to the Putti-Platt procedure.

Keywords: Shoulder instability, Shoulder instability classification, Shoulder arthroscopy, MRI, MR-arthrography, Shoulder instability surgery, Shoulder instability assessment, Outcome instruments.
LIST OF PUBLICATIONS

I. *Atraumatic shoulder instability. Discussion of classification and results after capsular imbrication.*

Salomonsson B, Sforza G, Révay S, Abbaszadegan H, Jonsson U.

II. *MRA, MR and Arthroscopy in shoulder instability. Agreement between methods and observers.*

Salomonsson B, von Heine A, Dahlborn M. Lillkrona U, Nils Dalén, Abbaszadegan H.
Submitted

III. *Western Ontario Shoulder Instability Index (WOSI): Validity, reliability and responsiveness retested in a Swedish translation.*

Salomonsson B, Ahlström S, Dalén N. Lillkrona U.
In press, Acta Orthopaedica 2009; 80 (2):233-238

IV. *Bony Bankart at MRI of primary shoulder dislocation only finding of predictive value: an 8-year follow-up.*

Salomonsson B, von Heine A, Dahlborn M. Abbaszadegan H, Ahlström S. Dalén N. Lillkrona U.
Submitted

V. *The Bankart repair versus the Putti-Platt procedure; a randomized study with WOSI score at 10-year follow-up in 62 patients.*

Salomonsson B, Abbaszadegan H, Revay S, Lillkrona U.
In press, Acta Orthopaedica 2009; 80 (3):
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIOS</td>
<td>Acquired Instability, Overstressed shoulder that requires Surgery.</td>
</tr>
<tr>
<td>ALPSA</td>
<td>Anterior Labroligamentous Periosteal Sleeve Avulsion</td>
</tr>
<tr>
<td>AMBRI</td>
<td>Atraumatic, Multidirectional, Bilateral instability, responds to Rehabilitation, in case of surgery Inferior capsular shift.</td>
</tr>
<tr>
<td>AMSI</td>
<td>Atraumatic Minor Shoulder Instability</td>
</tr>
<tr>
<td>CLC</td>
<td>CapsuloLabral Complex</td>
</tr>
<tr>
<td>CT</td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>EQ-5D</td>
<td>European Quality of life-5 Dimensions</td>
</tr>
<tr>
<td>EUA</td>
<td>Examination Under Anaesthesia</td>
</tr>
<tr>
<td>HAGL</td>
<td>Humeral Avulsion of Glenohumeral Ligament</td>
</tr>
<tr>
<td>GLAD</td>
<td>GlenoLabral Articular Disruption</td>
</tr>
<tr>
<td>IGHL</td>
<td>Inferior GlenoHumeral Ligament</td>
</tr>
<tr>
<td>MGHL</td>
<td>Middle GlenoHumeral Ligament</td>
</tr>
<tr>
<td>MR</td>
<td>Magnetic Resonance</td>
</tr>
<tr>
<td>MRA</td>
<td>Magnetic Resonance Arthrography</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>MRT</td>
<td>Magnetic Resonance Tomography</td>
</tr>
<tr>
<td>ROM</td>
<td>Range Of Motion</td>
</tr>
<tr>
<td>SGHL</td>
<td>Superior GlenoHumeral Ligament</td>
</tr>
<tr>
<td>SLAP</td>
<td>Superior Labral, Anterior to Posterior tear</td>
</tr>
<tr>
<td>SRM</td>
<td>Standardized Response Mean</td>
</tr>
<tr>
<td>T1</td>
<td>A MRI sequence, useful with contrast</td>
</tr>
<tr>
<td>T2</td>
<td>A MRI sequence, useful with water</td>
</tr>
<tr>
<td>TUBS</td>
<td>Traumatic, Unidirectional instability, with Bankart lesion that requires Surgery.</td>
</tr>
<tr>
<td>WOSI</td>
<td>Western Ontario Shoulder Instability Index</td>
</tr>
</tbody>
</table>
DEFINITIONS

Definitions of terms in shoulder instability

**Adolfsson classification**: Classification of intra-articular lesions in shoulders with a recurrent anterior glenohumeral dislocation, by arthroscopy and into three groups, A-C.

**ALPSA lesion**: A lesion is a variation of the Perthes lesion. In an ALPSA lesion with a retraction of the torn labrum medially and inferiorly, whereas the labrum stays in situ in Perthes lesions.

**AMBRI instability**: Atraumatic, Multidirectional, often Bilateral instability that often responds to Rehabilitation, but in case of surgery a Inferior capsular shift is indicated.

**AIOS instability**: Acquired Instability, Overstressed Shoulder (often in overhead repetitive motion) that requires Surgery.

**Andrew’s lesion**: A tear of the superior anterior labrum near the biceps tendon insertion.

**Apprehension**: The patient experiences apprehension in abduction and external rotation, and fears that the shoulder is going to slip out of place.

**Atraumatic instability**: Associated not with a trauma but rather with congenital hyper laxity of the glenohumeral joint capsule, or the development of joint laxity in association with rotator cuff weakness, often as multidirectional instability.

**Baker classification**: Classification of intra-articular lesions in shoulders with a primary anterior glenohumeral dislocation, by arthroscopy into three groups, 1 to 3.

**Bankart lesion**: A tear of the anterior-inferior glenoid labrum, and accompanying capsular injury in the area where the anteroinferior glenohumeral ligament originates.

**Bony Bankart lesion**: An avulsion fracture of the glenoid rim that carries with it the capsulolabral complex. See Ideberg classification!

**DePalma classification**: A classification based on open surgery of the arrangements of the glenohumeral ligaments and the synovial recesses into type I to VI.
<table>
<thead>
<tr>
<th><strong>Dislocation</strong></th>
<th>A complete loss of the humeral articulation with the glenoid fossa.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dislocation arthropathy</strong></td>
<td>Radiographic evidence of glenohumeral arthropathy after a single or multiple dislocations of the shoulder.</td>
</tr>
<tr>
<td><strong>European Quality of Life-5 Dimensions</strong></td>
<td>EQ-5D, is a standardised instrument to measure health outcome. EQ-5D was designed to complement other instruments but is also used as a single measure. An EQ-5D health state is converted to a single summary index by a formula. The EQ-5D was developed by the EuroQol Group, established in 1987.</td>
</tr>
<tr>
<td><strong>GLAD lesion</strong></td>
<td>This lesion consists of an anterior-inferior labral tear associated with an injury to the glenoid articular cartilage. The extent of the injury may vary from a cartilaginous flap tear to a depressed osteochondral injury.</td>
</tr>
<tr>
<td><strong>Glenoid</strong></td>
<td>A smooth and shallow depression, the glenoid cavity, or fossa, of the scapula in which the head of the humerus articulates.</td>
</tr>
<tr>
<td><strong>Glenohumeral instability</strong></td>
<td>The inability to maintain the humeral head in the glenoid fossa. Instability is an abnormal symptomatic motion for a shoulder which results in pain, subluxation or dislocation of that shoulder. See Dislocation and Subluxation!</td>
</tr>
<tr>
<td><strong>Glenohumeral stability</strong></td>
<td>The humeral head will remain centred in the glenoid fossa if the glenoid and humeral joint surfaces are congruent. If the net humeral joint reaction force is directed within the glenoid surface the glenohumeral joint will not dislocate.</td>
</tr>
<tr>
<td><strong>HAGL lesion</strong></td>
<td>An avulsion of the capsule including the IGHL from the neck of the humerus.</td>
</tr>
<tr>
<td><strong>Hermodsson lesion</strong></td>
<td>See Hill-Sachs lesion!</td>
</tr>
<tr>
<td><strong>Hill-Sachs lesion</strong></td>
<td>An irregularity seen in the posterolateral part of the humeral head following dislocation of the shoulder. It is caused by an impaction of the head of the humerus against the relatively hard anterior edge of the glenoid. Also called Hermodsson Lesion.</td>
</tr>
<tr>
<td><strong>Hyperlaxity</strong></td>
<td>Hypermobility. Unusual flexibility of the joints, allowing them to be bent or moved beyond a normal range of motion. See Laxity!</td>
</tr>
</tbody>
</table>
**Ideberg classification**

Used to describe glenoid fractures.

Type 1A, small anterior margin avulsion.

A Glenoid rim fracture, Bony Bankart lesion.

**Impingement syndrome**

Subacromial pain and pathologic changes resulting from the impingement of the acromion, coracoacromial ligament, coracoid process, or acromioclavicular joint on the rotator cuff.

**Johnson classification**

Classification of intra-articular labral lesions in shoulders with a recurrent anterior glenohumeral dislocation, by arthroscopy, into six groups, I to VI.

**Labrum**

The glenoid labrum is a ring of fibrous cartilage that runs around the cavity of the glenoid. The labrum deepens this cavity and effectively increases the surface of the shoulder joint.

**Laxity**

A partial loss of the glenohumeral articulation. Patients with laxity falls within a physiological range and is asymptomatic.

**Mc Laughlin sign**

Reverse Hill Sachs lesion. A compression fracture of the anterior aspect of the humeral head associated with posterior dislocation.

**Minor instability**

A pathological condition (AMSI) causing a dysfunction of the glenohumeral articulation, especially in combination with micro trauma, repetitive or not, or after a period of immobilization or inactivity.

**Multidirectional Instability**

An abnormal amount of excursion of the humeral head on the glenoid in all directions.

**Occult instability**

Is recognized as a shoulder dysfunction or pain, due to instability or subluxation, with no awareness of shoulder instability by the patient.

**Perthes lesion**

A variation of the Bankart lesion, the Perthes lesion occurs when the scapular periosteum remains intact but is stripped medially, and the anterior labrum is avulsed from the glenoid but remains partially attached to the scapula by the intact periosteum.

**Rowe score for shoulder instability**

A disease-specific score for shoulder instability patients presented in different versions since 1978 by Carter Rowe. Often the 1988 version is used, for evaluation at follow-up of instability surgery.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Secondary impingement</strong></td>
<td>Subacromial pain may occur as a result of weakness of the cuff. Secondary Impingement implies that there is a problem with keeping the humeral head centred in the glenoid fossa during movement of the arm.</td>
</tr>
<tr>
<td><strong>SLAP lesion</strong></td>
<td>A tear in the long head of the Biceps tendon insertion on the superior pole of the glenoid involving the superior portion of the glenoid labrum and, sometimes extending into a Bankart lesion.</td>
</tr>
<tr>
<td><strong>Subluxation</strong></td>
<td>A partial loss of the articulation, to the degree that symptoms are produced.</td>
</tr>
<tr>
<td><strong>Sulcus sign</strong></td>
<td>The patient sits while the examiner applies caudal traction on the humerus in an attempt to displace the humerus inferiorly. If inferior displacement occurs so that a sulcus is noticed lateral to the acromion, then the sulcus sign is present.</td>
</tr>
<tr>
<td><strong>Suture anchor</strong></td>
<td>The anchor inserts to the bone and the suture ties the soft tissue to the bone. The anchor may be a screw type or an interference type and may be made of metal or biodegradable material, which dissolves over time. The suture is attached to the anchor and may also be a non-absorbable or absorbable material.</td>
</tr>
<tr>
<td><strong>TUBS instability</strong></td>
<td>Traumatic, Unidirectional instability associated with a Bankart lesion which often requires Surgery. The most common shoulder instability.</td>
</tr>
<tr>
<td><strong>Voluntary dislocation</strong></td>
<td>The desire to voluntarily dislocate the shoulder. Could be associated with a psychiatric condition or alternative gain that cannot be treated surgically.</td>
</tr>
<tr>
<td><strong>Western Ontario Shoulder Instability Index</strong></td>
<td>The WOSI score, has 21 items representing 4 domains presented by Alexandra Kirkley 1998. It is a disease-specific self-evaluating quality of life measurement tool for patients with shoulder instability.</td>
</tr>
</tbody>
</table>
## Definition of Statistical terms

**Ceiling effect**  
Occurs when test items aren't challenging enough for a group of individuals. Because the test has a limited number of difficult items, the most highly functioning individuals will score at the highest possible score. This becomes a measurement problem when you are trying to identify changes - the person may continue to improve but the test does not capture that improvement.

**Cohen's kappa**  
Often called Kappa. A measure of agreement between two observers, suggested by Cohen in 1960. See Kappa statistics!

**Concurrent validity**  
To validate a new measure, the results of the measure are compared to the results of the gold standard obtained at approximately the same point in time (concurrently), so they both reflect the same construct.

**Construct validity**  
Reflects the ability of an instrument to measure an abstract concept, or construct. In the absence of a gold standard, construct validation occurs when the measure under investigation provides results that are consistent with these theories assessed.

**Content validity**  
Refers to the extent to which a measure represents all aspects of a given concept.

**Convergent validity**  
A type of validity that is determined by hypothesizing and examining the overlap between two or more tests that presumably measure the same construct.

**Correlation**  
The extent to which two or more variables are associated with one another. A correlation can be positive if the two variables follow each other, or negative if they diverge. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation.

**Chronbach's alpha**  
Chronbach’s alpha is a coefficient (a number between 0 and 1) that is used to rate the internal consistency (homogeneity) or the correlation of the items in a test.
Effect size

Effect size measures the magnitude of a treatment effect. Unlike significance tests, these indices are independent of sample size. It is generally measured as the standardized difference between two means.

Face validity

A form of content validity, face validity is assessed by having 'experts' review the contents of the test to see if the items seem appropriate. It is typically only used during the initial phases of test construction.

Floor effect

When data cannot take on a value lower than some particular number. Even if there is worsening of function it may not register as a change in score, because there are no items or scaling within the test that measure decline from the lowest possible score. See also Ceiling effect!

Gold standard

A measurement that is widely accepted as being the best available. As new methods become available the "gold standard" may change over time.

Inter-rater reliability

A type of reliability assessment in which the same assessment is completed by the same rater on two or more occasions. These different ratings are then compared, generally by means of correlation.

Intraclass correlation coefficient (ICC)

Intraclass correlation (ICC) is used to measure inter-rater reliability for two or more raters. It may also be used to assess test-retest reliability.

Kappa statistic

A measure of the degree of non-random agreement between observers or measurements of the same categorical variable. Kappa measures the percentage of data values in the main diagonal of the table and then adjusts these values for the amount of agreement that could be expected due to chance alone. See Cohen’s kappa!

Kruskal-Wallis

A non-parametric test that uses the ranks of the data to calculate the statistic. It is used to compare three or more independent groups of sampled data.
| **Pearson Product Moment Correlation** | The most commonly used method of computing a correlation coefficient between variables that are linearly related. Pearson's r is a measure of association, which varies from -1 to +1, with 0 indicating no relationship. |
| **Reliability** | Is generally understood to be the extent to which a measure is stable or consistent and produces similar results when administered repeatedly. There are many variations on the measurement of reliability including internal consistency, inter-rater agreement, intra-rater agreement, and test-retest. |
| **Responsiveness** | The ability of an instrument to detect clinically important change over time. |
| **Sensitivity** | Sensitivity refers to the probability that a diagnostic technique will detect a particular disease or condition when it does indeed exist in a patient. See also "Specificity." |
| **Spearman rank-order correlation** | A correlation coefficient for ranked, i.e., ordinal, data in which the items on the scale represent higher vs. lower values but are not of equal intervals. |
| **Specificity** | Specificity refers to the probability that a diagnostic test will indicate a negative test result when the condition is absent (true negative). |
| **Standardized response mean** | The standardized response mean (SRM) is calculated by dividing the mean change by the standard deviation of the change scores. |
| **Test-retest reliability** | A way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. |
| **Validity** | The degree to which an assessment measures what it is supposed to measure. |
Definition of Technical terms

Arthroscopy
A surgical technique whereby a tube-like instrument with a camera is inserted into a joint to inspect, diagnose and repair tissues.

Computed tomography
Computed tomography (CT) results in a large series of two-dimensional X-ray images. This imaging method may generate a three-dimensional image from the two-dimensional images.

Gadolinium
Gd, atomic number 64. A ferromagnetic metallic element of the rare earth group. Used as a contrast medium in MRI T1 images.

Magnetic Resonance
(MR) Absorption of certain frequencies of radio and microwave radiation by atoms placed in a magnetic field. The pattern of absorption reveals molecular structure without the use of radiation.

Magnetic Resonance Arthrography
(MRA) An is an imaging procedure that demonstrates the joint spaces. A liquid contrast material in the joint space allows joints to be visualized by the MRI.

Magnetic Resonance Imaging
(MRI) Primarily a medical imaging technique to visualize the internal structure of the body. MRI provides a contrast between the different soft tissues to obtain detailed images of the body.

Magnetic Resonance Tomography
(MRT) An imaging that uses MRI and a computer to produce detailed cross-sectional pictures of the inside of the body.

Pixel
The smallest unit of a digital image.

T1-weighted
A MRI sequence characterised by tissues with water appearing dark and fat bright in the contrast of the image.

T2-weighted
A MRI sequence characterised by tissues with water appearing bright and fat dark in the contrast of the image.

Tomography
The process for generating a tomogram, a two-dimensional image of a slice or section through a three-dimensional object. The tomogram is the picture and the tomograph is the apparatus.

Voxel
The smallest unit of a volume in a three-dimensional image. Analogous to a pixel in two-dimensional images.
1 BACKGROUND

1.1 INTRODUCTION

Shoulder instability and its treatment was described even in ancient times by Greek and Egyptian physicians, e.g. in the Hippocratic texts of 500 BC. Shoulder instability must have been experienced as posttraumatic shoulder pathology throughout human history, and evidence of shoulder dislocations has been found in archaeological and paleopathological examinations of human shoulders several thousands of years old (15).

Despite the long historical knowledge of the condition, we still encounter many difficulties in the management of shoulder instability. The special arrangement of the shoulder renders the glenohumeral joint at risk for clinical instability, and it is estimated that about 2% of the Swedish population experiences at least one shoulder dislocation (34, 68) and that the male dominance is above 85% (34, 25) The glenohumeral joint is unique in many ways, because it has a very high degree of mobility, with the need for both static and dynamic factors to maintain the stability throughout the motion range. The anatomy of this joint is complicated, and there is also a considerable individual variation that has posed a great challenge to shoulder surgery in creating an operative algorithm for treatment of shoulder instability.

The factors that have been discussed in maintaining glenohumeral stability are many (110). They play cooperative roles, and they may be modified by age, trauma and muscle function:

**Static factors:**

<table>
<thead>
<tr>
<th>Joint anatomy:</th>
<th>Articular congruence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Articular version</td>
</tr>
<tr>
<td>Soft tissue:</td>
<td>Glenoid Labrum</td>
</tr>
<tr>
<td></td>
<td>Ligaments</td>
</tr>
<tr>
<td></td>
<td>Capsule</td>
</tr>
<tr>
<td>Functional:</td>
<td>Laxity</td>
</tr>
</tbody>
</table>

**Dynamic factors:**

<table>
<thead>
<tr>
<th>Joint anatomy:</th>
<th>Negative pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft tissue:</td>
<td>Rotator cuff</td>
</tr>
<tr>
<td></td>
<td>Biceps tendon</td>
</tr>
<tr>
<td>Function:</td>
<td>Proprioception</td>
</tr>
<tr>
<td></td>
<td>Coordination</td>
</tr>
<tr>
<td></td>
<td>Scapulothoracic motion</td>
</tr>
<tr>
<td></td>
<td>Volition</td>
</tr>
</tbody>
</table>

Often, age is suggested as the main prognostic factor since it is well established that the risk of a recurrent dislocation is much higher in younger people (94, 112, 39).
1.2 EARLY HISTORY

The early history of shoulder instability treatment and surgery is well described in a book on recurrent shoulder instability by Mosely 1961 (66). In the 19th century, different autopsy studies described lesions both in the capsulolabral complex and the bony structures after shoulder dislocations. The introduction of radiographs made the impression fracture in the posterolateral head of the humerus well known (Hermodsson 1934). When surgery began, with reconstruction of the capsule and ligaments, e.g. Perthes 1906 and Thomas 1909, the number of publications increased. Numerous muscle transfers and tendon or fascia restrictors were tried and described (Clairmont 1913, Gallie 1927 and Nicola 1929), and bone-block procedures were introduced (Eden and Hybbinette in 1918).

The methods that remained in use in Sweden into the second half of 20th century (35) were mainly the bone block procedure by Eden and Hybbinette (105, 79), the anatomical reconstruction of the ligaments by a Bankart procedure (42, 43), the shortening of the subscapularis tendon by a Putti-Platt procedure (42, 22), and the Coracoid transfers by Bristow and Latarjet (36, 41).

1.3 DIAGNOSIS

Most of the patients with shoulder instability suffer from traumatic anterior instability and it is generally described that 95% of the dislocations are of that type (86).

The patient often describes the shoulder instability and the problem in detail, and can also tell the history of the first time it was experienced. This leads to the description of traumatic or atraumatic origin to the instability, but it may also be caused by overuse or repetitive micro trauma, which can lead to instability symptoms such as subluxation and pain (17).

Some patients do not recognise the problem as instability, only as pain, and this is sometimes defined as occult instability or described by the symptoms, as is the case in secondary impingement (24). The clinical examination is important, as its purpose is to determine whether any instability is present as the source of the patient’s shoulder problem. Another matter of interest is whether there is any pathological factor present which could influence the treatment.
1.4 CLASSIFICATION

Classification of shoulder instability is difficult, but it is clinically relevant since it may be that one type of treatment is successful for one type of instability, but is not useful for other types. As Neer and Foster (67) describes, a failure to completely correct the instability may increase instability in the direction left untreated.

When concentrating on recurrent instability, and on those shoulders that continue to be symptomatic, several questions arise. Multi-directional instability is considered a symptom, not a diagnosis, since it could occur in all types of instability given that a massive loss of stability will result in difficulties stabilising the shoulder in every direction, not only the direction of the lesion. The term involuntary is not easily differentiated considering that even if it is positional, muscular or psychological in nature, it can be beyond the patient’s control. It can also be difficult to differentiate whether a shoulder is unstable or just plain lax, and frequently a combination of pathologies may exist. Furthermore, patients may move from one group to another over time.

Thomas and Matsen (103) have stressed the importance of distinguishing between patients with TUBS (Traumatic Unidirectional with Bankart lesion that do well with Surgery) and those with AMBRI (Atraumatic Multidirectional and often Bilateral and generalized joint laxity that needs Rehabilitation, and if surgery is required, an Inferior capsular shift). Figure 1.

Many patients cannot be classified solely as TUBS or AMBRI, but are rather somewhere in between. Bigliani (8) describes the instability as a spectrum ranging from the Traumatic unidirectional to the Atraumatic multidirectional (Figure 2). In between the two, there are those with micro trauma and acquired instability, as discussed by Neer and Foster (67) and categorised as AIOS (Acquired Instability from Overuse of the Shoulder) or AMSI (Atraumatic Minor shoulder instability), as in Castangna, Nordlund and Karlsson (17).

To further complete the classification, Bayley (61) has described his Stanmore classification (The Bayley triangle), that also considers the contribution of muscular patterning problems to the instability (Figure 3). In this sense, the muscular patterning problem could be regarded as the function of proprioception and coordination of the joint forces. The classification also reflects the fact that many shoulders with atraumatic instability have structural lesions that may need to be addressed surgically. The model of a triangle highlights the continuum of findings that can occur in between the three types. Patients can be fitted into the three polar groups, or somewhere along the lines which join them, with a combination of pathologies.

A breakdown of the classification of shoulder instability suggested by Pollock and Flatow (76):

- **Timing**: acute, primary or recurrent, or chronic.
- **Degree**: dislocation, subluxation, or occult.
- **Direction**: anterior, posterior, inferior, or combinations.
- **Aetiology**: traumatic, atraumatic, or acquired.
- **Volition**: involuntary or voluntary (including positional, muscular, and psychological)
Development of the classification of shoulder instability through three classification models:

**Figure 1:** Thomas and Matsen 1989 (103):

\[
\begin{array}{c|c|c|c|}
 & TUBS & \text{AMBRI} & \\
\hline
\text{TUBS} & & & \\
\hline
\text{AMBRI} & & & \\
\end{array}
\]

**Figure 2:** Bigliani et al. 1994 (8), The spectrum of instability:

\[
\begin{array}{c|c|c|}
\text{Trauma} & \text{Micro trauma} & \text{Atraumatic} \\
\hline
\text{Less laxity} & \text{More laxity} & \\
\text{Unidirectional} & \text{Multidirectional} & \\
\end{array}
\]

**Figure 3:** Lewis, Kitamura, Bayley 2004 (61), The Stanmore classification (The Bayley triangle):

\[
\begin{array}{c|c|c|}
\text{Less muscle patterning problem} & \text{Polar type I} & \text{Polar type II} \\
\hline
\text{Traumatic structural} & \text{Atraumatic structural} & \\
\end{array}
\]

\[
\begin{array}{c|c|c|}
\text{Less trauma} & \text{Polar type III} & \\
\hline
\text{Muscle patterning problem} & \text{Non-structural} & \\
\end{array}
\]
1.5 EXAMINATION

The clinical examination should include a systematic evaluation of the patient. Findings of asymmetries, atrophy, weakness or neurological deficits frequently accompany shoulder instability problems. Discrepancies in passive and active ROM and hyper mobility in the shoulder joints, or generalised ligamentous joint laxity, may be revealed. Both shoulders should be examined for comparison.

Instability
Instability tests mainly consist of tests that provoke symptoms of the instability that the patient reports. If the vector of the force compressing the head of the humerus into the shoulder joint does not pass through the glenoid, the head will start to dislocate and reproduce the instability symptom. *Figure 4.* The patient’s experienced fear of an imminent instability episode is regarded as an apprehension of the instability. For the Apprehension test of anterior instability, the arm is placed in 90 degrees of abduction and then externally rotated. The test is positive when the patient experiences apprehension that the shoulder will dislocate with further provocation (106). The apprehension experienced by the patient is usually graded 0 for none, 1+ for some, and 2+ for marked apprehension.

*Figure 4:* The balance of the shoulder joint.  
*Figure 5:* Voluntary Sulcus sign.

Posterior Apprehension with subluxation can usually be produced by placing the arm in internal rotation at about 90 degrees of forward elevation. This can often be done by the patient, without provocation by the examiner (10).

Translation
Translation is difficult to assess since the normal variation of laxity is wide and influences the result. It is often reported when examined under anaesthesia, and then most patients with laxity or multidirectional instability have grade 2 or 3 when tested. The Sulcus sign consists of an observance of the distance between the acromion and the humeral head, often by palpation while pulling the arm with one hand in an inferior direction.
If an inferior laxity or massive instability is present a sulcus can be seen or palpated on the lateral aspect of the acromion (Figure 5). The amount of translation of the humeral head is usually graded 0 for none, 1 for some (up on the glenoid rim), 2 for marked (over the glenoid rim), and 3 for a full dislocation.

An active external rotation of the shoulders that reaches 90°, or a hyper abduction above 110°, may also imply a lax shoulder joint (23). Other joints like elbow, fingers, knee, and ankle should be examined to investigate general joint laxity in the patients (16, 93).

1.6 RADIOLOGY AND MRI

Indications for imaging of the shoulder in acute dislocations are to establish the diagnosis, document the reduction, and rule out fractures. Further investigation into the acute dislocation may be necessary to detect associated lesions, or even to assist in preoperative planning.

In patients with recurrent symptoms, common findings that might influence the treatment would be Bony Bankart lesions (glenoid rim fracture, Ideberg Type 1A) (44), as well as impression fractures in the posterior part of the humeral head (Hermodsson lesion, Hill-Sachs lesion) (32). Posterior dislocations are rare but could have an equivalent in the anterior part of the humeral head (Mc Laughlin sign, reversed Hill-Sachs lesion) (65).

Shoulder dislocation may cause a later posttraumatic arthropathy which is visible on radiographs, called dislocation arthropathy, even in shoulders without a recurrence (92, 40).

Plain radiology

Plain radiographs are used to document a dislocation or reduction of the joint. They may also give information on the status of the joint surfaces in cases with obvious arthritic changes and of glenoid wear. Usually, the three standard projections are sufficient; the Anteroposterior view (Figure 6), the Lateral view, and the Axillary view.

![Figure 6](image_url): Radiograph (Anteroposterior views) of an anteroinferior dislocation, and after reduction. A possible Bony Bankart lesion is shown (arrow).
Other radiological methods
Computed tomography is an even more sensitive tool for depicting the bony changes already discussed, but generates more radiation and is not always as available. CT can also show the soft tissue lesion of the labrum and the rotator cuff if combined with an intra-articular injection of contrast, when used as a CT arthrography (95).

Ultrasound has been shown to be useful for the soft tissue lesions, mainly for rotator cuff lesions, but labral lesions can also be identified (63). But the examination is dependent on the examiner’s ability to produce and understand the lesion at the time of the examination, because the examination is dynamic and difficult to save for later evaluation.

Magnetic Resonance Imaging
Magnetic Resonance Imaging in the shoulder is useful (18, 85, 108) used without contrast or as MR arthrography. MRI is a technique that combines soft tissue contrast with tomographic possibilities without the use of ionizing radiation, and it has become very useful in imaging instability patients since it can visualise both superficial and deep structures. MRI usually consists of three imaging planes: the sagittal oblique, the coronal oblique, and the axial. Figure 7a.

Figure 7: All images are from the same patient, after acute dislocation, and with the hemarthrosis filling the joint space used as a contrast where applicable.

Figure 7 a: Coronal Oblique Sagittal Oblique

Figure 7b: T1 Axial T2 Axial
The tissue signal in MRI is related to the spin of the atoms, and the signal in each pixel is dependent both on the density of the protons and on the molecular composition within the volume unit (voxel). Sequences of electromagnetic pulses are transmitted while the patient is inside the magnetic field. These energy pulses are at specific frequencies that distort the system equilibrium, flipping the atom spins to a 90-degree angle to the transverse plane and resulting in a higher energy state of the atoms. As the nuclear spins then return to a steady state, a transmitted signal is measured by a receiving coil placed over the patients shoulder. Altering the repetition rate of the energy pulses and the time interval allows one to determine the contrast levels between different kinds of tissue in the images. The MRI thus presents different contrasts between the tissues, usually described as T1- and T2-weighted sequences. In the traumatic dislocations the hemarthrosis served as a contrast medium in T2 images. Figure 7a and b.

On T1-weighted images, tissues with a high content of water will appear with a high signal (bright), fat will appear with a low signal (dark), and the opposite will be the case in T2-weighted images. Cortical bone and normal tendons will appear black on both T1 and T2. Beside these basic sequences others can be used to differentiate between high signal fluid and intermediate signal cartilage or low signal haemorrhage or calcifications depending on the actual question. MRA enhances the possibility to assess the intra-articular details with contrast fluid separating different structures. A combination of Gadolinium and saline makes it possible to achieve this in both T1 and T2. This has made MRA accurate in assessment of posttraumatic soft tissue lesions in the shoulder such as cuff ruptures, capsulolabral lesions and osteochondral lesions, and thus very useful for instability diagnostics (85).

Lesions on MRI and MR-Arthrography:

Figure 8: The shoulders at acute dislocation (MRI) and after 8 years (MRA).

a) Hill-Sachs Lesion

The impression is still visible at 8-year follow-up.
b) Bony Bankart
At 8-year follow-up, the Bony Bankart lesion is healed.

Acute

Healed

After 8 years

At 8-year follow-up, the Bony Bankart lesion is healed.

c) Bankart Lesion
At 8-year follow-up, the Bankart lesion is healed as an ALPSA

Acute

Healed as ALPSA

After 8 years

At 8-year follow-up, the Bankart lesion is healed as an ALPSA

d) Bankart Lesion
At 8-year follow-up, the Bankart lesion is healed and dislocation arthropathy with cysts is visible.

Acute

Healed, and Arthropathy

After 8 years

At 8-year follow-up, the Bankart lesion is healed and dislocation arthropathy with cysts is visible.
1.7 ARTHROSCOPY

Shoulder arthroscopy has been used increasingly since the early 1980s, and arthroscopic evaluation of the unstable shoulder can play a significant role in diagnosis and choice of treatment. Together with the dynamic visualisation of the joint space, the surgery also provides an opportunity to perform an examination under anaesthesia (EUA).

Normal arthroscopic anatomy
From the standard posterior portal the joint can be inspected by air or saline filling the joint space. The biceps tendon is usually a clear reference point, and is one of the structures to be inspected. The glenoid and humeral joint surfaces are inspected as well, as are the subscapularis and other rotator cuff tendons. In instability the anterior capsulolabral complex (CLC) is the usual site of the intra-articular lesions and this has a variable normal anatomy of the Glenohumeral (GH) ligaments and their origin, and is sometimes difficult to visualise if damaged during the dislocation of the humeral head, or covered by inflamed synovia. The most important structure of the CLC for stability is the Anteriorinferior glenohumeral ligament (AIGHL) (Figure 9). The posterior part of the joint is also inspected, usually from the anterosuperior arthroscopy portal. Normal anatomy is shown in Figures 10 and 11.

Figure 9:
The normal labrum and the Classic Bankart/Perthes lesion in relation to the AIGHL, a right shoulder seen from above.

Figure 10: Arthroscopic view of the normal CLC.
**Figure 11.** Ligaments and tendons of the normal shoulder, Right glenoid from a lateral view.

Infraspinatus tendon    Suprasspinatus tendon     Superior GlenoHumeral ligament
Glenoid surface        Long head of Biceps       Subscapularis muscle/tendon

Teres minor tendon
Posterior IGH ligament  Anterior IGH ligament  Middle GH ligament

The Buford complex (*Figure 12*) and the DePalma classification (*Figure 13*) show the great variability of the GH-ligament, and it is important to understand the normal variations to evaluate the possible lesions.

**Figure 12:** The Buford complex is a normal variant (right shoulder from lateral view):

This is characterised by the cord-like MGHL, and absence of the anterosuperior labrum. It is found in only a few percent of the shoulders but may be mistaken for a lesion on MRI or arthroscopy (113).
Figure 13: The De Palma classification (21) of the synovial recesses (in Red) and the GH-ligaments (right shoulder):

DePalma I
Above MGHL

DePalma II
Below MGHL

DePalma III
Both above and below MGHL

DePalma IV
Absent MGHL

DePalma V
Divided small MGHL

DePalma VI
No recesses

Arthroscopic anatomical pathology
Arthroscopic findings of most common bony lesions associated with shoulder instability is usually easily visualised as an indentation in the joint surface of the Humeral head (Hill-Sachs lesion) or even a fracture of the major tubercle, and as a chip fracture of the glenoid rim (Bony Bankart lesion) on the glenoid side. Figure 15.

Figure 15:

Anteriorly dislocated shoulder, indentation by the glenoid into the humeral head

After reduction, a visible impression fracture and glenoid rim fracture.
The labrum could be damaged anywhere around the glenoid rim, resulting in a SLAP lesion (biceps tendon insertion), an Andrews lesion of the anterior superior part, or a classical Bankart/Perthes lesion in the lower anterior quadrant of the glenoid. *Figure 16.*

**Figure 16:**  
**a)** Labral lesion in the different part of the glenoid.  
**b)** To the right, the normal labrum is seen from the side, and from below (cut through red line).

In acute lesions, the insertion of the CLC can be damaged in various locations, from the articular surface, the labrum including the periosteal insertion, to the ligaments and capsule. These are categorised in different ways by the classification systems (*Figure 17*): Baker (4) is described for primary dislocations, Ideberg for glenoid fractures (44) and Adolfsson is for recurrent shoulder instability (2).

*Figure 17:* Labral lesions of the anteroinferior glenoid margin.

Arthroscopy for the acute shoulder dislocation may show acute lesions of the above-mentioned types. There has been a suggestion that the lavage of the joint at arthroscopy might reduce the recurrence rate (114), but controversy remains concerning the existence of any beneficial effects (47).
The chronic lesions in the unstable joint can be of some additional variations (Figure 18). There may be a malpositioned healing of the CLC as an ALPSA lesion. In this the labrum is healed medial to the glenoid rim. In the GLAD lesion there has been a force to the glenoid surface resulting in a labral tear and glenoid cartilage injury. There may also be a fraying or tearing of the labrum and wear of the glenoid joint’s surface at the rim. Loose bodies can also be found in chronic instability. In a few shoulders there is a sublabral hole in the anterosuperior part of the labrum that is not a lesion but a normal variation. Capsular avulsion may also occur at the humeral insertion, as in a HAGL lesion. In lax shoulders the capsular volume may be capacious and is often associated with a hypoplastic labrum and thin ligaments.

**Figure 18:** Findings at the anteroinferior glenoid margin in chronic instability.

- **ALPSA lesion**
- **GLAD lesion**
- **Glenoid / Labral wear**
- **Hypoplastic labrum**

**Johnson classification**
Described by Johnson (48) divides the labral injuries of shoulder instability into 6 different lesions by the findings at arthroscopy, mostly by the dislocations of ligament and labrum in different combinations. Johnson was a pioneer of shoulder arthroscopy, but this classification is not in common use today.

**Adolfsson classification**
1989 Adolfsson and Lysholm (2) described a classification using three groups. Figure 17.

- **A** Bankart lesion with Labrum and AIGHL separated from the Glenoid.
- **B** Capsuloligamentous injury lateral to the Labrum.
- **C** A combination of A and B.

**Baker classification**
Baker et al. 1990 (4) classified acute lesions into three groups. Figure 17.

- **1** Capsular tear without labral lesion.
- **2** Capsular tear with partial labral detachment.
- **3** Complete disruption of labrum and ligament, including Bony Bankart lesions.
1.8 TREATMENT

Conservative treatment

Posttraumatic anterior instability

Acute anterior shoulder dislocation is most often the result of a major traumatic event. After reduction most patients are treated by a non-surgical rehabilitation consisting of a short immobilisation or pain relief by a sling. This is followed by a period of rehabilitation with some restriction and muscular exercises before return to full activity. Lately, studies by Itoi has shown immobilisation in external rotation of 30°-60° for 3-4 weeks to be promising in reducing the recurrence rate after a primary dislocation (46). But in patients above the age of 30 years of age the recurrence rate is low and the immobilisation time should be short to avoid stiffness.

Atraumatic multidirectional instability

If the diagnosis of joint laxity, acquired instability or secondary impingement is suspected, a prolonged rehabilitation is recommended to strengthen the rotator cuff muscles with the arm below the shoulder plane. Muscle coordination and joint proprioception is probably important in controlling the dynamic stabilisers of the shoulder, and this is also a goal of the therapy. Muscular rehabilitation is a slow process and if possible it should be tried for at least 6 months before being evaluated and if failed it might be worth considering surgery aiming at a capsular restriction to improve the effect of and response to the rehabilitation of the muscles (67, 104).

Surgical treatment

The modern history of surgical treatment of recurrent shoulder dislocation dates to the late nineteenth century when the descriptions of the pathoanatomy served as the foundation for current surgical reconstruction. Even at that point in time, the importance of a restoration to a normal anatomy was discussed and repair of the insertion of the CLC to the glenoid margin was suggested. This was described and made popular by Bankart in his paper of 1923 (6). However, since Bankart’s technique was considered demanding and difficult to perform, it is not surprising that more than 100 different operative procedures have been described for managing open surgery of anterior instability. These are mainly divided into a few groups depending on the effect by which they protect the shoulder from instability.

First, there are non-anatomical procedures such as the Putti-Platt procedure that induce scarring and tightening of the anterior structures of the shoulder, thus limiting external rotation (72). Other non-anatomical procedures provide a bony extension of the glenoid with either a bone graft (105) or a transfer of the coracoid process (38). Some procedures even include an osteotomy of the humeral head to redirect the rotation of the joint (111).

Second, there are the so-called anatomical procedures, which are designed to reconstruct the avulsed or stretched anterior CLC (6, 67). These anatomical procedures are the ones modified for the current standard shoulder stabilisation procedures especially in arthroscopic surgery, with the use of suture anchors to facilitate the repair of the CLC insertion to the glenoid with or without a capsular shift.

To further complicate an analysis of the result of the different methods they are often combined in different ways or performed with modifications to a various extent in patients with overlap symptoms of different instability patterns.
In Sweden the Putti-Platt procedure and the Eden-Hybbinette procedure was commonly used as the standard procedures, but during the 1980s they were questioned, and suspected of producing arthropathy from the intra-articular bone graft or a decreased external rotation (31, 26). Because of this the anatomical procedures were advocated. Also the suggestion that the capsular deformation needed to be addressed by a capsular shift in those shoulders with excessive laxity was a reason for the change of open procedures. In the beginning of the 1990s, at the time of the introduction of the suture anchors, the Bankart procedure was becoming the most common procedure (35).

1.9 ASSESSMENT OF SHOULDER FUNCTION

Instability of the shoulder is often problematic to assess, as symptoms are often intermittent, and characterised less by presence of a chronic pain or everyday symptoms than by the experienced problems or fear of symptoms in relation to activities.

Shoulder instability
The stabilising mechanisms of the shoulder are tested by clinical tests of joint stability, laxity and translation. Determining the degree of instability is subjective, with both intra- and inter-rater discrepancy, and requires a great deal of experience. Often the outcome of shoulder instability treatment is judged by noting new instability episodes such as recurrent dislocations or subluxations, or by the patients’ subjective feeling of stability or apprehension of instability.

Quality of life outcomes
A variety of outcome measures have been developed to provide objective scores of either clinical results or subjective patient satisfaction and selecting an appropriate outcome instrument is important. The first widespread score for surgical outcome of shoulder instability was the Rowe score of 1978 (88). It has been modified several times by the author, and in Sweden the 1988 version has often been used (87). The Rowe score is clinician-based and not thoroughly tested but its content it is regarded as highly sensitive to instability problems. Another shoulder score that is widely used is the Constant-Murley score from 1987 (19) which is also clinician-based, but not specific to shoulder instability. It is considered to be too insensitive to normal shoulder instability without daily impairment.
The modern shoulder instability scores such as the WOSI score (52) and Oxford instability score (20) are constructed in a more methodological manner and are more sensitive to the patient’s subjective opinion about the results, they are self-evaluated by the patient and easily distributed by a mail.
2 THE STUDY

2.1 AIMS OF THE STUDY

Our general aim of the study was to evaluate the clinical outcome of shoulder instability with respect to different diagnostic possibilities and different surgical treatments. The specific aims in the different studies were:

I
This prospective study addresses the problem of classification and the results of surgical treatment (Capsular imbrication procedure) for atraumatic shoulder instability. The aim was to analyse the possibility of predicting the outcome of surgery in subgroups of atraumatic shoulder instability.

II
The purpose was to compare labral and other lesions in recurrent instability of the shoulder on MR arthrography (MRA) with conventional MRI and with the arthroscopic findings. The purpose was also to make an assessment of agreement between observers and the observer repeatability of MRA.

III
The WOSI score questionnaire is a tool designed for self-assessment of shoulder function for patients with instability problems. The aim of the study was to analyse the psychometric properties of validity, reliability and responsiveness for the Swedish translation of the score.

IV
The aim of the study was to categorise the initial MRI findings after a first time dislocation and to try to correlate these to the final outcome of stability and shoulder function according to the WOSI score.

V
The purpose of this randomised study was to compare the long-term clinical results after an anatomical repair (Bankart repair) with the results after a less anatomical but commonly used method (Putti-Platt procedure).
2.2 PATIENTS

Inclusion criteria
Shoulder instability symptoms.
Patients at Danderyd Hospital, Stockholm.
For atraumatic shoulder instability, the failure of conservative treatment.
For traumatic shoulder instability, recurrent instability or symptoms.
For treatment studies, those treated with open surgery.
For primary dislocation, MRI within 2 weeks.

Exclusion criteria
Prior surgery to the studied shoulder.
Patients that did not wish to participate in the study.
Those treated arthroscopically.
Study I, those with posttraumatic instability.
Study V, those with atraumatic instability or general joint laxity.

Patient distribution
Study I
24 patients with 27 shoulders operated for atraumatic shoulder instability during 1992 to 1995 were included in the study.

Study II
50 consecutive patients scheduled for elective surgery for shoulder instability between October of 1993 and April of 1997 participated in this prospective study. Of the 50 patients, 46 went through with the scheduled treatment and underwent open shoulder stabilisation with an initial examination by arthroscopy at the beginning of the procedure.

Study III
During the period of 1994 to 1997, 60 patients with a primary traumatic anterior shoulder dislocation were treated by closed reduction and a sling for a few days. 32 of these returned a WOSI score twice and were examined clinically at follow-up 8 years later.
A second group of 22 patients were all treated with a surgical stabilisation of the shoulder at our department during 2005 and 2006 and had a WOSI score both preoperatively and at follow-up within one year.
As a reference 45 students who reported a healthy shoulder without known instability, or other shoulder problems, completed the WOSI score in 2008.

Study IV
During the study period of 1994 to 1997 all patients identified as having primary posttraumatic shoulder dislocations, and who were examined with MRI at our radiological department, were studied. There were 60 patients examined by the MRI protocol using the hemarthrosis or effusion present in the joint (maximum 2 weeks) after a primary dislocation as a natural contrast for arthrography. They had a follow-up 8-years later and 45 of these are included in study III.

Study V
Between November of 1991 and April of 1995, 66 patients who had a history of recurrent anterior unidirectional posttraumatic shoulder instability were selected for surgery and after giving their consent, included in the randomised study.
Table 1:
During the period November 1991- November 1995, when the treatment studies were conducted, a total of 137 elective shoulders were surgically treated for shoulder instability at the Orthopaedic Department of Danderyd hospital.

<table>
<thead>
<tr>
<th>Study</th>
<th>Elective surgery</th>
<th>Acute dislocation</th>
<th>Healthy students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study I</td>
<td>27 shoulders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study II</td>
<td>50 (+ 20*)</td>
<td>22 shoulders</td>
<td>32 shoulders</td>
</tr>
<tr>
<td>Study III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study IV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study V</td>
<td>66 shoulders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 20 patients with shoulder impingement were mixed in with the instability patients to blind the radiologist at retest.

Table 2:
Some shoulders were included in 2 of the studies. 7 shoulders from study I, and 10 shoulders from study V, were also part of study II, of MRA and arthroscopic examination. The 32 shoulders in study III (group A) were also included in study IV.

<table>
<thead>
<tr>
<th></th>
<th>Posttraumatic instability</th>
<th>Atraumatic instability</th>
<th>Acute dislocation</th>
<th>Other shoulders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study II</td>
<td>32</td>
<td>18</td>
<td>60</td>
<td>20*</td>
</tr>
<tr>
<td>Study IV</td>
<td>10</td>
<td>7</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Study III</td>
<td></td>
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<tr>
<td>Study I</td>
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<td>27</td>
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<td>67</td>
</tr>
<tr>
<td>Study V</td>
<td></td>
<td>66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 20 patients with shoulder impingement were mixed in with the instability patients to blind the radiologist at retest.
2.3 MATERIAL

Study I
The 24 patients (27 shoulders) from Study I were categorised as having atraumatic shoulder instability with a traumatic component that was very small or non-existent. With a mono-articular or generalised laxity it was classified in the AMBRI or AIOS group. Almost 80% of the patients were first assigned to a rehabilitation program for the deltoid, the rotator muscles and the scapula stabilisers for at least 6 months. After this failed they were treated at our department with the Rockwood technique (116) of imbrication.

Study II
Patients in study II were examined with radiography (AP and lateral view), conventional MRI (n=50) and MR arthrography (n=48). One patient declined MRA and in one case there was insufficient time to perform both examinations. Of the 50 patients, 46 went through with the scheduled treatment and underwent surgery with an initial examination by arthroscopy at the beginning of the procedure. Of the 50 patients with unstable shoulders 32 patients had posttraumatic anterior instability, while 18 patients had atraumatic multidirectional instability (of these 2 had mainly posterior instability).
A re-examination of the MRA was performed for testing the agreement between observers and the observer repeatability. To blind the radiologists to the diagnosis the 48 sets of MRA images of instability patients were mixed with 20 additional sets of MRA images of impingement patients. These 20 additional examinations were performed with the same radiological protocol. The patients were scheduled for an arthroscopic procedure and had no previous history of instability. Fifteen of these patients later underwent surgery by an acromioplasty.

Study III
In study III three different patient materials were used for the assessment of the score.
Group A consisted of 32 patients with a primary posttraumatic shoulder dislocation treated by closed reduction. More than 8 years later the patients were contacted by mail and asked to complete a questionnaire including a self-evaluating shoulder instability quality of life score (WOSI) and were also asked to participate in a clinical examination. Thirty-two patients returned the WOSI-score on 2 occasions within 2 months, and also underwent a clinical examination with a Rowe score (87).
Group B included 22 patients. They had all been treated with a surgical stabilisation of the shoulder at our department. They completed the WOSI score and EQ-5D (a global health measure consisting of 5 items) (14) preoperatively and by mail 6 months postoperatively. Postoperatively the patients were also asked to grade their satisfaction with the treatment in categories, as well as their perception of their general shoulder function and their own perception of the effect of the treatment on VAS scales.
In Group C there were 45 students who reported a healthy shoulder without known instability or other shoulder problems who completed the WOSI score.

Study IV
During the study period, which stretched from 1994 to 1997, all patients identified as having primary posttraumatic shoulder dislocations and who were examined with MRI at our radiological department were studied. They were already treated by closed reduction and had radiographs immediately after reduction and were then informed of the study and asked to participate. There were 60 patients examined by the MRI protocol using the hemarthrosis or effusion present in the joint (maximum 2 weeks) after a primary dislocation as a natural contrast.
for arthrography. The reasons for primary stabilisation were large bony Bankart lesions in 2 shoulders and a substantial Bankart lesion requested a primary stabilisation in 6 patients. All conservatively treated patients (n=43) received a sling for a few days and were instructed on muscular rehabilitation.

More than 8 years later (median 105 months) we performed a follow-up of these 53 patients. All patients were contacted by mail and asked to complete a questionnaire and a self-evaluating shoulder instability quality of life score (WOSI) (52) in a validated Swedish translation (91) and were also asked to participate in a clinical examination of their shoulder including stability test, which allowed for assessment according to the Rowe score of 1988 (87).

One radiologist and one orthopaedic surgeon in consensus reviewed the initial MRI examination and radiographs by following a protocol were the labrum, the glenoid, the humeral head and the glenohumeral ligaments were evaluated. We also measured the glenoid version, the size of the Hill-Sachs lesion and the width of the rotator interval.

Study V
Between November 1991 and April 1995, 66 patients who had a history of recurrent anterior unidirectional posttraumatic shoulder instability and were selected for surgery and were after consent, included in the randomised study. Randomisation was performed by opening the next in a series of consecutively numbered sealed envelopes on admission the day before surgery. Each envelope contained information as to which procedure was to be performed. These were either a modified Putti-Platt procedure (P group, n=33) (98, 99) or a Bankart repair combined with Capsular imbrication (B group, n=33) (83, 116). For the Bankart repair Mitek GI/GII anchors were used and the surgical procedure was performed by 1 of 3 shoulder surgeons.

2.4 METHODS

Patient examination
An interview concerning history, including a subjective rating of shoulder functioning at work and during sports activities, was carried out before surgery in study I and V and at follow-up. General joint laxity was considered to be present if three of four criteria were found (hyperextension of the first carpometacarpal and the other metacarpophalangeal joints, the elbow or the knee) (16).

For each patient the range of motion both shoulders was measured pre- and postoperatively with a goniometer in study I and study V and at follow-up in study IV. An independent physiotherapist assessed both active and passive ROM concerning flexion and abduction as well as external and internal rotation. Muscle strength in abduction and internal rotation was measured with an Isobex (Figure 19) in study I and in study V. In study IV the strength was measured in elevation, external and internal rotation with a Macmesin myometer. Figure 19.
Surgical technique

Study I

Capsular imbrication procedure. Figure 20.
The technique described by Rockwood was used (116). As these patients had lax shoulders, we aimed to reduce the capsular volume as much as possible on the basis of an individual judgement for each patient. In this way we tightened the capsule rather more than the original description recommends.

Figure 20: Anterior capsular imbrication by Rockwood was used (116).

Study V

The Bankart procedure. Figure 21.
The Bankart repair and capsular imbrication was performed as described by Rockwood (83, 116) combined with Mitek suture-anchors.

The Putti-Platt procedure. Figure 21.
Putti and Platt developed this procedure independently of one another in the early 1920’s. It was not until 1948 that the procedure was named Putti-Platt when described by Osmond-Clarke in
In this study the modified technique for Putti-Platt described by Symenoides (99) was used.

**Figure 21:** Bankart procedure with suture anchors  
Modified Putti-Platt procedure

In all the patients the postoperative immobilization period was 4 weeks in a shoulder brace, followed by a restricted rehabilitation program for a further 8 weeks, and a return to contact sport 6 months after surgery at the earliest.

**MRI and MRA technique**

**Study II**

Following a standardised protocol for the MRA examinations of the shoulders both conventional MRI and MRA were performed on the same occasion. In 2 of the 50 patients it was not possible to obtain MRA examinations.

The MRI was performed in a 0.5 Tesla scanner (Vectra II/Signa contour General Electric Medical Systems) using a dedicated, receive only, surface coil. Identical imaging protocols were performed before and after intra-articular injection (Figure 22) of 15-20 ml of diluted gadolinium (Gd-DTPA, Magnevist, Schering). The injection was given under fluoroscopic guidance and with initial confirmation of the position of the needle was made using iodinated contrast medium. The protocol included sagittal oblique and coronal oblique proton density, T2 weighted spin echo images, axial T2 and T1 weighted images with 4 mm slice thickness and arthrographic effect in all sequences.

**Figure 22:** The same shoulder before and after injection of contrast (Gadolinium).

The two examinations were then separately analysed and interpreted by two experienced MRA radiologists, working independently, and following a specific protocol in which a plain
radiography examination was added to the conventional MRI examination, but not to the MRA examination. This was done to evaluate MRA as a stand-alone examination. These primary examinations were randomised between the two observers to analyse either the conventional MRI images with additional plain radiographs, or the MRA images alone. Thus 24 MRA examinations and 25 conventional MRI examinations, together with radiographs, were examined by each observer.

The MRA findings were categorised as either positive or negative for the presence of a labral lesion, glenoid lesion and impression fractures of the humeral head.

**Study IV**

The MRI was performed with a 0.5 Tesla scanner (Vectra II/Signa contour General Electric Medical Systems) using a dedicated, receive only, surface coil. The protocol included sagittal oblique and coronal oblique proton density, T2 weighted spin echo images, axial T2 and T1 weighted images with 4 mm slice thickness.

Measurements of the size of the Hill-Sachs lesion were done on a transaxial slice at the place of the largest extent in the upper half of the humeral head. Figure 23. The depth was measured in mm similar to the technique used by Ito, as well as Kralinger (45, 58). Figure 24.

**Figure 23**: Region of transaxial cut  
**Figure 24**: Hill-Sachs depth measurement

The version of the glenoid was calculated on a transaxial slice as the angel of a line over the anterior and posterior border of the glenoid compared to the line 90° to the axis of the scapula as by Nyffeler (70). Retroversion was measured as a negative number and anteversion as a positive number. Figure 25.

The rotator interval was measured in a sagittal slice through the tip of the coracoid process and the ac-joint similar to the measurement described by Kim (50). The distance between the border of the subscapularis tendon and the subscapularis tendon was measured in mm. Figure 26.

**Figure 25**: Measurement of glenoid version  
**Figure 26**: Rotator interval distance
**Arthroscopic technique**

**Study III**
The same protocol as for MRA was then used for categorising the findings at arthroscopy in study III using the standard posterior and anterior portals. These arthroscopic examinations were performed by two of three shoulder surgeons pairwise, without prior knowledge of the imaging findings. Before ending the arthroscopy procedure the protocol was completed and the sealed envelopes containing the results from the conventional MRI and the MRA examination were then opened and compared. If necessary a second view was performed before the end of the arthroscopic examination to check diverging findings, and these were noted separately. Open surgery was then performed as planned preoperatively and in no case did the result of the arthroscopy or MRA thus cause a change in that plan.

**Shoulder function assessment**

**Study I**
The VAS score for pain and the Rowe score were used. Postoperatively the Constant and ASES scores were also assigned (89) (81). The Rowe shoulder score was assessed for all patients by the same surgeon (BS).

**Study III-V**
The WOSI score and the Rowe score were used. The WOSI score instrument (52) consists of 21 items, asking the patient to grade the function of a specific item on a horizontal visual analogue scale from 0 to 100 mm. The questions are divided in 4 sections (domains). There are 10 questions addressing physical symptom and pain. Sport, recreation, and work are addressed by 4 questions. There is a domain with 4 questions dealing with lifestyle and social functioning and another domain for emotional well being with 3 questions. Each question results in a figure between 0-100 and the total score may be presented as a figure between 0-2100 points (0=no deficit, 2100=worst). The score could also be presented as a 0-100 percent of a normal healthy shoulder which might be more clinically useful.

We had made a translation and cross-culture adaptation of WOSI to Swedish according to the guidelines presented by Guillemin (28). These guidelines include several steps: Translation from the original score to the new language by two independent translators (step I). Then a consensus of the translations is made (step II) and to check for discrepancies this consensus is translated back into the original language (step III). Then again in consensus a final version is produced (step IV) and this is tested by selected users on patients looking for practical problems or possible misunderstandings (step V) that could be necessary to adjust for.

*The Swedish WOSI score and the 1988 Rowe score are presented in the Appendix.*
2.5 STATISTICAL METHODS

Study I
The Chi-square and paired t-tests were used and a p<0.05 was considered significant.

Study II
Statistical analysis of agreement was made using Cohen's kappa, and was considered as poor if \(k \leq 0.20\), fair if \(0.20 < k \leq 0.40\), moderate if \(0.40 < k \leq 0.60\), substantial if \(0.60 < k \leq 0.80\) and good if \(k > 0.80\). The advantage of the kappa is that it is adjusted for the amount of agreement that can be expected to occur by chance alone. The expected frequencies for cells are added up and divided by the total number of observations to give the proportion of agreement. It is noteworthy that kappa is dependent both on the number of categories (value is greater if there are fewer categories) as well as on the proportion of subjects in each category. Kappa = 1 implies perfect agreement, and kappa = 0 suggests that the agreement is no better than chance alone, whereas a negative value is considered worse than chance. The major disadvantage of kappa is that there are no objective criteria for judging intermediate values but kappa is often judged as a poor, fair, moderate, good, or substantial agreement as described earlier. Analyses of reliability for the diagnostic methods by sensitivity and specificity were performed. Using the Chi-square and the ANOVA t-test a p<0.05 was considered significant.

Study III
When assessing scores the methods were chosen for comparison with the original score (52), and the methods used were Pearson’s (product-moment) correlation coefficient, the Intraclass Correlation Coefficient (ICC), Chronbach’s alpha, effect size, SRM (standardized response mean), and descriptions of floor and ceiling effects.

Study IV
The results were analysed by ANOVA t-test for the findings on MRI compared to the WOSI score and by Chi-square to the stability at follow-up. The level of significance was set at p<0.05. Analysis by logistic regression was made for prediction of stability and WOSI score at follow-up.

Study V
The Students’ t-test was used for testing between groups at a 5% level of significance. Chi-square and the Kruskal-Wallis test were used for non-parametric data. Power analysis of the possibility to detect a difference between the two surgical methods concerning recurrent instability or for detection of late postoperative osteoarthritis was made before the study began. It was found that a minimum of 80 patients were required in each group to have a 80% chance of detecting a difference of 15% (5% versus 20% for the two groups for both recurrence rate and the incidence of late postoperative osteoarthritis) at the 5% level of significance using the Chi-squared test. We could not hope to recruit that number of patients and therefore it was not a main aim of the study to examine data related to recurrence rate or dislocation arthropathy.

A valid and reliable instrument must be able to measure what it is supposed to evaluate, and in the same way if given twice, as well as to reflect relevant changes as the patient gets worse or improves. This is why the instrument is judged by its validity, reliability and responsiveness in the methodology.
Figure 27: Methodology of validating a score.
From AO handbook: What makes a quality outcomes instrument (97).

**Methodology**

**Validity**

- **Construct validity**
  *Quantitative form of Assessing instrument Validity.*

- **Divergent**
  *Two instruments although similar do not correlate highly if the measure different concepts.*

- **Convergent**
  *Two instruments have a high correlation with each other.*

- **Content validity**
  *An instrument’s comprehensiveness, or how adequate the instrument reflects.*

- **Face validity**
  *Inferred from a panel of experts who evaluate the relevance of the content.*

- **Criterion validity**
  *Correlation with a “gold standard” measure of the same theme.*

- **Predictive validity**
  *Ability to predict a future state of affairs.*

- **Concurrent validity**
  *Ability to accurately predict the status compared to another existing test.*

**Reliability**

- **Internal consistency**
  *How consistent are the questions in measuring the same outcome?*

- **Reproducibility**
  *How close are the results of an instrument from two different occasions?*

- **Test-retest**
  *How closely does the observers agree using the same instrument on the same patient?*

**Responsiveness**

- **Ability of the instrument to change as the status of the patient changes.*
2.6 ETHICS

The studies received Ethics Committee approval.

Study I
Ethics Committee Stockholm (2005/422)

Study II
Ethics Committee Karolinska Sjukhuset, Stockholm (nr 94-303)

Study III
Ethics Committee Stockholm (2003-557 and 2006/54-31/2)

Study IV
Ethics Committee Stockholm (2003-557)

Study V
Ethics Committee Karolinska Sjukhuset, Stockholm (nr 92:210)
3 SUMMARY OF PAPERS

Paper I
Atraumatic shoulder instability. Discussion of classification and results after capsular imbrication.
Salomonsson B, Sforza G, Révay S, Abbaszadegan H, Jonsson U.

Objective: The group of patients with atraumatic and multidirectional shoulder instability is usually considered to be more of a challenge to treat surgically (than that with posttraumatic unidirectional instability), but studies of surgery on these patients show promising results. This prospective study addresses the problem of classification and the results of surgical treatment and analyzes the possibility of predicting the outcome of surgery in subgroups of atraumatic shoulder instability.

Material and Methods: For the 24 patients studied the traumatic component was very small or non-existent and with a mono- or multi-articular laxity it was classified in the AMBRI or AIOS group. After the failure of at least 6 months of conservative treatment these patients underwent a surgical imbrication procedure of capsular shift. 27 shoulders in the 24 patients whose atraumatic shoulder instability was treated with the imbrication procedure described by Rockwood, was followed up after 2 years or more.

Results: After surgery voluntary instability was still present in 4 patients (2 had redislocations and 2 subluxations); 2 of these had bilateral involvement but only one of these patients was operated in both shoulders. No other patient had had a redislocation but 5 patients had debilitating pain. Clinical signs of joint laxity had decreased after surgery. Rowe score showed 67% excellent or good, 15% fair and 18% poor. No significant differences in dominance, shoulder demands or intensity of participation were observed when sports activities were resumed. Those with voluntary instability were more lax at follow-up and also had a tendency to have poorer results. Otherwise we found no reliable preoperative prediction of the patients with poorer results. The difficulties of classifying shoulder instability by such factors as trauma, laxity and direction of instability are discussed.

Paper II
MRA, MR and Arthroscopy in shoulder instability. Agreement between methods and observers.
Salomonsson B, von Heine A, Dahlborn M. Lillkrona U, Nils Dalén, Abbaszadegan H.
Submitted

Objective: To compare detection of labral lesions in recurrent instability of the shoulder on MR arthrography imaging (MRA), conventional MRI and subsequently compare these against the arthroscopic findings. The purpose was also to make an assessment of agreement between observers and observer repeatability for MR arthrography. The hypothesis of this study was that MRA would be superior to conventional MRI combined with plain radiographs and that it could be equal to arthroscopy for diagnostic purposes as a stand-alone examination.
Material and Methods: The prospective study comprised 50 patients with symptomatic shoulder joint instability (MR in 50 patients and MRA in 48). 46 of 50 shoulders were examined using arthroscopy prior to surgery. The MRA images were independently re-evaluated more than 6 years later.

Results: MRA compared with arthroscopy showed moderate agreement for the presence of labral lesions (k=0.54) and fair agreement of glenoid wear or lesions (k=0.28) as well as for impression fractures in the humeral head (k=0.39). The agreement between observers was moderate for both the labrum (k=0.48) and Hill-Sachs lesions (k=0.45) and for the glenoid it was substantial (k=0.61). Repeatability among observers of MRA was moderate for labral lesions (k=0.56) and Hill-Sachs lesions (k=0.57), while for the glenoid it was substantial (k=0.72).

Paper III
Western Ontario Shoulder Instability Index (WOSI): Validity, reliability and responsiveness retested in a Swedish translation.
Salomonsson B, Ahlström S, Dalén N. Lillkrona U.
In press Acta Orthopaedica 2009; 80 (2): 233-238

Objective: The WOSI score questionnaire is a tool designed for self-assessment of shoulder function for patients with instability problems. We made a translation into Swedish and retested the score by analyzing the psychometric properties of validity, reliability and responsiveness.

Material and Methods: 3 patient materials were used for the assessment.
Group A: A follow-up on a group of 32 patients more than 8 years after having primary posttraumatic shoulder dislocation. Evaluation of Pearson’s correlation coefficient between WOSI and Rowe score and for test-retest reliability was made. Group B: 22 patients treated with a surgical stabilization of the shoulder at our department were evaluated with Pearson’s correlation coefficient between WOSI and EQ-5D and WOSI, and VAS-scale of shoulder function. Also Chronbach’s alpha, effect size and floor, and ceiling effects were analyzed. Group C: 45 students fulfilled the WOSI score as a reference to a population with healthy shoulders.

Results: The construct validity (Pearson’s correlation coefficient) was adequate (0.59) between the WOSI score and the Rowe score. The agreement with an ICC value (test-retest) for the WOSI score was excellent (0.94). Chronbach’s alpha (internal consistency) was satisfactory with 0.89 preoperatively and 0.95 postoperatively. All 22 patients (group B) reported improvement in the WOSI score (mean 29%). Responsiveness was excellent with an effect size of 1.67 for the WOSI score. There were no floor or ceiling effects for the Swedish WOSI score. The WOSI score from group C with 45 normal healthy shoulders was as a mean 96%, with no floor but high ceiling effects.

Paper IV
Bony Bankart at MRI of primary shoulder dislocation only finding of predictive value: an 8-year follow-up.
Salomonsson B, von Heine A, Dahlborn M. Abbazadeh H, Ahlström S. Dalén N. Lillkrona U.
Submitted
**Objective:** It would be of great advantage if it were possible to categorise the patients with first time dislocations to the initial treatment with the most beneficial outcome. MRI could be a way to find prognostic lesions after shoulder dislocation.

**Material and Methods:** 60 patients with primary posttraumatic shoulder dislocation were treated by closed reduction and were examined by MRI after maximum 2 weeks. We used the hemarthrosis or effusion present in the joint after the primary dislocation as a contrast for arthrography and we identified the lesions present on MRI. At follow-up more than 8 years later, the MRI findings were compared to the shoulder function, shoulder stability, Rowe score and Western Ontario Shoulder instability Index (WOSI).

**Results:** The factors analysed showed that an age above 30, and on MRI, an isolated fracture of the major tubercle, and also a Bony Bankart lesion were all prognostic factors for a good functional outcome.

**Paper V**

The Bankart repair versus the Putti-Platt procedure; a randomized study with WOSI score at 10-year follow-up in 62 patients.
Salomonsson B, Abbaszadegan H, Revay S, Lillkrona U.
In press Acta Orthopaedica 2009; 80 (3):

**Objective:** This randomized study compares clinical results after surgery with either an anatomical repair or an older less anatomical but commonly used method. The less anatomical procedure has been considered quicker and less demanding, but questioned regarding the clinical result. Therefore we wanted to study the clinical outcome comparing the two different procedures. The hypothesis was that the anatomical repair would give less residual impairment postoperatively.

**Material and Methods:** Patients with anterior posttraumatic shoulder instability were consecutively randomized the day before surgery to either a Bankart repair using Mitek GI/GII anchors combined with capsular imbrication (B) (n=33) or a Putti-Platt procedure (P) (n=33).

Follow-up was performed by examination at 2 years and by a self-evaluating WOSI score at 10 years.

**Results:** At the 2-year follow-up no difference in muscle strength between patients treated with the two surgical methods was found and there were no statistically significant differences in the Rowe scores (mean 90 units for both groups). Compared to preoperatively, the decrease in external rotation 2 years after surgery was 10 degrees in the P group and 3 degrees in the B group (p=0.025).

10 years after surgery 62 of 66 replied to a questionnaire sent by mail. It included a self-evaluating quality of life score for shoulder instability (WOSI) for evaluation of their shoulder function. In the P group 15, and in the B group, 19 patients reported they had experienced either a redislocation or a subluxation with a new feeling of shoulder instability. Mean WOSI score was similar in the P and B groups, 80% versus 83%. The WOSI score was 87% for patients with stable shoulders (n=28) and 77% for those with unstable shoulders (n=34) (p=0.005).
4 DISCUSSION

4.1 DISCUSSION ON THE MATERIAL

Categorisation of patients’ shoulder instability into different diagnostic groups is crucial. The development of the classification systems during the last few decades has clarified some of the differences between traumatic and atraumatic shoulder instability, but the intermediate positions often remain difficult to judge using only the above-mentioned entities. During the enrolment of patients into treatments (for studies I and V), we performed 120 surgeries for instability. About 2/3 of these cases were posttraumatic, and 1/4 were atraumatic in origin. This is not the relation usually described in the literature (ref). Lately, intermediate groups with acquired instability (17) as well as muscle patterning problems (60) have been described. The patients in the present studies were, with a few exceptions, consecutive, and this can thus be regarded as a representative material from our department during these years.

4.2 DISCUSSION ON THE METHODS

Surgical technique
The surgical procedures were performed by three different shoulder surgeons, usually by two of them in cooperation. Mitek GI/GII suture anchors were used to perform Bankart repairs, and there were no known cases of anchors not being properly seated in the glenoid when the suture was tied. In preparation for study V, a visit to Dr Rockwood was undertaken to learn the surgical technique of capsular imbrication, which was to be used together with the Bankart suture, and for capsular reduction in atraumatic instability in study I. The modified Putti-Platt procedure was already in use at our department.

MRI and MRA technique
MRI scans were performed in a 0.5 Tesla scanner (Vectra II/Signa contour General Electric Medical Systems) using a dedicated, receive-only, surface coil. This is now considered to be an outdated MR technique, but study II still highlights the importance of a well established classification that is applicable for both surgeon and radiologist.
A detailed classification is often difficult to achieve in chronic instability, as shown by Waldt (107), and the arthroscopic classifications of instability-related lesions are not ideal for the non-dynamic MRI examinations. On the other hand the MRI gives a depiction of rotator cuff tears and damage to extra-articular soft tissues that cannot be visualised by means of arthroscopy.

Arthroscopical technique
Arthroscopic examination of the unstable glenohumeral joint requires a proper understanding of the normal anatomy and knowledge of the structures and lesions that influence the control of the glenohumeral stability. This is, therefore, an examiner-dependent evaluation of the shoulder, and even though it is very useful it cannot always be considered a “gold standard” to be compared to imaging modalities such as MRI, that can be evaluated several times and by
different examiners if required. To the experienced shoulder surgeon, however, it is sometimes crucial for deciding how to perform the surgery in cases with mixed or less well-defined diagnoses. Especially in subluxations and occult instability, the dynamic possibilities of the examination can be of use in deciding on the treatment. In study II, the arthroscopy was considered the gold standard for intra-articular lesions, but it could not compare to MRI for evaluation of extra-articular cases.

**Postoperative rehabilitation**
Rehabilitation after surgery of the shoulder is as important as the surgery, and the patient can usually start with the program before surgery. In atraumatic shoulder instability and secondary impingement the treatment should begin with the rehabilitation program, and surgery only be performed if rehabilitation fails. In these patients, the surgery is broadly intended to temporarily enhance the effect of the rehabilitation program, since the postoperative restriction of the ROM often returns to normal levels within two years. In the present studies, we have used the same postoperative rehabilitation guidelines for all patients. These are not particularly unrestricted, consisting of 4 weeks immobilisation in a shoulder brace before active exercises were continued. Return to sports or heavy manual work was allowed at 12 weeks postoperatively if strength, muscular control and ROM were sufficiently restored (with some restriction in external rotation anticipated). If uncontrolled trauma was expected, as in contact sports for example, this was allowed at 6 months at the earliest. The rehabilitation was supervised by the physiotherapists at our department, and was customised depending on the individual’s progress postoperatively.

4.3 **DISCUSSION ON THE RESULTS**

**Study I**
The present study revealed no differences in the outcome of surgery when the different factors were analysed separately and in combinations, except for cases of voluntary instability. In these patients we found a higher frequency of residual postoperative joint laxity compared to those with involuntary instability. We also found no difference in outcome between the AMBRI and AIOS groups.
At surgery, the degree of anteroinferior capsular laxity determines the extent of the cut in the capsule as well as the amount of imbrication necessary to reduce the volume of the joint. It is recommended that sutures are tied with the arm at 20 to 25 degrees of external rotation and 20 to 30 degrees of abduction, to control the final range of external rotation (116). The mean value of endpoint of external rotation during surgery was 17 degrees. This means that we had a somewhat tighter capsular imbrication in this atraumatic group. No patient complained of decreased range of motion. We found no correlation between external rotation at surgery and range of motion at follow-up. In our experience shoulders with excessive laxity can even be tied at 0 degrees of external rotation without residual stiffness.
Pape et al used the same surgical procedure for multidirectional instability and in 1995 (74) they regarded their success rate as adequate with a recurrence rate of 12%. The results of the present study are comparable, as 74% of the patients were satisfied and 85% considered their shoulder function to have been improved by surgery. We are of the opinion that the results justify the use
of the capsular imbrication method for atraumatic shoulder dislocation in cases where physical rehabilitation and lifestyle adjustment have failed.

**Study II**

In order to compare favourably with arthroscopy, MR imaging must show the complete Capsulolabral complex (CLC). MR arthrography clearly does this in a better way than conventional MRI, and it has the potential to become a comprehensive, diagnostic tool of choice for radiological examination of the shoulder.

Arthroscopy was considered the best available method for diagnosis of intra-articular lesions. When comparing the findings of impression fractures in the humeral head (Hill-Sachs lesions) the agreement was good in 32 cases, but in 14 cases the findings of lesions at arthroscopy did not correlate to MR arthrography. A bare area with irregular edges could be interpreted as a shallow impression at arthroscopy, but it is not noted on MRA if there is no recent dislocation with a subsequent subcortical oedema visible on T2-weighted sequences. On the other hand, a bruising of the bare area from a relatively recent dislocation could produce an oedema in the bone visible on MRA. This more intense signal could be interpreted as an impression that is not visible at arthroscopy. In a study by Workman et al. 1992 (117) comparing MR imaging, radiology and arthroscopy only 12 of 30 Hill-Sachs lesions in 76 patients were identified using all three techniques. Workman found that MR imaging was the most likely to be correct, and MR imaging seems to be the most useful tool to diagnose a Hill-Sachs lesion in shoulder instability.

In accordance with other studies of MRA in shoulders (82, 5, 62, 53), the agreement between MR arthrography and arthroscopy, as well as inter- and intra-observer agreement can be judged as moderate in this study.

MRA can be a useful diagnostic tool and may be used to identify certain types of lesions that cannot be seen at arthroscopy. This study emphasises the need for good cooperation and communication between the surgeon and radiologist. The possibility of classifying and categorising lesions for preoperative planning is limited, however, as is also reported by Green (27). The overall agreement among observers interpreting MRA is acceptable and there is good agreement concerning the detection, but not the classification, of capsulolabral lesions. We found it reliable enough to be a stand-alone examination as a substitute for arthroscopy in shoulder instability.

**Study III**

This first psychometric assessment of a translated WOSI score shows that it is a valid, reliable and sensitive instrument for assessment of groups of patients, and in some aspects also for individual patients with shoulder problems associated with instability.

The Swedish WOSI score had acceptable criterion validity as it correlated well with the Rowe score. It is interesting to note that Pearson’s correlation coefficient with the Rowe score, 0.59, is very close to the 0.61 correlation presented by Kirkley for the original English version of the score (52). The correlation with the subjective VAS shoulder function was higher than that with the Rowe score. This could be because a large proportion of the Rowe score is attributed to frank instability and range of motion, which minimises the effect of many other symptoms that can be relevant for the patient’s subjective evaluation of their function. As expected, EQ-5D, a global health measure, has a low correlation to the disease-specific WOSI.

The test-retest reliability of the WOSI was high, with ICC values for the different items between 0.75 and 0.97. As an ICC value of 0.9 is considered acceptable for reliable decision making even for individual patients (11), the WOSI score can be used for that, as well as for the
separate domains apart from “Sport, recreation and work”. The finding that the ICC is 0.94 for the Swedish WOSI score compares well with the ICC of 0.95 in the original paper. This indicates that the translation did not dramatically change the properties of the score.

All 22 patients reported improvement in the WOSI score and this is in agreement with the large effect size of 1.67 for the WOSI score. The standardised response mean was 1.40 and this is higher than the 0.93 given in the original presentation by Kirkley (52). This difference in SRM is not explained, but it could be due to different and small patient materials and different treatments.

As expected the mean and median values were very high for reference group C with very high ceiling effects in all items. Some questions can still be raised concerning the suboptimal score value among students without shoulder problems. It must be remembered that several items refer to symptoms that are not entirely shoulder-related, but may still be relevant and sensitive for a patient with a shoulder instability history. For example, questions 5, 6, and 7 relate to clicking, stiffness, and symptoms from neck muscles that are not necessarily related to shoulder disorders or impaired function. The fact that the value of the score is not 100% among all individuals with healthy shoulders supports the idea the score is sensitive also for patients with modest symptoms.

**Study IV**
We could not find any prognostic factors for future stability after a first dislocation other than the age of the patient and the presence of bony lesions on MRI. MRI findings of a tuberculum major fracture or a Bony Bankart lesion are also predictive of the functional outcome in the WOSI score. Vermeiren (112) also found that a concomitant fracture was prognostic for good stability. The small glenoid rim fractures would be classified as Baker III in the Baker arthroscopic classification of a Bankart lesion (4) or an Ideberg type 1A (44) from the radiographic classification. But that does not give any information on the status of the capsulolabral complex. Other studies of acute lesions have not found any prognostic value from the glenoid rim fracture (37, 101, 102), but have confirmed the good outcomes in terms of stability after a fracture of the major tubercle. Even though fractures are more common in the older age group, it was not only the age that was prognostic in the present study. The fracture itself was prognostic in a regression analysis. The observed stability could have been the result of a more restricted range of motion after a fracture, but we found no such difference between patients with or without a Bony Bankart lesions. The healing of a fracture by bony healing could be the reason for the more favourable results in these small rim fractures, since we already selected and treated, and thereby excluded, the patients with large Bony Bankart lesions and primary recurrent subluxations with a treatment involving primary stabilisation.

In this study we find that in primary shoulder dislocation a patient age above 30 years, as well as the presence of a bony lesion, is a prognostic factor for stability and a better functional outcome by the self-evaluating WOSI score. MRI was useful in the assessment of acute shoulder dislocations as it was more sensitive than plain radiography in detecting the small glenoid rim fractures.

**Study V**
After shoulder stabilisation there are, in addition to dislocation or subluxation, several other symptoms that may affect the patient’s well being. At the 2-year follow-up, the Putti-Platt group
had more shoulder pain and a greater restriction in external rotation than the Bankart repair group. The decrease in external rotation after Putti-Platt procedure was smaller in our series than has been reported in other studies (55, 73). This could have been caused by the technical modification that we used. This modified procedure, in which the lateral stump of subscapularis tendon is not sutured to the tighter labral structures at the glenoid margin, but only overlapped and attached to the capsule in such a way that the Bankart lesion is not repaired, has been described by several surgeons (13, 98, 59). The Putti-Platt procedure has been criticized because of a risk of decreased range of motion and has not been recommended for young patients or for patients with high demands on shoulder function (80, 22). Several studies on the Putti-Platt technique have reported recurrence rates of 20% or higher (42, 109, 22, 57). Pap et al. (73) presented a 36% recurrence rate at 7-year follow-up. It is interesting to note that in a study by Kiss et al. (55), the recurrence rate after 9 years was only 9%, but there was also a 24 degree reduction in external rotation, and as many as one third of the patients had problems with pain.

The Bankart repair has been considered a demanding procedure (1, 69, 49), but there have been many reports of good results (88, 42). Suture-anchors have been developed, and this has made the method less technically demanding (69, 49). Many surgeons combine a Bankart repair with a capsular shift to reduce the amount of capsular tissue and restore the anatomy (88, 78, 83, 69, 49).

The reported recurrence rates following Bankart repair varies. Rowe et al. (88) had a recurrence rate of 3% at 6 years after surgery. Hovelius et al. (42) presented a 7-year follow-up with only 2% recurrences. In a retrospective study of the Putti-Platt procedure compared to a classic Bankart suture Varmarken and Jensen (109) found a redislocation rate of 13% in the Bankart group compared to 22% in the Putti-Platt group at the 4-year follow-up. Many recent reports show higher recurrence rates. After having used suture anchors for Bankart repair in open surgery failure rates of 17 to 30% have been reported, (64). Other studies describe redislocation rates after open suture anchor repair between 5 and 10% (69, 49).

4.4 STRENGTHS AND LIMITATIONS

Study I
The group of patients studied is small and that is a weakness to the study. The manoeuvres for testing the ROM and direction of instability are all examiner-related. To reduce these problems, and to increase the validity of the results, the examinations at follow-up were performed by a team consisting of one independent physiotherapist and two surgeons. It is a strength of the study that the patients were thoroughly examined and categorised preoperatively.

Study II
One disadvantage of this type of study is that the radiological examination is observer-dependent. Other disadvantages are the lack of a standard reference and the fact that diagnosis by arthroscopy is also dependent on the observer. It can be questioned whether the results of arthroscopic examination should always be the standard of reference. The diagnostic utility is limited in the old low-field Tesla MRI system used in the study, and utility is possibly enhanced
in both conventional MRI and MRA with the use of a high-field Tesla MRI system (62), but this has not been tested in this study.

**Study III**
The limitation of our study is that there is heterogeneity among the patients. Although they have all had instability problems, they consist of 2 small study groups.

**Study IV**
A weakness of our study is that we intended to perform a new MR-arthrography at the follow-up, but never managed to recruit enough of the stable shoulders for analysis. Among the strengths of our study are the long follow-up time and the fact that there was an MRI examination at the primary dislocation.

**Study V**
A weakness of our study is that it does not include radiographs at the 10-year follow-up. The strengths of our study include its random selection between two frequently used methods in a selected and well defined patient group with traumatic anterior recurrent dislocations of the shoulder, the fact that the outcome was measured by a self evaluation score, that the subluxations are included as recurrences of instability, and that we have a high follow-up-rate after 10 years.

## 4.5 GENERAL DISCUSSION

Regarding shoulder instability, careful consideration is required to combine trauma, laxity and direction of instability into a classification, to be able to foresee what to expect during surgery and to identify the atraumatic patients among the true posttraumatic cases. For example, if a patient describes a trauma, further questioning could be crucial to the choice between open or arthroscopic surgery. A trauma affecting a lax shoulder joint could be a major one, and lead to a typical posttraumatic dislocation in a predisposed shoulder. In other cases, the trauma could be minor, but strong enough to overcome the resistance of the joint and the neuromuscular balance. For the atraumatic instability patients it is recommended to start a conservative rehabilitation program of at least 6 months for the deltoid, the rotator muscles and the scapula stabilizers. Not every patient can follow the conservative rehabilitation program. Sometimes the reason for this is excessive pain, and sometimes it is the time needed for rehabilitation. In these patients, immediate surgery could be the best way to reach a better situation to begin rehabilitation, which is just as necessary in the postoperative period.

In study I, the surgically treated patients reached almost the same external rotation 2 years postoperatively as they had preoperatively, although a substantial decrease was measured at operation after wound closure. This led us to believe that the result with a better stability at follow-up, despite the connective tissue healing in the imbricated part of the capsule and retaining its elasticity, is due to the postoperative muscular rehabilitation in atraumatic instability.

One problem that needs to be addressed is the absence of a relevant nomenclature and a classification system for describing findings in shoulder instability. There may be a need for a mutual classification system of intra-articular lesions which allows for the description of MRA findings as well as findings at arthroscopy. The classifications of Johnson (48) and DePalma
(21) were found to be unsuitable for classifying MR arthrography, probably as these were constructed for classification during surgery. The high number of categories to choose from also made classification by arthroscopy difficult. The classification by DePalma was especially uncertain with arthroscopy in shoulders with a chronic instability, and as discussed by Waldt (107) DePalma’s classification has little clinical value in shoulders with a deranged capsulolabral complex.

Fractures, such as bony Bankart lesions, are reported to be more easily detected on plain radiological examination or CT, compared to MRA (29), and to often be missed on a routine radiographic evaluation (9). A reason for the difference in the reported frequency of a small glenoid rim fracture may be the difference in the diagnostic methods where a plain radiograph might not be as effective as an MRI examination in the acute dislocations, while it may be the opposite in the healed fractures. A difference in assessing the glenoid was found between the two methods. Whereas arthroscopy can be used to visualise even slight anterior wear, we found this difficult to assess using MRA. Anterior-inferior glenoid cartilage injury is a finding usually seen on MRA in association with labral injury in the same area. The findings could then be difficult to differentiate as two different lesions using MRA, and if the defect is focal the detection will also be dependent on the slicing thickness used when producing the MRA images.

The quality of life score WOSI (52) has high validity, reliability, and responsiveness for instability situations compared to several other scores. The total WOSI score among patients with unstable shoulders was lower than among those with stable shoulders. It is particularly in the domain for emotional well-being that the score is lower among the patients who have persisting recurrent instability compared to those with a stable shoulder. The WOSI score was also lower for those with unstable shoulders than in those re-operated for recurrent instability. It is not difficult to understand that the WOSI score, which has been designed to address symptoms in instability patients, gives lower ratings for patients with recurrent instability after surgery. It is more interesting that the mean WOSI score in our group with stable shoulders after stabilisation was far from perfect and that the patient to some degree is aware of the impairment in the quality of life, which is in agreement with other studies (12, 90). One possible explanation could be that the surgical stabilization of an unstable shoulder does not prevent the development of dislocation arthropathy in the long term as described by Pelet et al. (75) and by Hovelius et al. (41). This supports the idea that evaluation of shoulder stabilisation surgery needs a quality of life outcome measure, not only the description of recurrence rates and long follow-up time.

Assessing scores is an important issue. It is necessary to evaluate the overall quality of an instrument for measuring clinical function. An instrument must be able to measure what it is supposed to evaluate, it must be sensitive to small but relevant changes after treatment, and it must give the same result with different observer. The instruments validity, responsiveness, and reliability must be examined. Traditional physician-based parameters such as motion and strength do not provide direct evaluations of shoulder functions, which are essential to outcome assessment.

An ideal scoring system should be strongly weighted towards functional outcome, the patients perspective must be prioritized (84). In the WOSI score evaluation there are convincing indications that the score also assesses other important symptoms than instability itself.

A question that remains to answer concerns the size of the smallest clinically relevant change in the WOSI score. The preliminary data from the development of the score indicate that an
individual change in the WOSI score of 10% represents a minimally clinically important change, and that a moderate improvement in quality of life would be about 22% (54). Improvement in the outcome of shoulder stabilisation surgery may be difficult to detect when one is only looking for new instability symptoms, and other factors may be of clinical relevance. Visualisation of moderate differences requires instruments that are highly sensitive to clinical change. Our study shows that the translated WOSI has a very high sensitivity whether it is expressed as effect size or as standardised response mean. One advantage of a highly responsive score is that fewer subjects are required in clinical trials to show a statistically significant difference between treatment groups. (52). In comparison to other investigated shoulder scores the WOSI score does well in terms of sensitivity to change for instability disorders of the shoulder (84, 51, 56). A high responsiveness also indicates that a score is valid, which is supported by the high content validity showed by minimal floor and ceiling effects.

Wintzell (115) made a conventional MRI examination at follow-up after 6 months in 30 patients on whom MRI was performed at the time of the primary dislocation. He concluded that without the arthrographic effect of joint effusion, the capsulolabral complex could not be evaluated. In the present study we considered it adequate to use the joint effusion after the trauma for MRI contrast, and for evaluation of the lesions that can be associated with a shoulder dislocation. Other studies of recurrent instability have shown that in recurrent instability glenoid wear or a Bankart lesion is prognostic of postoperative recurrences, but it might not be valid for lesions after primary instability, where wear from recurrences is not present. Description of lesions found in unstable shoulders is usually based on findings at surgery after a recurrence, which might include secondary trauma and additional lesions (33, 9, 30). The studies that have examined primary dislocations have not yet identified any specific prognostic factors except age and gross instability that imply a certain need for surgical treatment. The other studies of MRI in primary shoulder dislocation (3) (96, 115) have shown age-related findings similar to those in this study, but provide no data on long-term stability or functional results. The high redislocation rate with both techniques in study V is not easily explained, but may also be related to other factors than our chosen modifications of the procedures. Our patients had a high number of recurrences before surgery, which could influence the outcome negatively (77) as could the long time from the first dislocation until surgery. Other factors that we share with some of the studies with a high recurrence rate are a long follow-up time and an extensive definition of recurrence (64, 7). The degree of shift in the Bankart repair group and the duplication of the capsule in the Putti-Platt group, measured during surgery as the restriction in external rotation directly after closure of the wound, was judged as adequate and substantial. The postoperative rehabilitation program was not especially unrestricted and it seems unlikely that the high rate of recurrences could be dependent on this. The reported recurrence rates following Bankart repair varies. Rowe et al. (88) had a recurrence rate of 3% at 6 years after surgery. Hovelius et al. (42) presented a 7-year follow-up with only 2% recurrences. In both these studies the capsulolabral complex was fixed to the glenoid with sutures through drill holes. Tamai et al. (100) performed Bankart repairs using either trans-osseous fixation or suture anchors, and found a higher redislocation risk when anchors were used. There might be a difference in favour of the trans-osseous suture technique, assuming that it demands a more extensive preparation of the anterior border of the glenoid, or that the sutures
transpose the labrum and ligaments further into the glenoid surface, and assuming that those differences improve the potential for healing by better positioning of the soft tissues.

One possible contribution to the high recurrence rate could be that we found a rather high percentage of bilateral shoulder instability at the 10-year follow-up. A high frequency of bilateral instability has also been reported in other studies (71, 55). However, the high rate in our study is remarkable since we had excluded all patients (23% of all primary stabilizations) with atraumatic instability and excessive joint laxity.

4.6 CLINICAL RELEVANCE

Surgery for atraumatic instability may be considered when conservative treatment fails, and then gives a good result.

The WOSI score is a reliable instrument for assessment of shoulder instability patients. In patients that are stable after surgery the score is not as high as in a healthy shoulder. This shows that it is important not only to measure the recurrence rate at follow-up, but also the quality of life by such disease specific outcome measurement.

The WOSI score is now validated in a Swedish translation and may be used for follow-up of shoulder instability patients. It could be used in multicenter studies, and registers of outcome after treatment, since it can be administered by mail.

Although MR-arthrography may be a useful diagnostic tool in shoulder instability there are difficulties in classifying the lesions in an arthroscopic classification systems. MRI cannot identify the patients that will have recurrence after a primary dislocation of the shoulder, but shoulders with a Bony Bankart have a better prognosis.
5 CONCLUSIONS

I
The results justify considering the capsular imbrication method a good treatment for involuntary atraumatic shoulder instability in cases when physical rehabilitation and lifestyle adjustment have failed.
Of the subgroups within atraumatic group of shoulder instability patients, the patients with voluntary instability have the worst outcome, and those with a structural lesion to repair do best at follow-up.

II
MR arthrography is a potentially useful tool in the detection of fractures and labral lesions associated with shoulder instability with acceptable reliability and repeatability.
Conventional MRI does not provide as comprehensive visualisation of the Capsulolabral complex as MR arthrography does.

III
The high ICC and sensitivity makes the WOSI score able to monitor progress of an individual patient.
At this retest the WOSI score has good validity, high reliability, and high responsiveness, all in the same level as in the original publication.
We recommend using the WOSI for evaluating patients with instability problems.

IV
MRI findings of an isolated fracture of the major tubercle, and also a Bony Bankart lesion, and an age above 30, were prognostic factors for a good functional result and a stable shoulder 8 years after a primary dislocation.

V
With assessment of pain and general shoulder function only a small difference was found between the two surgical methods, with a slightly better outcome (in pain and ROM) with a Bankart suture compared to the Putti-Platt procedure.
The WOSI scores for stable shoulders indicate that some shoulders still had an impaired function even though the shoulders had become stable.
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7 REFERENCES