Bone destruction, upward migration, and medialisation of rheumatoid shoulder: a 15 year follow up study

J T Lehtinen, E A Belt, M J Kauppi, K Kaarela, P P Kuusela, H J Kautiainen, M U K Lehto

Abstract

Objective—To evaluate bone destruction, upward migration, and medialisation of the glenohumeral (GH) joint in a cohort of 74 patients with seropositive and erosive rheumatoid arthritis followed up prospectively.

Methods—At the 15 year follow up 148 shoulders were radiographed by a standard method. Bone destruction in the GH joint was examined from the radiographs by four methods, of which three measured the migration and one the remodelling of the humeral head. The distances from the greater tuberosity of the humeral head to the coracoid process (medialisation distance (MD)) and to the articular surface of the humeral head (GA) have been previously developed to evaluate the pre-operative offsets of the arthritic GH joint. Medial displacement index (MI) and upward migration index (UI) have been recently developed to evaluate the destructive pattern of the rheumatoid GH joint. Destruction of the GH joints was assessed by the Larsen method on a scale of 0 to 5. The relation between the measurements and the grade of destruction of the GH joints was examined. UI was compared with our previous measurements of the subacromial space.

Results—Both the MI and the UI had a negative correlation with the GH joint destruction (Larsen grade), r = −0.49 (95% CI −0.36 to −0.60) and r = −0.58 (95% CI −0.46 to −0.68). The UI correlated significantly with the subacromial space, r = 0.90 (95% CI 0.86 to 0.93). The mean MI and UI measurements of the non-affectected joints were within the reported normal variations. The mean MD collapsed between Larsen grades 4 (83.0 mm) and 5 (65.5 mm). The morphology of the humeral head began to flatten and erode from the grade 3 onwards and medial head destruction was detected at grade 5.

Conclusions—Medialisation seems to be preceded by upward migration of the humeral head, indicating rotator cuff damage. Symptomatic Larsen grade 3 shoulders should be intensively followed up by clinical and radiological means. If a total shoulder arthroplasty is considered, an orthopaedic consultation is worthwhile at a sufficiently early stage (Larsen 3 and 4), when soft tissue structures responsible for function are still in proper condition and timing of the operative procedure can be well planned.

Most (67–91%) patients with rheumatoid arthritis (RA) have shoulder pain, and more than one in five present moderate or severe glenohumeral (GH) joint destruction during the first 15 years from the disease onset. Continuous plain radiographs of the rheumatoid shoulder are the primary diagnostic means of evaluating the glenohumeral joint and planning shoulder arthroplasty. Medial migration and remodelling of the humeral head with medialisation of the GH joint due to bone destruction are common radiographic findings in rheumatoid arthritis (RA). As far as we know, no previous studies have thoroughly measured the relation between GH joint destruction and upward migration and medialisation of the humeral head in patients with RA.

This study aimed at analysing the upward migration and medialisation of the humeral head and their relation to rheumatoid destruction of the GH joint in an inception cohort study of 74 patients with RA followed up for 15 years.

Materials and methods

During the period 1973–75 a total of 121 patients with recent (<6 months) RA were studied at the Rheumatism Foundation Hospital, Heinola, Finland. The selection criteria, data collection strategy, and details of the patients have been described elsewhere. At the three year follow up 102 patients had rheumatoid factor positive, erosive RA. Subsequently, 24 patients died and four patients failed to attend the 15 year follow up. Thus 74 patients (18 men, 56 women) were the subjects of this study; their age at onset ranged from 17 to 66, mean 42 (SD 12) years.

Radiographs of all the 148 shoulders were taken at the 15 year follow up as part of a radiographic survey study. The following standard positioning was used: patients supine, turned 20° to the imaged side, and the arm in external rotation, palm facing upwards. The same trained radiographer confirmed correct positioning and took x-ray pictures by the standard technique: the straight (central beam 90° towards the GH joint) anteroposterior projection (distance 95 cm) was used with exposure factors of 48 kV and ~63 mA.
size of the film (Kodak Lanex Regular) was 18\times24 cm.

Destruction of the glenohumeral joints was assessed by the Larsen method on a scale of 0 to 5. One shoulder arthroplasty was performed 13 years after onset of the disease, and in this case the preoperative radiograph (Larsen grade 5) was assessed and measured.

Medialisation (MD) of the GH joint was measured as the distance from the lateral aspect of the greater tuberosity to the medial margin of the coracoid process as described by Figgie et al (fig 1A). The upward migration index (UI) was obtained by dividing the distance between the centre of the humeral head and the central point of the subacromial surface (U) by the radius of the humeral head (R) (fig 1B). The medial displacement index (MI) was obtained by dividing the distance between the centre of the humeral head and the glenoid surface (M) by the radius of the humeral head (R) (fig 1C), as described by Hirooka et al. The position of the centre of the humeral head was determined with a circle fitting technique. In shoulders with destruction the bony morphology, the radius of the humeral head, and the original glenoidal and subacromial surfaces were confirmed and measured from the earlier radiographs. Subacromial space measurements from our previous study were compared with the UI. The perpendicular distance from the superior aspect of the greater tuberosity to the superior articular surface (GA) was measured (fig 1D), as illustrated by Figgie et al.

Statistical comparison between shoulders with different grades of destruction was performed using analysis of variance (ANOVA). Correlations were estimated by Pearson’s and Spearman’s coefficients. The normality of continuous variables was evaluated by the Kolmogorov-Smirnov statistics with a Lilliefors significance or Shapiro-Wilk statistics. No adjustment was made for multiple testing.

Results
There was no systematic right-left difference in any of the measuring methods in either sex, and therefore the measurements of the two sides were pooled. Table 1 shows the distribution of the GH joints (n=148) according to the Larsen grading and the mean measurements of destruction in each group, as well as ANOVA statistics models.

The diminution of the MI between different grades of destruction showed a significant trend (p<0.001). The correlation coefficient between MI and Larsen grading was −0.49 (95% CI −0.36 to −0.60). The MI correlated also with the MD, r=0.53 (95% CI 0.40 to 0.64), though the medialisation occurred late.
and had no significant correlation with Larsen grading. The mean MI of the non-a
ected joints (Larsen grades 0 and 1) was 0.89 (SD 0.04). The mean MD of the
non-a
ected joints was 83.0 (SD 6.7) mm.

The diminution of the UI between increas-
ing grades of destruction had a significant
trend (p<0.001). The correlation coe-
cycient between UI and Larsen grading was −0.58
(95% CI −0.46 to −0.68). A remarkable corre-
lution occurred between the subacromial space
r
=0.90 (95% CI 0.86 to 0.93). The
mean UI of the non-a
ected (Larsen grade 0
and 1) joints was 1.26 (SD 0.08).

The GA also decreased with increasing
destruction (p<0.001). There was a slight cor-
rrelation between GA and Larsen grading,
r=−0.29 (95% CI −0.14 to −0.43). However, it
had no significant correlation with either
upward migration index or subacromial space
measurements.

Discussion
The results of this study confirm the visually
observed medialisation in radiographs of rheu-
matoid shoulder.4 7 10–12 The mean distance
from the lateral aspect of the humeral head to
the coracoid process collapsed between Larsen
grades 4 and 5 (figs 2 and 3). The medial dis-
placement index (MI) takes into account the
size of the bones of the patient by dividing the
medial distance by the radius of the humeral
head (fig 1C).18 It shows more precisely that
medialisation is evident already between
Larsen grades 3 and 4, before the remarkable
reduction between grades 4 and 5 occurs. The
mean MI of the non-a
ected GH joints was
within 2SD of the mean of normal controls, as
measured by Hirooka et al.18 An MD <70 mm
(mean of non-a
ected joints − 2SD) could be
considered as a sign of definite medialisation of
the GH joint when evaluating a shoulder
radiograph taken at 0.95 mm distance.

The UI correlated well with the subacromial
space measurements, emphasising our previ-
ous results for the rotator cuff involvement in
the rheumatoid shoulder.14 The mean UI of the
non-a
ected GH joints was within 2SD of the
mean of normal controls, as measured by
Hirooka et al.18 The previous subacromial
space measurements of the non-a
ected joints
were also normal.20 Although upward migra-
tion of the humeral head seems to be an inevi-
table consequence of rheumatoid affection,
there seems to be an evident step in rotator cuff
involvement during the course of GH destruct-
ion in RA.15 Medialisation of the GH joint
seems to be slightly preceded by superior
migration of the humeral head according to our
results (fig 2) and as reported previously.17 18
However, if the concavity of the superior
glenoidal articular surface is destroyed by ero-
sions, the resultant force from the deltoid and
theoretically intact rotator cuff can pull the
humeral head into superior subluxation.21
Computed tomography measurements have
shown that the medial displacement of the gle-
noid surface was greatest at the upper and
middle levels: the surface was inclined superi-
or rather than inferiorly.22 Yet, at the time of

Table 1 Radiographic assessment of 148 glenohumeral (GH) joints according to the Larsen grading and the mean
medialisation distance (MD), medial displacement index (MI), upward migration index (UI), and greater
tuberosity-articular surface (GA) measurements for each group

<table>
<thead>
<tr>
<th>Larsen grade</th>
<th>Number of GH joints (%</th>
<th>MD, mm (mean, SD)</th>
<th>MI (mean, SD)</th>
<th>UI (mean, SD)</th>
<th>GA, mm (mean, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>33 (22)</td>
<td>85.4 (6.3)</td>
<td>0.90 (0.04)</td>
<td>1.27 (0.06)</td>
<td>6.8 (1.7)</td>
</tr>
<tr>
<td>1</td>
<td>44 (30)</td>
<td>81.2 (6.6)</td>
<td>0.88 (0.05)</td>
<td>1.24 (0.09)</td>
<td>6.5 (1.7)</td>
</tr>
<tr>
<td>2</td>
<td>40 (27)</td>
<td>87.6 (8.2)</td>
<td>0.87 (0.05)</td>
<td>1.20 (0.08)</td>
<td>6.8 (1.5)</td>
</tr>
<tr>
<td>3</td>
<td>14 (9)</td>
<td>85.6 (8.1)</td>
<td>0.84 (0.08)</td>
<td>1.14 (0.14)</td>
<td>6.1 (2.3)</td>
</tr>
<tr>
<td>4</td>
<td>10 (7)</td>
<td>85.0 (4.9)</td>
<td>0.71 (0.07)</td>
<td>0.97 (0.14)</td>
<td>4.7 (1.6)</td>
</tr>
<tr>
<td>5</td>
<td>11 (7)</td>
<td>64.5 (8.5)</td>
<td>0.49 (0.15)</td>
<td>0.82 (0.16)</td>
<td>2.9 (3.1)</td>
</tr>
<tr>
<td>Total</td>
<td>148 (100)</td>
<td>85.2 (9.3)</td>
<td>0.84 (0.12)</td>
<td>1.16 (0.15)</td>
<td>6.2 (2.1)</td>
</tr>
</tbody>
</table>

ANOVA* p Values between:

<table>
<thead>
<tr>
<th>Different Larsen groups</th>
<th>&lt;0.001</th>
<th>&lt;0.001</th>
<th>&lt;0.001</th>
<th>&lt;0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linearity of destruction</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Eta coefficient</td>
<td>0.64</td>
<td>0.87</td>
<td>0.78</td>
<td>0.49</td>
</tr>
</tbody>
</table>

*ANOVA = analysis of variance.

Figure 2 Radiograph of a rheumatoid shoulder. Extensive erosive destruction on the articular margins, leaving part of
the original articular surface still intact (Larsen 4). Evident superior migration of the humeral head is present and
the joint space has disappeared. However, there is no evident medialisation of the humeral head.
Bone destruction: the rheumatoid shoulder

The commonly described flattening of the humeral head in rheumatoid shoulder is supported by the diminution of the distance between the greater tuberosity and the superior articular surface (GA). Flattening is evident in Larsen grade 3 and more obvious in grades 4 and 5, when the superior humeral head is almost even (figs 2 and 3). However, flattening had no correlation with decreasing subacromial space and UL, suggesting that it is not caused by friction with the inferior acromion. This finding is probably caused by erosive destruction, which is more common on the superior joint margin of the humerus.

Shoulder arthroplasty yields excellent pain relief for the painful rheumatoid shoulder. However, the improvement in range of motion and function lag far behind that routinely expected after hip and knee replacements.

In clinical practice symptomatic Larsen grade 3 shoulders with persisting synovitis should be monitored carefully and the result of conservative treatment should be evaluated regularly. When symptoms continue and radiographic findings are progressive, operative treatment should not be delayed, because destruction may develop beyond the possibility of adequate repair. We emphasise that those patients with RA, who have glenohumeral erosions and a sign of upward migration of the humerus on a plan radiograph (fig 4), should be candidates for a rapid orthopaedic consultation and advanced soft tissue imaging like ultrasound or magnetic resonance arthrography.

Overall functional results of the arthroplasty are related to the physical condition as well as the motivation of the patient and the status of the rotator cuff. Total shoulder arthroplasty will not survive without sufficient glenoid bone stock and neither will it function properly without adequately preserved soft tissue structures. An orthopaedic consultation is worth-while at a sufficiently early stage (Larsen 3 and 4), so that timing of the operative procedure can be well planned.

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Figure 3. Radiograph of a rheumatoid shoulder. Gross bone destruction of the humeral head has occurred (Larsen 5). Superior and medial migration of the humeral head has occurred and remarkable loss of the glenoid bone stock is present.


17 24 Total shoulder arthroplasty will not survive without sufficient glenoid bone stock and neither will it function properly without adequately preserved soft tissue structures. An orthopaedic consultation is worthwhile at a sufficiently early stage (Larsen 3 and 4), so that timing of the operative procedure can be well planned.
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