Posterolateral rotatory rotatory laxity following surgery to the head of the radius

BIOMECHANICAL COMPARISON OF TWO SURGICAL APPROACHES

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The lateral ligament complex is the primary constraint to posterolateral rotatory laxity of the elbow, and if it is disrupted during surgery, posterolateral instability may ensue. The Wrightington approach to the head of the radius involves osteotomising the ulnar insertion of this ligament, rather than incising through it as in the classic posterolateral (Kocher) approach. In this biomechanical study of 17 human cadaver elbows, we demonstrate that the surgical approach to the head can influence posterolateral laxity, with the Wrightington approach producing less posterolateral rotatory laxity than the posterolateral approach.

Posterolateral rotatory instability is attributed mainly to disruption of the lateral collateral ligament (LCL) complex,1-3 which may occur as a result of trauma, chronic overload, or iatrogenically during surgery to the head of the radius or release for tennis elbow,4,5 particularly when using the posterolateral (Kocher) approach.6 We have previously described the Wrightington approach,7,8 which involves elevation of the anconeus from the ulna, and osteotomising the attachment of the LCL to the ulna. The LCL is thereby not violated.

We have recently shown, in a cadaver study,8 that there is more varus/valgus laxity using the posterolateral approach. This approach also results in more external rotation and the Wrightington approach in more internal rotation.8

The aim of this study was to determine whether there is any difference in posterolateral rotatory laxity following the use of the two approaches when performing surgery on the head of the radius.

Materials and Methods

The left arms were obtained from 17 fresh-frozen cadavers. None had any macroscopic pathology. They were thawed to room temperature prior to use. An electromagnetic tracking system (Isotrak II, Polhemus, Vermont) was used to measure the kinematics of the ulnohumeral joint. The experimental set-up included a wooden platform, to which a custom-made holding device and the source of Isotrak II were fixed. All soft tissue was removed from the shaft of the humerus. The ligamentous, capsular and muscular attachments to the distal humerus were left intact. The skin and subcutaneous fat were removed from the forearm, which was placed in full supination and maintained in this position by a 4 mm screw joining the distal ulna and the radius, allowing the forearm to move as a single unit. The sensor of Isotrak II was fixed to the distal ulna. The humerus was fixed in neutral rotation, so that when the elbow was flexed to 90° the forearm was parallel to the floor. The gravity varus stress position was achieved by placing the experimental platform so that the medial epicondyly of the elbow was facing upwards and the lateral epicondyle downwards. Gravity varus stress was assessed by rotating the whole of the experimental platform through 180°, so that the lateral epicondyle was facing upwards. In this way, the weight of the forearm and hand produced an inherent varus or varus force on the elbow joint. A hole was drilled from the posterior crest of the shaft of the ulna to the medial half of the volar surface, 12 cm from the tip of the olecranon, through which a metal rod was inserted. A 10 N weight was attached to this rod 10 cm from the ulnar surface, which exerted an external rotation load on the ulna relative to the humerus (Fig. 1). A model which resembled the testing conditions for posterolateral rotatory laxity was created by placing the forearm in a fixed supinated position, the arm in a valgus loaded position, and applying an additional external rotation load. The amount of external rotation around the long axis of the ulna obtained under these conditions was considered to be a measure of posterolateral rotatory laxity. Flexion at the
elbow joint was undertaken by the same examiner by grasping the hand and moving the forearm through three cycles of flexion and extension, and kinematic data were recorded using Isotrak II software run on a personal computer (Toshiba, Tecra, Weybridge, United Kingdom). The following steps were performed.

1. The intact elbows were taken through three cycles of flexion and extension. This step was repeated twice to assess the reproducibility of the experimental model.

2. Four 2 mm metal screws and the metal rod on which the weight was applied were taped onto the proximal forearm, and the data collected were used to assess whether the use of metallic material in the electromagnetic field of Isotrak II influenced the recordings.

3. The anterior band of the medial collateral ligament was identified and divided.

4. Either a posterolateral or Wrightington approach to the head of the radius was performed, with eight elbows randomly assigned to the posterolateral and nine to the Wrightington approach.

**The posterolateral approach.** The deep fascia was incised and the interval between extensor carpi ulnaris and anconeus was identified and bluntly dissected. These muscles were retracted to expose the underlying structures. The capsule and LCL complex, including the annular ligament, were divided along a line passing from the lateral epicondyle to the mid-level of the anteroposterior diameter of the head of the radius. The deep capsular tissues were not detached from the lateral epicondyle. For closure, the LCL complex, extensor musculature and fascia were repaired as separate layers in a side-to-side fashion using interrupted 2/ Vicryl.

**The Wrightington approach.** The deep fascia was incised along a line from the level of the lateral epicondyle to the ulna. Anconeus was lifted off from posterior to anterior, exposing the underlying LCL complex. The ulnar insertion of the LCL was osteotomised (Fig. 2), exposing the head of the radius. The margins of the osteotomy were marked with an osteotome and the osteotomy performed with a saw. For
After closure, the osteotomy site was reattached using 2 mm cortical screws. The anconeus was sutured to the fascia, which was repaired using interrupted 2/0 Vicryl.

In each group the assigned approach was then used for each of the following steps.

1. A three-part partial articular fracture of the head of the radius (Mason II) was created (Fig. 3). This involved the lateral aspect of the head. The fractured fragment was removed and its articular border was outlined on graph paper to determine its size. It was then cut into two and replaced in the joint, and the fracture fixed with 2 mm cortical screws.

2. The head of the radius was excised. The height of excision was measured to match the height of the prosthesis to be used in the next step. The articular border of the excised head was outlined on graph paper to determine its size. In this way the proportion which was fractured was calculated.

3. The head was replaced with an Ascension prosthesis (Ascension Orthopaedics, Austin, Texas) which is available in three sizes, small, medium and large.

The elbow was then disarticulated and the forearm weighed.

Statistical analysis. The data recorded by Isotrak II were used for analysis. First, the cycle of flexion was determined as previously described. With the elbow in the valgus loaded position, the varus/valgus angle was considered a measure of valgus laxity, and with the elbow loaded in varus a measure of varus laxity. With the elbow in the valgus loaded position and a supination load applied, external rotation of the ulna was considered to be a measure of posterolateral rotatory laxity. For each elbow, the mean rotation and varus/valgus angles for the studied cycles of flexion were calculated for each 10° of flexion at each step of the protocol. The mean laxity across the whole range of flexion, for each step, was also calculated. Statistical analysis was performed with SPSS software version 11.5.0 using simple and repeated-measures analysis of variance (ANOVA). The results are presented as means and 95% confidence intervals (CI). The demographics of the two groups were compared using an independent-groups t-test. Statistical significance was established as p = 0.05.

Results

Comparison between the two groups as regards the demographics of the elbows used, the percentage of the head which was fractured and the size of the prostheses used showed no significant difference (Table I). The readings obtained between successive flexion/extension cycles in the intact elbows were highly reproducible, with no significant difference between successive cycles. Similarly, the taping of the metal screws and rod on the intact forearm showed no significant change in the readings.

There was no significant difference in the changes in laxity following division of the medial collateral ligament between the two approaches. Following each further step in the protocol the change in laxity of the eight elbows in the posterolateral group was then compared with those in the Wrightington group. The changes in laxity were determined with reference to the elbow after division of the medial collateral ligament.

The posterolateral rotatory laxity was significantly higher in the posterolateral group for all the steps in the protocol (Table II). The differences were particularly pronounced for fixation of the fracture of the head and after its excision (Fig. 4). Similarly, the posterolateral approach led to more varus at each step, and more valgus for most steps compared with the Wrightington approach (Table III).

Discussion

Iatrogenic damage to the LCL complex may lead to chronic posterolateral rotatory instability, which involves external rotation at the ulnohumeral articulation and resultant posterolateral subluxation of the head of the radius. Clinically it is assessed by the pivot shift test. In this study, a cadaver model was used which resembled the conditions of the pivot shift test. We have previously shown that the posterolateral approach confers a greater increase in varus and valgus laxity than the Wrightington approach. In that study we also observed that spontaneous rotation at the ulnohumeral articulation during varus and valgus loading differs between the two approaches, with external rotation seen following the posterolateral and internal rotation seen following the Wrightington approach. In this study we have gone further, creating a model where a rotatory load was applied and thus testing directly for posterolateral rotatory laxity. Our results suggest that the Wrightington approach is associated with less posterolateral rotatory laxity than the posterolateral approach. The LCL is a constraint to external rotation. It may be that in the posterolateral approach, incising and repairing the LCL complex disrupts...
its integrity, causing an increase in external rotation. In the Wrightington approach the insertion of the LCL is osteotomised and its substance is not violated. The reduced posterolateral rotatory laxity in the Wrightington approach may also be related to the anconeus being lifted off the ulna but then sutured back to the deep fascia during closure. This may tighten the tissues laterally, forcing the ulna towards internal rotation. It is also possible that in osteotomising the ulnar insertion of the LCL complex, removal of bone using a saw may result in over-tensioning of the LCL at the time of repair of the osteotomy, thereby reducing any posterolateral laxity.

It has traditionally been thought that a distinct ligament, the lateral ulnar collateral ligament, exists as part of the LCL complex, and that this is its main stabilising force. It has therefore been suggested that in performing the posterolateral approach the lateral ulnar collateral ligament should be isolated and preserved, and that incisions in the LCL complex should be made in its anterior part to avoid the lateral ulnar collateral ligament. We feel that the LCL complex is more of a continuous ligamentous sheet, consisting of the lateral ligament, annular ligament and joint capsule, with no clearly identifiable lateral ulnar collateral ligament. In accordance with this view, Cohen and Hastings, in a study of 40 cadaver elbows failed to show a distinct band passing from the lateral epicondyle to the ulna, and in a histological study Imatani et al. described the lateral ulnar collateral ligament as a vague structure with indistinct boundaries. We believe that any violation of the LCL complex substance is significant, and hence favour a surgical approach that protects it.

There are limitations to this study. It is possible that repeated testing of the specimens could have influenced our results, in particular the repeated soft-tissue repair in the posterolateral approach compared with the screw fixation in the Wrightington procedure. The inclusion of a control group in which repeated surgical exposures were performed

![Fig. 4a](image1.png)

Changes in posterolateral rotatory laxity in the Wrightington (squares) and posterolateral (circles) groups following a) radial head fixation and b) excision, compared with the elbow with isolated medial collateral ligament division. The vertical axis represents posterolateral rotatory laxity (°) and the horizontal axis elbow flexion (°). The greater the negative value, the greater the laxity.

![Fig. 4b](image2.png)

Table I. Demographics of the posterolateral and Wrightington approach groups. Values are given as means and ranges

<table>
<thead>
<tr>
<th>Variable</th>
<th>Posterolateral approach</th>
<th>Wrightington approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>77 (50 to 96)</td>
<td>72 (55 to 97)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Forearm weight (kg)</td>
<td>0.99 (0.95 to 1.27)</td>
<td>1.05 (0.86 to 1.32)</td>
</tr>
<tr>
<td>Percentage of articular surface fractured</td>
<td>44 (40 to 46)</td>
<td>40 (30 to 50)</td>
</tr>
<tr>
<td>Radial head sizes used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Medium</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Large</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
without any other intervention could have resolved this issue, but was not undertaken owing to the limited availability of cadaver specimens. Nevertheless, we believe that repeated testing did not have a major effect on our results because, as shown in Table II, the difference in laxity between the two approaches did not progressively increase with subsequent steps in the protocol, which would have been anticipated if repeated testing had a significant influence. Thus, although the difference in posterolateral rotatory laxity between the two approaches increased up to fixation of the head, it decreased after the excision and subsequent replacement. Statistically significant differences between the two approaches were seen after performing the procedure for the first time, prior to repeated testing of the specimens. It could be argued that the differences in laxity between the two groups were small, but they may be more pronounced in vivo, where cyclic loading occurs.

We assessed surgery to the head of the radius in a cadaver model with a divided medial collateral ligament, as this would be clinically relevant in acute injuries, where the head is fractured and the medial ligament disrupted, and also in chronic conditions such as inflammatory arthropathies where the medial ligament is chronically attenuated. With complex fractures of the head associated with dislocation of the elbow, the LCL is usually avulsed from its humeral attachment, and in such cases the Wrightington approach would not be indicated. It is for simple fractures not associated with dislocation but which may have disruption of the medial ligament, as well as in elective arthroplasty of the head, that the Wrightington approach has a major role. With fracture of the head it may be useful to check for disruption of the LCL complex by testing for posterolateral and varus laxity prior to surgery. If such tests suggest that the LCL is disrupted, the Wrightington approach should be avoided.

As the Wrightington approach involves an osteotomy there is a theoretical risk of nonunion of the osteotomy site. However, this did not occur in the clinical series of Stanley et al., nor were there any cases of heterotopic ossification, which might be encountered when dealing with Monteggia fractures. In this study we measured the height of the excised head to match the height of the prosthesis to avoid over- or under-stuffing of the radiocapitellar joint. Although this is possible in an experimental study, in clinical situations where the radial head is severely comminuted the use of anatomical landmarks such as the ulnar sigmoid notch to determine the height of the prosthesis may be all that is possible. It could be argued that, because of its posterior location, the Wrightington approach would give access primarily to the posterior and central parts of the head, and might limit access to anterior articular fractures. However, we feel that osteotomising the ulnar insertion of the LCL complex provides enough exposure to allow anterior injuries to be dealt with.

Within the limitations of this study, our results suggest that the surgical approach to the radial head can influence the early posterolateral rotatory laxity. The Wrightington and posterolateral approaches seem to confer different changes in early posterolateral and in varus and valgus laxity. The extent to which such differences translate to post-operative instability remains to be shown by clinical studies.

### Table II. Mean differences in changes of posterolateral rotatory laxity between the posterolateral and the Wrightington approach groups following each step. Mean differences are given following each protocol step, compared with the elbow with isolated medial collateral ligament division

<table>
<thead>
<tr>
<th>Protocol step</th>
<th>Mean difference in posterolateral rotatory laxity (°) with 95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical exposure</td>
<td>1.44 (1.19 to 1.69)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Radial head fracture</td>
<td>2.35 (1.97 to 2.73)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Radial head fixation</td>
<td>3.15 (2.70 to 3.60)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Radial head excision</td>
<td>2.87 (2.49 to 3.25)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Radial head replacement</td>
<td>1.99 (1.40 to 2.58)</td>
<td>0.012</td>
</tr>
</tbody>
</table>

* 95% CI, 95% confidence interval

### Table III. Mean differences in change of varus and valgus laxity between posterolateral and Wrightington approach groups following each protocol step. Mean differences are given following each protocol step, compared with the elbow with isolated medial collateral ligament division

<table>
<thead>
<tr>
<th>Protocol step</th>
<th>Varus (°) mean difference with 95% CI</th>
<th>p-value</th>
<th>Valgus (°) mean difference with 95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical exposure</td>
<td>0.55 (0.45 to 0.65)</td>
<td>&lt; 0.001</td>
<td>0.20 (0.15 to 0.25)</td>
<td>0.02</td>
</tr>
<tr>
<td>Radial head fracture</td>
<td>0.99 (0.89 to 1.09)</td>
<td>&lt; 0.001</td>
<td>0.01 (-0.09 to 0.11)</td>
<td>0.82</td>
</tr>
<tr>
<td>Radial head fixation</td>
<td>1.42 (1.27 to 1.57)</td>
<td>&lt; 0.001</td>
<td>0.20 (0.05 to 0.35)</td>
<td>0.07</td>
</tr>
<tr>
<td>Radial head excision</td>
<td>1.83 (1.68 to 1.98)</td>
<td>&lt; 0.001</td>
<td>4.96 (3.71 to 6.21)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Radial head replacement</td>
<td>2.59 (2.44 to 2.74)</td>
<td>&lt; 0.001</td>
<td>3.43 (3.07 to 3.79)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

* 95% CI, 95% confidence interval
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References


