Assessment of medial elbow laxity by gravity stress radiography: comparison of valgus stress radiography with gravity and a Telos stress device

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Background: Valgus instability was reported to be higher with the elbow in 60° of flexion, rather than in 30° of flexion, although there are no studies using valgus stress radiography by gravity (gravity radiography) with the elbow in 60° of flexion.

Methods: Fifty-seven patients with medial elbow pain participated. For both elbows, valgus stress radiography by use of a Telos device (Telos radiography) and gravity radiography, with the elbow in 60° of flexion, were performed for the assessment of medial elbow laxity. In both radiographs, the medial elbow joint space (MJS) on the affected side was compared with that on the opposite side, and the increase in the MJS on the affected side was assessed.

Results: For the Telos radiographs, the mean MJS was 4.7 mm on the affected side and 4.0 mm on the opposite side, with the mean increase in the MJS on the affected side being 0.7 mm. For the gravity radiographs, the mean MJS was 5.0 mm on the affected side and 4.2 mm on the opposite side, with the mean increase in the MJS on the affected side being 0.8 mm. There were significant correlations between the Telos and gravity radiographs in the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side (respectively, \( P < .0001 \)). There was also a high level of intraobserver and interobserver reliability for the assessment of the gravity radiographs.

Conclusions: Gravity radiography is useful for assessment of medial elbow laxity, similar to Telos radiography.

Level of evidence: Level I, Diagnostic Study.
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conditions, and has also been widely used for the assessment of medial elbow laxity.5-7,12,15 In previous studies, two different techniques for gravity stress radiography have been reported, in which subjects for both techniques were placed supine on a table with the shoulder at 90° of abduction and 90° of external rotation and the elbow at 15° to 30° of flexion.5,7,9,15 The first technique, however, involves only gravity of the forearm,7,9 whereas the second involves not only gravity of the forearm but also a weight attached to the wrist.5,15 However, the intraobserver and interobserver reliabilities of these valgus stress radiography techniques have not yet been assessed, and little is known about which is better at assessing elbow laxity.

Both Telos stress radiography and gravity stress radiography have been performed extensively with the elbow in 15° to 30° of flexion.3-5,7,9,11-13,15 However, Søjbjerg et al14 reported that in normal cadaveric elbows, transection of the medial collateral ligament caused valgus instability with a mean maximum of 20.2° in 60° of flexion. This result suggests that valgus instability is higher with the elbow in 60° of flexion than in 30° of flexion. Therefore, we have performed Telos and gravity stress radiography with the elbow in 60° of flexion. The aim of this study was to address the efficacy of gravity stress radiography for assessment of medial elbow laxity.

Methods

This is a prospective cohort study of diagnostic tests to assess medial elbow laxity. Fifty-seven athletes with medial elbow pain participated. There were 55 men and 2 women, aged between 10 and 29 years (mean, 18.1 years). The types of sports played by the subjects were baseball in 49, tennis in 2, basketball in 2, judo in 2, cycling in 1, and badminton in 1. The reason for onset of elbow pain was chronic overload of the medial collateral ligament caused valgus instability in 54 subjects and acute traumatic events in 3 (judo, 2; cycling, 1). Forty-seven subjects had right elbow pain, 9 had left elbow pain, and 1 had bilateral pain. The diagnosis of medial elbow pain was ulnar neuritis in 30 subjects, medial collateral ligament injury in 25, osteochondritis dissecans of the capitellum in 8, medial epicondyle injury in 4, posterior elbow injury in 4, and ulnar sublime tubercle avulsion fracture in 1. For both elbows, valgus stress radiography was performed with a Telos device and gravity to assess medial elbow laxity.

Anteroposterior radiographs of both elbows were taken with a standard radiographic unit. For Telos stress radiography (Telos GA-JIE stress device; Telos, Wetterstad, Germany), the subjects sat on a chair with the shoulder in 60° of abduction, the elbow in 60° of flexion, and the forearm in a neutral position; 60° of abduction, the elbow in 60° of flexion, and the forearm in a neutral position; 60° of flexion, and the forearm in a neutral position. Similar to Telos stress radiography, the elbow was confirmed to be flexed at 60° with use of a polystyrene foam triangular frame set at the correct angle. Anteroposterior radiographs were obtained while a force of 50 N was applied to the lateral aspect of the elbow (Fig. 1). The valgus force was applied with a screw-threaded shaft that allowed a gradual increase in stress. For gravity stress radiography, subjects were placed supine on a table with the shoulder in 90° of abduction, the elbow in 60° of flexion, and the forearm in a neutral position. Similar to Telos stress radiography, the elbow was confirmed to be flexed at 60° with use of a polystyrene foam triangular frame. Anteroposterior radiographs were obtained with the gravity stress being applied to the elbow (Fig. 2). Another polystyrene foam frame was placed under the upper arm, just proximal to the elbow, so the valgus force was easily applied with the stress from gravity. In both the Telos and gravity stress radiographs, the shortest distance between the most distal point on the curved contour of the medial epicondyle and the ulnar coronoid process was measured, and this was considered to be the medial elbow joint space (MJS) (Fig. 3). For the measurement of the MJS, anteroposterior radiographs by both Telos and gravity stress radiography were enlarged with electronic software (Vox-Base; J-Mac System, Sapporo, Japan) to obtain accurate MJS measurements to the 0.01-mm unit. For both the Telos and gravity stress radiographs, the MJS on the affected side was compared with that on the opposite side, and the increase in the MJS on the affected side was determined.

An orthopedic clinician with more than 10 years of experience (examiner A [M.H.]) measured the MJS on both the Telos and gravity stress radiographs. We investigated the correlation of the MJS between these 2 techniques by comparing the MJS from the Telos stress radiographs with that from the gravity stress radiographs. To investigate the correlation of MJS between the Telos and gravity stress radiographs, a statistical analysis of the data was carried out by the Pearson correlation coefficient and Student t test. A correlation coefficient of ±0.4 to ±1.0 and a significance level of P < .05 were considered to be significant.

To determine the intraobserver reliability of using Telos and gravity stress radiography, examiner A also measured the MJS again approximately 3 months after the first measurement. Furthermore, to investigate the interobserver reliability of using Telos and gravity stress radiography, another orthopedic clinician (examiner B [M.M.]) measured the MJS with both methods. We evaluated the intraobserver and interobserver reliability of MJS measurements with these two methods by an intraclass correlation coefficient. A coefficient of 0.8 or more was considered to be significant. The analysis of intraobserver and interobserver reliability was performed with Microsoft Excel for Windows version 2002 (Microsoft, Redmond, WA, USA).

Results

The Telos stress radiographs showed that the mean MJS was 4.7 ± 0.9 mm (range, 3.3-8.1 mm) on the affected side and 4.0
The mean increase in the MJS on the affected side was 0.7 ± 0.5 mm (range, 0.5 to 1.9 mm). The MJS on the affected side was significantly increased relative to that on the opposite side (P = .0003) (Table I). The gravity stress radiographs showed that the mean MJS was 5.0 ± 0.8 mm (range, 3.7-6.6 mm) on the affected side and 4.2 ± 0.9 mm (range, 2.6-5.9 mm) on the opposite side. The mean increase in the MJS on the affected side was 0.8 ± 0.7 mm (range, −0.8 to 3.3 mm). The MJS on the affected side was significantly increased relative to that on the opposite side (P = 0.0001) (Table I).

**Correlation of the MJS between Telos and gravity stress radiography**

The correlation coefficient for the MJS between the 2 techniques was 0.798 on the affected side and 0.870 on the opposite side. It was determined that there were strong significant correlations between these radiographic assessments (respectively, P < .0001) (Fig. 4). Similarly, the correlation coefficient for the increase in MJS was 0.758 on the affected side. It was determined that there was a strong significant correlation between these radiographic assessments (P < .0001) (Fig. 4).

**Table 1**  
Difference of the MJS by either Telos or gravity stress radiography

<table>
<thead>
<tr>
<th>MJS</th>
<th>Unit</th>
<th>Telos 1</th>
<th>Gravity 1</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected side</td>
<td>mm</td>
<td>4.7 ± 0.9</td>
<td>5.0 ± 0.8</td>
<td>.04</td>
</tr>
<tr>
<td>Opposite side</td>
<td>mm</td>
<td>4.0 ± 1.0</td>
<td>4.2 ± 0.9</td>
<td>.31</td>
</tr>
<tr>
<td>Increase in the MJS*</td>
<td>mm</td>
<td>0.7 ± 0.5</td>
<td>0.8 ± 0.7</td>
<td>.21</td>
</tr>
</tbody>
</table>

Mean ± SD. MJS, medial elbow joint space.
* Increase in the MJS: difference between affected side and opposite side.
1 Telos stress radiography.
2 Gravity stress radiography.

**Difference of the MJS by either Telos or gravity stress radiography**

The mean MJS on the affected side was 4.7 mm by Telos stress radiography and 5.0 mm by gravity stress radiography. The MJS on the affected side for the gravity stress radiographs was significantly increased compared with that for the Telos stress radiographs (P = .04) (Table I). The mean MJS on the opposite side was 4.0 mm for the Telos stress radiographs and 4.2 mm for the gravity stress radiographs. There...
was no difference between the 2 techniques ($P = .31$) (Table I). The mean increase in the MJS on the affected side was 0.7 mm for the Telos stress radiographs and 0.8 mm for the gravity stress radiographs. There was no difference between the two techniques ($P = .21$) (Table I).

**Intraobserver reliability of using Telos and gravity stress radiography**

The intraobserver reliabilities of using Telos stress radiography, based on the intraclass correlation coefficient, for the assessment of the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were 0.9051, 0.9569, and 0.7365, respectively (Table II). The intraobserver reliabilities of using Telos stress radiography for the MJS on the opposite side were significant, but those for the MJS on the affected side and the increase in the MJS on the affected side were not significant. The intraobserver reliabilities of using gravity stress radiography, based on the intraclass correlation coefficient, for the assessment of the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were 0.9202, 0.9131, and 0.8106, respectively (Table II). The intraobserver reliabilities of using gravity stress radiography for the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were all significant.

**Interobserver reliability of using Telos and gravity stress radiography**

The interobserver reliabilities of using Telos stress radiography, based on the intraclass correlation coefficient, for the assessment of the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were 0.7382, 0.8416, and 0.7703, respectively (Table III). The interobserver reliabilities of using Telos stress radiography for the MJS on the opposite side were significant, but those for the MJS on the affected side and the increase in the MJS on the affected side were not significant. The interobserver reliabilities of using gravity stress radiography, based on the intraclass correlation coefficient, for the assessment of the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were 0.8833, 0.9244, and 0.8897, respectively (Table III). The interobserver reliabilities of using gravity stress radiography for the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side were all significant.

**Discussion**

As a quantitative tool for the assessment of medial elbow laxity, Telos stress radiography has an advantage as it is
able to assess laxity under uniform conditions. However, there are disadvantages as well, including the need to purchase the Telos device, and the procedure, using this device, is often difficult to perform. On the other hand, the advantages of gravity stress radiography, which was used in our study, are that special equipment, such as a Telos device, is not required and the procedure can be performed under uniform conditions. Therefore, gravity stress radiography can be performed in every hospital as a quantitative tool for the assessment of medial elbow laxity.

Previous studies using Telos stress radiography have shown that the valgus forces applied to the elbow include 25 N, 69 N, 130 N, and 150 N. In our study, the valgus force applied to the elbow with this method was 50 N, which was relatively lower than in the previous studies. However, even this amount of force caused many of our subjects to complain of elbow pain. These findings suggest that the valgus force used in our study was appropriate.

In previous studies, with regard to degrees of elbow flexion during valgus stress radiography, valgus instability with the elbow in 30° of flexion was confirmed to be increased relative to that in 0° of extension. In addition, both Telos stress radiography and gravity stress radiography have been performed extensively with the elbow in 15° to 30° of flexion. When the elbow is flexed at 90°, the contribution of the medial collateral ligament, with regard to constraining the elbow against valgus stress, becomes large and the contribution of the osseous articulation becomes small. In previous studies, with use of normal cadaveric elbows, elbow instability and degrees of elbow flexion were examined after transection of the medial collateral ligament. It was concluded that valgus instability was increased to a greater degree with the elbow in 60° of flexion than in 30° of flexion. We used anteroposterior radiographs to assess the elbow in 90° of flexion, but it was difficult to assess the MJS because a head interrupted the x-ray exposure to the elbow when 90° of flexed position was used. However, we were able to assess the MJS in anteroposterior radiographs with the elbow in 60° of flexion. Therefore, we assessed medial elbow laxity on valgus stress radiography with the elbow in 60° of flexion, which is close to 90° of flexion and is equivalent to the maximum stress angle that occurs during baseball pitching. Furthermore, valgus instability was increased to a greater degree with use of this angle, compared with a 30° flexion angle. This study is the first

<table>
<thead>
<tr>
<th>Table II</th>
<th>Intraobserver reliability of using Telos and gravity stress radiography</th>
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</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Telos stress radiography</td>
</tr>
<tr>
<td></td>
<td>Affected side</td>
</tr>
<tr>
<td>First time (examiner A)</td>
<td>4.7 ± 0.9</td>
</tr>
<tr>
<td>Second time (examiner A)</td>
<td>4.7 ± 1.0</td>
</tr>
<tr>
<td>Coefficient1</td>
<td>0.9051</td>
</tr>
<tr>
<td>Measurement</td>
<td>Gravity stress radiography</td>
</tr>
<tr>
<td></td>
<td>Affected side</td>
</tr>
<tr>
<td>First time (examiner A)</td>
<td>5.0 ± 0.8</td>
</tr>
<tr>
<td>Second time (examiner A)</td>
<td>5.1 ± 0.8</td>
</tr>
<tr>
<td>Coefficient1</td>
<td>0.9202</td>
</tr>
</tbody>
</table>

Mean ± SD. MJS, medial elbow joint space.  
* Increase in the MJS: difference between affected side and opposite side.  
1 Intraclass correlation coefficient.

<table>
<thead>
<tr>
<th>Table III</th>
<th>Interobserver reliability of using Telos and gravity stress radiography</th>
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</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Telos stress radiography</td>
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<tr>
<td></td>
<td>Affected side</td>
</tr>
<tr>
<td>First time (examiner A)</td>
<td>4.7 ± 0.9</td>
</tr>
<tr>
<td>First time (examiner B)</td>
<td>4.8 ± 0.8</td>
</tr>
<tr>
<td>Coefficient1</td>
<td>0.7382</td>
</tr>
<tr>
<td>Measurement</td>
<td>Gravity stress radiography</td>
</tr>
<tr>
<td></td>
<td>Affected side</td>
</tr>
<tr>
<td>First time (examiner A)</td>
<td>5.0 ± 0.8</td>
</tr>
<tr>
<td>First time (examiner B)</td>
<td>5.0 ± 0.7</td>
</tr>
<tr>
<td>Coefficient1</td>
<td>0.8833</td>
</tr>
</tbody>
</table>

Mean ± SD. MJS, medial elbow joint space.  
* Increase in the MJS: difference between affected side and opposite side.  
1 Intraclass correlation coefficient.
to assess medial elbow laxity by valgus stress radiography with the elbow in 60° of flexion.

Although we were unable to find any previous study that has compared the MJS assessed by gravity stress radiography with that assessed by Telos stress radiography, Lee et al7 compared the MJS in gravity stress radiography with that in valgus stress radiography assessed with both gravity and a weight attached to the wrist. In their study, a valgus stress of 25 N was applied by both gravity and an attached weight, and valgus stress radiography was performed to assess the MJS in 40 subjects with no history of elbow trauma or instability. The results showed that the MJS determined by valgus stress radiography under a stress of 25 N, created by both gravity and weight, was significantly higher than that determined by valgus stress radiography employing gravity alone. This study is the first to assess medial elbow laxity by valgus stress radiography with the elbow at a 30° flexion angle.

In our study, in both Telos and gravity stress radiography, the MJS on the affected side was significantly increased relative to that on the opposite side. These results suggest that most of these subjects had medial elbow laxity. However, for a diagnosis of medial elbow pain caused by medial collateral ligament injury to be made, not only valgus stress radiography with gravity or a Telos stress device but also tenderness of the medial collateral ligament, moving valgus stress test, and magnetic resonance imaging are needed. In our study, medial elbow laxity was assessed by gravity stress radiography with the elbow in 60° of flexion. For the MJS on the affected side, that on the opposite side, and the increase in the MJS on the affected side, there were strong significant correlations between use of a Telos device and gravity. The MJS on the affected side determined by gravity stress radiography was also significantly increased compared with that determined by the Telos device. There was a high level of intraobserver and interobserver reliability when gravity stress radiography was used. These results suggest that gravity stress radiography is useful for the assessment of medial elbow laxity, similar to use of a Telos device.

**Conclusion**

We assessed medial elbow laxity in 57 athletes with medial elbow pain, using valgus stress radiography, with the elbow in 60° of flexion. We addressed the efficacy of gravity stress radiography by comparing it to the use of a standard Telos device.

For the MJS on the affected side, the MJS on the opposite side, and the increase in the MJS on the affected side, there were strong significant correlations between gravity stress radiographic assessment and use of a Telos device. The MJS on the affected side determined by gravity stress radiography was also significantly increased compared with the use of a Telos device.

There was a high level of intraobserver and interobserver reliability when gravity stress radiography was used. Gravity stress radiography is useful for the assessment of medial elbow laxity, similar to use of a Telos device.

**Disclaimer**

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