A modified system of stress radiography for patellofemoral instability

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Axial radiographs were obtained under valgus and external rotation stress at 45° of knee flexion with and without contraction of the quadriceps muscle in order to assess the dynamics of patellar subluxation or dislocation. The radiography was performed on 82 knees in 61 patients with patellofemoral instability, and on 44 normal knees. The lateral patellofemoral angle and the congruence angle were measured and compared with the conventional Merchant views. Both parameters showed greater differences between symptomatic and normal knees on the stress radiographs obtained without quadriceps contraction. There was a major difference in the lateral patellofemoral angles between the groups, which clearly distinguished symptomatic knees from normal controls. Congruence angles on stress radiography had a significant correlation with the functional scores obtained after a period of conservative treatment and a positive correlation with the frequency of patellar subluxation.

When the quadriceps contracted, two patterns of patellar shift were observed. While the patella reduced into the trochlear groove in all normal knees and about 70% of the symptomatic knees, contraction of the quadriceps caused further subluxation of the patella in the remaining symptomatic knees. All the knee joints which showed this displacement failed to respond to conservative treatment and eventually required surgical treatment. Thus, this technique of stress radiography is a simple, cost-effective and useful method of evaluating patellar instability and predicting the prognosis.

Although patellofemoral instability is common in the adolescent knee, it is not easy to evaluate the pathology with conventional techniques of radiography. The instability is usually underestimated, and even undetectable because the joint is often congruous at rest. Several radiographic techniques and methods of measurement have been proposed, but their diagnostic value is limited. Many investigators have devised methods of stress radiography and instrumented measurement to demonstrate instability. Techniques using CT and MRI have been reported to give good results. However, in spite of their advantages, these methods have not proved to be suitable for routine clinical use due to their specificity, complexity or expense.

Based upon the dynamics and mechanism of subluxation, we have developed a new method of stress radiography for patellofemoral instability, and have used it in evaluating a series of patients.

Patients and Methods

Between April 1992 and March 2001, stress radiography was performed on 94 knees in 71 patients who had a clinical diagnosis of recurrent dislocation or subluxation of the patella. Among this group, seven patients were lost to follow-up and were not included in the study. Three others were also excluded as they had knee problems other than patellar instability or a history of previous knee surgery. The remaining 82 knees in 61 patients were included in this series; 21 had bilateral symptoms. There were five males and 56 females with a mean age of 24.3 years (13 to 48).

Stress radiographs were routinely obtained at the initial visit. If the patient had knee pain or an effusion, the radiography was delayed three to eight weeks until the symptom improved.

All patients were initially treated conservatively with physiotherapy, strengthening by closed chain exercises, modification of athletic activities, and anti-inflammatory medication, followed by progressive rehabilitation. Patella bracing was used on 32 knees in 24 patients, mostly because these patients wanted to continue athletic activities. Conservative treatment was continued for at least three months. If the symptoms did not improve to a satisfactory state, proximal and distal realignment surgery was performed. Recurrent patellar subluxation during daily activities was a
clear indication for operative treatment. Those patients who were treated without surgery were re-examined at one year after the initial stress radiography, using the functional score described by Kujala et al. They were questioned as to how often they had experienced insecurity or giving way in the course of their daily activities during the previous month. For those who had surgical treatment, the evaluation was performed immediately before surgery.

Control radiographs were taken of 44 knees of 22 volunteers who had no history of knee pathology and a normal knee on examination. This control group comprised four males and 18 females; their mean age was 23.9 years (17 to 32).

**Radiography.** An axial radiograph was obtained according to the method of Merchant et al., with valgus and external rotational stress on the knee joint (Fig. 1). The patient was placed supine on the radiography table, with the knees flexed at 45° over the edge of the table, using a standard Merchant frame with the quadriceps muscle relaxed. The angle of flexion was confirmed with a goniometer in each patient. Wearing lead gloves and an apron, the examiner applied valgus and external rotational stress to the knee. For this, the foot was pulled laterally and rotated externally with one hand, while the thigh was stabilised with the other. The maximum strain was applied without causing discomfort. The radiographic tube was placed proximally, with the film cassette positioned distally on the lower leg, perpendicular to the X-ray beam (Fig. 1, arrow). A standard distance of 120 cm was maintained between the tube and the film. The first radiograph was taken in this position with complete relaxation of the thigh muscles. Subsequently, the patient was instructed to contract the quadriceps muscles isometrically, resisting the examiner’s hand, and the second radiograph was obtained.

On these radiographs, the lateral patellofemoral angle and congruence angle were measured and compared with those on the conventional Merchant views (Fig. 2). In order to determine the clinical significance of the radiographic parameters, the correlation was studied between each of the parameters and the functional scores which were obtained one year after the radiography. Furthermore, the relationship between these parameters and the frequency of patellar subluxation in daily activities was established.

Linear regression analysis and one-way factorial analysis of variance (one-way ANOVA) were used for statistical analysis, and Fischer’s PLSD was used as a post-hoc test when necessary. The calculation was performed using a Statview software package 5.0 (SAS Institute, Cary, North Carolina), and a p value of < 0.05 was set as significant.
Results

In 15 symptomatic knees, the stress radiographs were taken at intervals of between two and seven months. Differences between the parameters obtained on these two separate occasions were within 6%, indicating that the method has an acceptable reproducibility. Forty-eight knees were treated conservatively and 34 surgically. Clinical evaluation was performed after a mean of 14.2 months (11 to 19) for the knees treated conservatively, and 8.5 months (5 to 14) for those treated surgically.

With the quadriceps muscle relaxed, valgus and external rotation stress produced a lateral shift of the patella. This was observed in both normal and symptomatic knees, but its extent was much smaller in normal knees (Fig. 3, middle column). The lateral patellofemoral angle

| Table I. Comparison of radiographic parameters between the conventional Merchant view and stress radiography obtained without quadriceps contraction |
|-----------------|-----------------|-----------------|
|                 | Merchant view   | Stress radiography without quadriceps contraction |
| Lateral patellofemoral angle |                 |                 |
| Control knee    | 44   | 9.8 ± 2.6  | 7.5 ± 2.7  |
| Symptomatic knee| 82   | 1.7 ± 5.6  | -10.6 ± 6.4|
| Congruence angle|                 |                 |
| Control knee    | 44   | -7.3 ± 8.1  | 10.2 ± 10.6|
| Symptomatic knee| 82   | 11.7 ± 11.2 | 44.7 ± 13.5|

Data are shown as mean ± SD
decreased and the congruence angle increased when stress was applied (Table I). The change in these angles was greater in the symptomatic knees. Consequently, the differences in these parameters between the normal and symptomatic knees were more obvious on the stress radiographs, compared with those on the conventional Merchant views. In particular, the difference in lateral patellofemoral angles was so apparent that the two groups were clearly distinguishable (Fig. 4), which was not possible using either of the parameters on the conventional Merchant views.

Of the two radiographic parameters evaluated, congruence angles on the stress radiographs without quadriceps contraction had a significant correlation with the patients’ functional scores obtained after a series of conservative treatments ($r = -0.242$, $p < 0.0001$) (Fig. 5). Furthermore when comparing the four groups of symptomatic knees, divided according to the frequency of patellar subluxation, congruence angles were significantly different ($p < 0.0001$ or $p < 0.05$) (Fig. 6). The differences in the lateral patellofemoral angles did not reach significance.

In normal knee joints, quadriceps contraction caused a reduction of the patella into the trochlear groove (Fig. 3a, right column and Fig. 4). In knees with an unstable patella two patterns of patellar shift were observed with quadriceps contraction. In 59 of 82 symptomatic knees, the patella reduced into the femoral trochlea in a manner similar to the normal knees (Fig. 3b, right column and Fig. 4). Contraction of the quadriceps muscle induced a further subluxation of the patella in the remaining 23 symptomatic knees, and in those knees, the lateral patellofemoral angles were reduced (Fig. 3c, right column and Fig. 4). A review of patient records revealed that all these knees eventually required surgical treatment, after the failure of conservative treatment.

Discussion

Patellar subluxation often occurs with abduction and external rotation of the knee. Using stress radiography, we attempted to reproduce the location of the patella in that situation. When abduction and external rotation stress is applied to the knee, the patella is pulled laterally by the iliotibial tract through the lateral retinaculum. Since the tibial tuberosity shifts laterally with the stress, the patellar tendon may pull the patella laterally even when the quadriceps
muscle is relaxed. Therefore, if the medial retinaculum is stretched and the femoral facet is shallow, the patella is unstable and shifts laterally. Our observations demonstrate that the lateral patellofemoral angle on a stress radiograph is a reliable indicator of patellofemoral instability.

Another system of stress radiography with external rotation alone has been reported previously.\(^\text{1,6}\) Although no comparison was performed, we think that the current method could be more useful. This technique reveals the apparently contradictory effect. In this study, we took radiographs at 45° of knee flexion, because it was often impossible to obtain a view at smaller angles of flexion when the quadriceps contracted. Although the position in flexion at 45° is often used for axial radiography,\(^\text{20}\) the patella is already engaged in the femoral trochlea in this position.\(^3,9\) Therefore, it is not surprising that the patella is reduced into the trochlear groove, in spite of an increased Q-angle.

We noted that all the knees in which quadriceps contraction caused further patellar subluxation in our series could not be managed conservatively and required operative treatment. Since no traumatic force was necessary to produce patellar shift seen on the stress radiograph, the shift of the patella observed with quadriceps contraction can happen during daily activities.

We believe that this study has shown our method of stress radiography to be useful for both the detection of patellofemoral instability and the prediction of the patient’s prognosis. Since no special device is necessary and two images are enough for an evaluation, stress radiography can be a rapid, cost-effective method of screening.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


