POSTERIOR INSTABILITY OF THE KNEE NEAR EXTENSION

A CLINICAL AND STRESS RADIOGRAPHIC ANALYSIS OF ACUTE INJURIES OF THE POSTERIOR CRUCIATE LIGAMENT

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We evaluated the accuracy of six clinical tests for posterior instability in 24 knees with acute surgically-proven posterior cruciate ligament injuries and intact anterior cruciate ligaments. We also performed stress radiography under anaesthesia.

The gravity sign and the posterior drawer test in near extension and its passive reduction were diagnostic in 20 of the 24 knees, and the active reduction of posterior subluxation was diagnostic in 18. The reversed pivot shift sign helped to diagnose severe posterior and posterolateral subluxations, but the external rotation recurvatum test was negative in all 24 knees. Stress radiography in near extension revealed a highly significant increase in posterior tibial subluxation in the injured knees.

Testing for an acute posterior cruciate ligament injury is frequently difficult: a tense haemarthrosis, skin abrasions or lacerations and concomitant injuries may prevent adequate clinical evaluation because of pain, so that examination without anaesthesia and relaxation is not reliable. At 20° of knee flexion (near extension), anterior instability tests for anterior cruciate ligament injury have a high diagnostic value (Palmer 1938; Torg, Conrad and Kalen 1976; de Montmollin and Le Coeur 1980; Jonsson et al 1982; Daniel et al 1985; Donaldson, Warren and Wickiewicz 1985; Müller et al 1988), but testing for posterior cruciate ligament injuries near extension is controversial: Trillat, Dejour and Bousquet, personal communication (1977) and Chambat (1978), considered that posterior tibial subluxation was diagnostic for posterior cruciate injuries, and Müller (1983) advocated testing in 30° of knee flexion. On the contrary, Trickey (1980) stated that abnormal anteroposterior laxity at 10° of knee flexion only indicated a torn anterior cruciate ligament and that the movement was anterior.

We have attempted to determine the diagnostic value of six clinical tests for abnormal posterior knee movement near extension in patients with known acute posterior cruciate ligament injuries, using stress radiography near extension as well as clinical evaluation under anaesthesia.

PATIENTS AND METHODS

We studied 24 acute, surgically-proven posterior cruciate ligament injuries in 22 patients, two with simultaneous bilateral injuries. The anterior cruciate ligament was intact in all 24 knees. Eighteen injuries were in men and six in women; their average age was 32 years (range 16

Fig. 1

Gravity sign near extension. The unsupported proximal tibia is displaced by gravity giving a concave anterior contour, tilting the patella downwards, and displacing the tibial tubercle posteriorly as compared with the uninvolved opposite knee. Both tibial plateaux can be felt in a position relatively posterior with respect to the femoral condyles.

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to 47 years). In 18 patients the initial injury occurred in a high velocity motor vehicle accident; only six were due to sporting activities. The left knee was affected 14 times; the right knee 10 times. Fourteen injuries were in victims of multiple trauma, only 10 were isolated events.

Resting position. Each patient was examined lying supine, with both distal femora supported by a 15 cm thigh support and both heels resting on the end of the examining table. The proximal tibia was not supported and the thigh muscles were relaxed, with the knee in slight flexion (10° to 15°).

Clinical tests. The results of six clinical tests were recorded. The gravity sign near extension (Fig. 1) and the active reduction of posterior tibial subluxation (Fig. 2) were observed in the conscious patient. Anaesthesia was then induced and the passive posterior drawer test near extension (Fig. 3), passive reduction into the neutral position (Fig. 4), the external rotational recurvatum test (Hughston and Norwood 1980), and the reversed pivot shift test (Jakob, Hassler and Staebli 1981) were performed.

Stress radiography. Stress radiographs were taken (Figs 5 and 6) to document the direction, magnitude and limit of tibial subluxation near extension (Stäubli et al 1983, 1985).

Posterior stress. With a thigh support under the distal femur, a manual force of 25 to 30 kg was applied downward on the tibia (in each case by the same examiner, H-US). After two preloading cycles, a stress radiograph was taken in the posteriorly-loaded position (Fig. 6) with the radiographic tube orientated from 6° to 8° craniolaterally to caudomedially so that the central ray was through the superimposed femoral condyles.

Anterior stress. An anterior stress radiograph was obtained by placing the thigh support under the proximal tibia (Fig. 5), with a manual load applied downward on the femur; 10° of knee flexion was maintained by holding the heel down on the examining table, resulting in an anterior force vector at the proximal tibia (Jakob, Stäubli and Deland 1987).

On the films, lines were drawn parallel to the posterior aspect of the cortex of the middle third of the tibial shaft, tangential to the most posterior aspects of the medial and lateral tibial plateaux and the femoral condyles (Fig. 7). These landmarks were then used to measure skeletal displacement in the medial and the lateral compartments of the knee.

RESULTS

Clinical tests without anaesthesia. The gravity sign near extension was detectable in 20 knees, but in the other four, two with ipsilateral femoral and tibial shaft fractures and two with interposed bucket handle tears of the lateral meniscus, the test was unreliable. In 18 of the 20 with obvious posterior subluxation, active reduction was possible by quadriceps contraction.

Fig. 2

Active reduction of posterior tibial subluxation. The patient is asked to lift the heel 2 to 3 cm from the table; the resulting changes are observed from the lateral side of the knee. The gravity sign near extension is reduced, restoring anterior contour of the involved knee to normal and reversing posterior sagging. A normal relationship between the anterior margins of the tibial plateaux and the femoral condyles is restored.

Fig. 3

Passive posterior drawer test near extension. A posterior force is applied to the proximal tibia with one hand and the thumb and index finger of the other hand are used to palpate the anterior margins of the tibial plateaux and their relation to the femoral condyles, estimating compartmental shift in millimetres for both the injured and uninvolved knees. The stiffness of the posterior end-point is recorded and the posterior tibial subluxation is graded from 0 to 4 (Müller et al 1988).

Fig. 4

Passive reduction of posterior tibial subluxation. The examiner applies an anterior force to the proximal tibia, reducing tibial subluxation to the neutral position; any additional anterior displacement depends on the compliance of the anterior cruciate ligament. The anterior end-point is described as 'hard', 'altered', or 'soft'.

Lateral stress radiograph and diagram showing the *anterior* displacement of the medial and lateral tibial plateaux in a knee with an intact anterior cruciate ligament. Anterior displacement of the lateral plateau was 7 mm, that of the medial plateau was 2 mm. This is normal anterior joint play. AD – anterior displacement.

Fig. 5

Lateral stress radiograph and diagram showing the *posterior* displacement of the tibial plateaux in a knee with a posterior cruciate ligament injury. Posterior displacement of the medial tibial plateau was 12 mm and of the lateral tibial plateau 8 mm. This represents postero-medial subluxation, due to injuries to the posterior cruciate ligament and the postero-medial structures. PD – posterior displacement.

Fig. 6

Table I. Clinical posterior tibial displacement under anaesthesia in 24 knees with posterior cruciate injury

Grade	Displacement (in mm)*	Number of knees
0	0 to 2	0
1	3 to 5	0
2	6 to 10	5
3	11 to 15	11
4	16 to 20	4
Uncertain		4

* in near extension; in near flexion average results were one grade higher

Table II. Posterior displacement of medial and lateral compartments on stress radiographs

	Posterior cruciate ligament			
	Intact* (n = 114)		Deficient (n = 24)	
	Medial	Lateral	Medial	Lateral
Displacement ± range (mm)	4.0 ± 3.0	3.3 ± 2.6	10.7 ± 2.4†	10.0 ± 3.9†
Mean	3.7 ± 2.1		10.4 ± 2.4†	

* results for normal knees from Stäubli et al (1989)

† difference from intact knees highly significant, $p < 0.001$

Clinical tests under anaesthesia. Under anaesthesia, 20 knees showed a positive passive posterior drawer sign with the knee near extension; this ranged from 2 + to 4 + (Table I). The posterior cruciate end-point was judged 'hard' in two, 'altered' in 12, and 'altered-soft' in

Fig. 7

Diagram of a posterior stress radiograph. Lines parallel to the posterior tibial cortex (PTC) are drawn tangential to the most posterior contour of medial (FTM) and lateral (FTL) femoral condyles and the medial (TTM) and lateral (TTL) tibial plateaux. The distances between these tangential lines are measured directly on the radiograph. In this knee the posterior displacement of the lateral tibial plateau was 8 mm and of the medial tibial plateau 13 mm, showing both posterior translation and internal rotation, representing posterior cruciate ligament rupture with damage to the posteromedial structures.

six knees. The posterior tibial subluxation could be reduced passively into the neutral position in 20 knees all of which showed a firm anterior cruciate ligament end-point.

The external rotational recurvatum test was negative in 20 knees and the reversed pivot shift was graded negative in three knees, 1 + in two, 2 + in 11 and 3 + in four.

Stress radiography. The mean posterior displacement of the medial tibial plateau was 10.7 ± 2.4 mm and of the lateral tibial plateau 10.0 ± 3.9 mm (Table II). There

Fig. 8

Diagrams to show the three types of posterior subluxation in a near extended position. In *posterior subluxation*, the posterior displacements of the medial and lateral compartments are approximately equal. In *posterolateral subluxation*, the posterior displacement of the lateral tibial plateau is greater than that of the medial plateau. There is combined posterior translation and lateral rotation, due to injury of the posterior cruciate and of the posterolateral structures. In *posteromedial subluxation*, the posterior displacement of the medial tibial plateau is greater than that of the lateral plateau. There is combined posterior translation and medial rotation.

was no statistical difference between mean posteromedial and mean posterolateral tibial displacement, but further analysis showed that there were three kinds of abnormal movement patterns. These were: posterior subluxation, posterolateral subluxation, and posteromedial subluxation (Fig. 8). Each had specific anatomical defects.

DISCUSSION

Fukubayashi et al (1982) demonstrated experimentally that isolated division of the posterior cruciate ligament allows increased posterior subluxation of the tibia on the femur irrespective of the flexion angle during the tests. However, comparing posterior subluxation near extension with that near flexion, an average increase of 5 mm of posterior tibial displacement could be detected in the flexed position (Table I). This may be due to progressive retensioning, that is, the recruiting of more posterior cruciate ligament fibres when the knee reaches full extension (O'Brian et al personal communication 1988).

Our clinical findings agree with those of Grood, Stowers and Noyes (1988) that, after section of the posterior cruciate ligament, there is a progressive increase in posterior translation with an increasing angle of flexion (Fig. 9). Our findings from stress radiography agree with

biomechanical evaluations of anteroposterior knee movement in vitro (Fukubayashi et al 1982) and in vivo (Torzilli, Greenberg and Insall 1981).

At the initial clinical evaluation of an acute posterior cruciate ligament injury, there may be only a small posterior tibial shift when the knee is tested at 0° to 15° of flexion. This may be explained by the orientation of the posterior cruciate ligament fibres near extension (Grigis et al 1975; Odensten and Gillquist 1988).

Importance of the resting position. Butler, Noyes and Grood (1980) observed that a false-positive anterior drawer test after rupture of the posterior cruciate ligament may be recorded because of the posterior shift in the starting position of the tibia. This is true for both active and passive drawer tests, both near extension and near flexion. De Montmollin and Le Coeur (1980) and Cross, Schmidt and Mackie (1987), noted that active contraction of the quadriceps in an anterior cruciate ligament deficient knee causes the tibia to displace anteriorly. This active anterior drawer test in 30° of knee flexion must be differentiated from the active reduction of posterior tibial subluxation into the neutral position.

In a posterior cruciate deficient knee, with gravity induced posterior subluxation of the tibia in the starting position (Trickey 1968, 1978), the patellar tendon has a

Fig. 9

Posterior stress radiographs at 10°, 20°, 60° and 80° flexion with a constant posterior load, show an increasing posterior subluxation with increasing flexion.

posterior orientation. Contraction of the quadriceps then results in an anterior force vector (Daniel et al 1988). If posterior sagging near extension and the altered posterior end-point stiffness are not perceived at the initial clinical evaluation, reduction of posterior tibial subluxation into the neutral position may be misinterpreted and recorded as anterior tibial displacement (Daniel et al 1988).

We found that the reversed pivot shift was markedly positive in posterolateral subluxation of the tibia (Jakob et al 1981). These clinical results agree with the experimental finding by Grood et al (1988) that subsequent to the functional loss of the posterior cruciate ligament the posterolateral structures (including the popliteus tendon) play an important role in limiting posterior translation and external rotation of the tibia in respect to the femur. This observation is consistent with the biomechanical measurements of Butler et al (1980): after loss of the posterior cruciate ligament, the arcuate ligament complex provided 58% of the secondary restraint to the posterior drawer test.

The external rotational recurvatum test, however, was never positive in our series. This may be due to the

fact that all our patients had a competent anterior cruciate ligament which precluded hyperextension (Kennedy and Grainger 1967). These findings support those of Trickey (1980), who stated that complete division of the posterior cruciate ligament and the entire posterior capsule will not permit the joint to hyperextend unless there is some stretching of the anterior cruciate ligament. This contrasts with the findings of Hughston et al (1980) and Baker, Norwood and Hughston (1984) in their reports on the clinical significance of the external rotational recurvatum test in acute and chronic posterolateral knee instability.

Conclusions. We detected three kinds of abnormal posterior knee movement both clinically and by stress radiography (Fig. 8):

- 1) posterior translation alone (*posterior subluxation*);
- 2) posterior translation and medial rotation (*posteromedial subluxation*); and
- 3) posterior translation and lateral rotation (*posterolateral subluxation*).

Posterior stress radiography in a near extended position revealed significant posterior tibial subluxation in all our cases and was a valuable adjunct in determining the limits of compartmental subluxation after an acute posterior cruciate ligament injury.

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