RADIOGRAPHIC ASSESSMENT IN PATELLAR INSTABILITY AND CHONDROMALACIA PATELLAE

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Minor degrees of malalignment of the patella and anatomical abnormalities including a flattened sulcus angle and an increased ratio between patellar tendon length and patellar length (PT:P) have been suggested as predisposing factors in the causation of chondromalacia patellae, as well as patellar instability. In order to confirm or refute this hypothesis a prospective study has been performed comparing the congruence and sulcus angles and the PT:P ratio in a group of 35 patients with chondromalacia confirmed by arthroscopy and a group of 33 patients with instability, with those of a group of 50 knees in normal volunteers.

While there was a statistically significant correlation between an increased sulcus and congruence angle and a high-riding patella in patients with instability, no correlation could be identified in patients with idiopathic chondromalacia.

Anterior knee pain can be due to a number of conditions of which the most controversial is chondromalacia patellae. This is a clinical syndrome characterised by persistent retropatellar pain following either prolonged sitting with the knees flexed or athletic activity; it is accompanied by fibrillation of the cartilage of the undersurface of the patella. These articular cartilage changes are predominantly found on the medial and "odd" facets and are most probably due to a combination of compression and shearing stresses. There is no clear relationship with instability of the patella, though several authors have suggested the possibility (Hughston 1968; Insall, Falvo and Wise 1976). Other authors (Lancourt and Cristini 1975; Aglietti and Cerulli 1979) have considered that minor degrees of malalignment of the patella with the femoral condyles is an important causative factor in the aetiology of chondromalacia.

Several radiographic techniques have recently been described which are claimed to be useful in indicating anatomical anomalies of patellar alignment associated with either patellar instability or chondromalacia. Laurin *et al.* (1978) described a radiographic technique in which the knees were flexed 20° to 30°. From the resulting tangential radiograph of the patellae the angle was drawn between a line across the femoral condyles and a line from the lowest point on the patella to its most lateral point on the articular surface (the patellofemoral angle). They found that the angle opened laterally in 97 of 100 normal patients and the two lines were parallel in

three patients. In 30 patients with subluxation of the patella, the lines formed an angle open medially in six and were parallel in 24. In patients with chondromalacia, the radiographic study was of no diagnostic value. Merchant *et al.* (1974) described the "congruence angle" of the patella in tangential radiographs taken with the knee flexed at 45° (Fig. 1). A congruence angle with a value of +16° indicated instability of the patella. In addition, these authors pointed out that a flattened sulcus angle (Fig. 1) of the femoral condyles was associated with instability of the patella. Aglietti and Cerulli (1979), using the same technique, confirmed the findings for patellar instability and also stated that both the congruence angle and the sulcus angle were significantly increased in patients with chondromalacia. The diagnosis in their study was based solely on clinical symptoms and signs without arthroscopic confirmation.

Insall and Salvati (1971) described a technique of

Fig. 1

Congruence angle: the angle (XAD) between the line from the lowest point on the patella (D) to the lowest point in the sulcus (A) and the line bisecting the sulcus angle (XA). Sulcus angle: the angle (BAC) between the highest point of the medial (B) and lateral (C) condyle and the lowest point in the sulcus (Merchant *et al.* 1974).

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0301-620X/86/2065 \$2.00

Fig. 2

The patellar tendon:patella ratio (Insall and Salvati 1971) is the comparison of the length *BC* to *AB*, in this case being 1.8.

measuring the position of the patella by comparing the length of the patellar tendon with the diagonal length of the patella using the lateral radiograph of the knee when flexed about 30° (Fig. 2). Using this technique, several authors have claimed that an increased ratio was found in patients with patellar instability and in patients with chondromalacia (Lancourt and Cristini 1975; Aglietti and Cerulli 1979). Marks and Bentley (1978), however, found a correlation with chondromalacia only when this was very severe.

In order to evaluate the significance of the congruence angle, sulcus angle and patellar tendon-patella (PT:P) ratio in identifying minor degrees of malalignment in patients with patellofemoral pain, a prospective study was performed in patients with chondromalacia proven by arthroscopy and in those with patellar instability diagnosed by examination under general anaesthesia. These were compared with a comparable group of knees in normal volunteers of both sexes and within the same age group.

MATERIALS AND METHODS

Radiographs were taken of a control group of 50 normal knees in volunteers without any knee symptoms. There were 30 males and 20 females with an age range of 11 to 39 years (mean 24 years). This control group was compared with a group of 35 patients (13 male, 22 female) with chondromalacia proven clinically and arthroscopically without evidence of patellar instability (age range 11 to 28 years; mean 23 years). A further group of 33 patients (11 male, 22 female) with patellar instability, seven with bilateral symptoms and signs, were included in

the investigation (age range 14 to 35 years; mean 25 years). Patellar instability was diagnosed in those patients with a definite history of patellar dislocation or in those with a history of giving way of the knee, associated with patellar laxity confirmed on examination under general anaesthesia. Instability was confirmed to be present when the medial edge of the patella could be pushed onto the edge of the lateral margin of the femoral groove.

Tangential radiographs of the knees were taken using the technique described by Merchant *et al.* (1974), but with the knee flexed to 30°. From the radiographs, both the sulcus angle and the congruence angles were measured (Fig. 1). Lateral radiographs of the knees were taken with the knees flexed between 30° and 50° to ensure that the patellar tendon was tense; the ratio between the lengths of the patellar tendon and the length of the patella was measured (Fig. 2).

RESULTS

Controls: Normal knees (Tables I and II). In the control group, the mean sulcus angle was 139°, the congruence angle -8.1°, and the PT:P ratio 1.03. The results in the two sexes were compared using the Student's *t*-test. In the normal group of knees, the mean sulcus angle and congruence angle were not significantly different in males and females. However, there was a significantly increased incidence of a high-riding patella in females ($P < 0.001$).

Table I. Radiographic measurements in 50 normal knees

	Mean	Range	SD
Congruence angle	-8.1	-20 to +10	±6.8
Sulcus angle	139	120 to 150	±6.3
PT:P ratio	1.03	0.8 to 1.4	±0.13

PT:P, patellar tendon:patella ratio

Table II. PT:P ratios in 50 normal knees

	Men <i>n</i> = 30	Women <i>n</i> = 20
Mean	1.01	1.13
Range	0.8 to 1.4	0.84 to 1.4
SD	±0.1	±0.18

$P < 0.001$

Patients with chondromalacia (Table III). The sulcus angle, congruence angle and PT:P ratio in the group with chondromalacia showed no significant difference compared to the control group; nor was there any statistical difference for the three measurements when the groups were sex-matched.

Patients with instability (Table IV). When the three measurements in the group with patellar instability were compared with those of the control group, both the sulcus angle and the PT:P ratio were found to be significantly

Table III. Radiographic measurements in 35 knees with chondromalacia

	Mean	Range	SD
Congruence angle	-6.48	-30 to +3	±6.7
Sulcus angle	138	120 to 150	±8.1
PT:P ratio	1.09	0.75 to 1.34	±0.16

There was no statistically significant difference between these figures and those of normal knees

Table IV. Radiographic measurements in 40 knees with patellar instability

	Mean	Range	SD	P value*
Congruence angle	-1.8	-30 to +55	±20.3	<0.05
Sulcus angle	147	137 to 172	±7.3	<0.001
PT:P ratio	1.25	1.04 to 1.62	±0.13	<0.001

* When compared with the normal knees

increased ($P < 0.001$), but there was a less significant difference in the congruence angle ($P < 0.05$) (Table IV). In fact, only 8 out of the 40 knees with instability had a congruence angle greater than the 95th percentile of the normal group. Comparison of control and unstable knees when sex-matched produced similar results.

DISCUSSION

Radiographic diagnosis of patellar instability (subluxation and dislocation)

Both Merchant *et al.* (1974) and Aglietti and Cerulli (1979) found that the congruence angle was significantly increased in patients with patellar instability. Our series showed a similar trend when patients with subluxation and obvious recurrent dislocation were grouped together. However, in only 8 of the 40 patients with instability was the congruence angle outside the 95th percentile of the normal group and in these eight recurrent dislocation was obvious from the history and clinical examination (Fig. 3). Furthermore, other patients with definite instability had normal congruence angles (Fig. 4). These findings suggest that measurement of the congruence angle is not a useful method of identifying lesser degrees of subluxation and that it confirms the diagnosis in only some patients with clinically obvious subluxation or dislocation. One of the main reasons for this may be that instability appears to be a dynamic phenomenon associated with capsular laxity probably combined with abnormal muscle pull and an abnormal insertion of the patellar tendon, factors which in themselves may not produce changes on the tangential radiograph which is taken in a static situation. A statistically

Fig. 3

Tangential radiographs of the patellofemoral joints in a 25-year-old man. Bilateral subluxation of the patella with abnormal congruence angles (left +20, right +30), sulcus angles (left 150, right 172) and patella alta (high PT:P ratio - left 1.3, right 1.5).

Fig. 4

Tangential radiograph of a 16-year-old girl with bilateral recurrent dislocation of the patellae. The sulcus angle, congruence angles and PT:P ratio were within normal limits.

Fig. 5

Tangential radiographs of a 19-year-old girl with recurrent dislocation of the patella with abnormal sulcus angles (left 150°, right 151°) and PT:P ratio (left 1.3, right 1.27), but normal congruence angles.

significant increased sulcus angle (Fig. 5) and PT:P ratio were observed in this series, confirming the findings of previous authors (Brattström 1964; Merchant *et al.* 1974; Aglietti and Cerulli 1979). However, these measurements were found to be within the normal range in a few patients with obvious instability and outside the normal range in patients without symptoms.

Radiographic diagnosis of chondromalacia patellae

Aglietti and Cerulli (1979) stated that there was a significant increase in both the sulcus angle and the congruence angle in patients with chondromalacia patellae. These findings were not confirmed in our series. In their paper, the diagnosis of chondromalacia was not confirmed by arthroscopic examination or by examination under anaesthesia to exclude instability. Leslie and Bentley (1978) have shown that only 50% of patients with a clinical diagnosis of chondromalacia have changes on the patellar surface at arthroscopy. In our series, other causes of patellofemoral pain, especially instability, were carefully excluded and arthroscopic confirmation of the diagnosis was made. Previous authors including Lancourt and Cristini (1975) and Aglietti and Cerulli (1979) showed a statistically significant relationship between a high-riding patella and clinically diagnosed chondromalacia of the patella. Marks and Bentley (1978) pointed out that the study by Lancourt and Cristini may have contained false-positives since the diagnosis was not confirmed by arthroscopy. The latter also used males as controls and compared them with a group of patients who were probably predominantly female. Again, in the study by Aglietti and Cerulli, the control group were not sex-matched to patients with chondromalacia. In our series, there was a statistically significant difference in the control group between the mean of the PT:P ratio in males compared with females, but no difference between normal females and females with chondromalacia, and normal males and males with chondromalacia. We consider that the reported higher ratio in patients with chondromalacia simply reflects the higher incidence of the disease in females, who normally have a higher PT:P

ratio and does not demonstrate a relationship between a high-riding patella and chondromalacia.

CONCLUSIONS

The present investigation confirmed that patellar instability was associated with an increased PT:P ratio and an increased femoral sulcus angle above 139°. However, an abnormal congruence angle was present in only 20% of patients with instability and those patients had clinically obvious instability. Mild degrees of instability assessed clinically were not associated with significant alteration in the congruence angle.

We found that patients with chondromalacia patellae affecting the medial or "odd" facets without clinical instability did not have malalignment of the patella which could be detected radiologically by measurement of the congruence angle, or by measurement of an anatomical abnormality such as an increased femoral sulcus angle or increased patellar tendon length in relation to patellar length.

REFERENCES

- Aglietti P, Cerulli G. Chondromalacia and recurrent subluxation of the patella: a study of malalignment, with some indications for radiography. *Ital J Orthop Traumatol* 1979;5:187-201.
- Brattström H. Shape of the intercondylar groove normally and in recurrent dislocation of patella: a clinical and X-ray anatomical investigation. *Acta Orthop Scand* 1964;Suppl 68:1-148.
- Hughston JC. Subluxation of the patella. *J Bone Joint Surg [Am]* 1968;50 A:1003-26.
- Insall J, Falvo KA, Wise DW. Chondromalacia patellae: a prospective study. *J Bone Joint Surg [Am]* 1976;58 A:1-8.
- Insall J, Salvati E. Patella position in the normal knee joint. *Radiology* 1971;101:101-4.
- Lancourt JE, Cristini JA. Patella alta and patella infera: their etiological role in patellar dislocation, chondromalacia, and apophysitis of the tibial tubercle. *J Bone Joint Surg [Am]* 1975;57 A:1112-5.
- Laurin CA, Lévesque HP, Dussault R, Labelle H, Peides JP. The abnormal lateral patellofemoral angle: a diagnostic roentgenographic sign of recurrent patellar subluxation. *J Bone Joint Surg [Am]* 1978;60 A:55-60.
- Leslie JJ, Bentley G. Arthroscopy in the diagnosis of chondromalacia patellae. *Ann Rheum Dis* 1978;37:540-7.
- Marks KE, Bentley G. Patella alta and chondromalacia. *J Bone Joint Surg [Br]* 1978;60 B:71-3.
- Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg [Am]* 1974;56 A:1391-6.