From the University Department of Orthopedics in Lund, Sweden

The Dislocating Patella

Etiology and Prognosis in Relation to Generalized Joint Laxity and Anatomy of the Patellar Articulation

BY

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To Margaretha, Elisabeth and Johan

Contents

Figures

Tables

Definitions

Quadriceps muscle	The rectus femoris, vastus intermedius, medialis and lateralis muscles
Quadriceps tendon	The patella and the patellar ligament
Q-angle	The angle between the quadriceps muscle and the quadriceps tendon
Insall index	The relation between the ligamentous and patellar portions of the quadriceps tendon
Norman index	The vertical position of the articulating surface of the patella in relation to the distal part of the femoral condyles
Condylar angle	The angle between the femoral condyles in the condylar groove
Fractures	*avulsion fracture,* avulsion of a bone fragment from the medial margin of the patella, corresponding to the insertion of the capsule *osteochondral fracture,* fracture engaging the articular surface of the patella or femoral condyle
Quadriceps transfer	Distal and/or medial transfer of the quadriceps tendon

Introduction

The dislocating patella has been a focus of interest for successive generations at the Department of Orthopedics in Lund after Gunnar Wiberg was appointed head in 1945. Wiberg (1941) described the different morphologic types of the patella, and he pointed out the importance of anatomic incongruence in the patellar articulation as a factor in cartilage degeneration. Ståhl (1950) was one of the first to describe the avulsion fracture associated with dislocation of the patella. Fractures in dislocation of the patella were further studied by Scheller and Mårtenson (1974) after the latter had moved to Gothenburg. Brattström (1964) analysed the patellar articulation radiographically, and demonstrated the association of dislocation with the shape of the condylar groove. Following this tradition I have tried to quantify Bauer's (1964) concept of the multifactorial etiology of patellar instability, presented as a Venn diagram of symbolic logic, unifying trauma, generalized laxity, and anatomic abnormality.

The purpose of this investigation was to explore the possibility that a clinically relevant classification of patellar instability can be derived from observations of generalized laxity and local anatomic abnormality.

The investigation was based on patients treated in the Department of Orthopedics and examined in the special unit for locomotor system problems, established 1953 by Olof Norman in the Department of Diagnostic Radiology.

Patients and Methods

This investigation included all patients treated during the period 1975—1977 at the Department of Orthopedics in Lund under the diagnosis dislocation of the patella; patients in whom the diagnosis had been made earlier and/or who had received treatment for this diagnosis earlier were included if they sought treatment during the period of the investigation. None of these patients had permanent dislocation nor systemic disease of the Marfan or Ehlers-Danlos types.

Criteria for diagnosis

All patients were examined at least once by me. The diagnosis required at least one of the following criteria:

(1) the patient or an onlooker had observed that the patella was dislocated;
(2) avulsion fracture from the patella and/or osteochondral fracture(s) of the patella or the lateral femoral condyle were observed by radiographic examination;
(3) the patient experienced giving way of the knee, that something got out of joint *and* had a positive apprehensive test (p 14);

Unless criteria 1 and 2 were present the diagnosis was not accepted in patients whose objective symptoms were adequately explained by some other intraarticular or ligamentous injury.

Probands

A total of 37 males and 67 females met the criteria for acceptance as probands (Figure 1). The age at examination was 22 (12—47) years in males and 22 (12—43) years in females. In 66 probands the patella had been observed to be dislocated, and in 20 of these fractures were identified radiographically. In 20 probands the diagnosis was made on the basis of radiographically identified fractures and positive apprehensive test. The apprehensive test was not performed in one proband operated acutely for fracture, and it was only questionably positive in one proband with fracture. All the other 102 probands had positive apprehensive tests; in 16 of these probands neither dislocation nor fractures were observed, but all complained that their knees gave way.

All data pertinent to this investigation are presented in code form in an appendix (p 47).

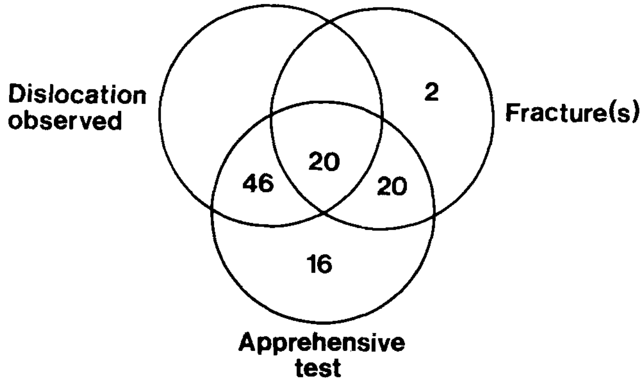


Figure 1. Diagnosis in patellar dislocation.

Diagnostic criteria applied to the probands of this investigation. In the 36 bilateral cases the diagnostic criteria were applied to the first dislocating knee.

Comments

It is easy to diagnose a patellar dislocation when it has stayed dislocated on the outer aspect of the lateral femoral condyle (Figure 2). The normal somewhat pointed profile of the knee is flattened, and the knee is painful and kept in flexion. In rare cases the knee joint may be extended or the patella may have rotated around its vertical axis. In this material the majority of the probands had observed that the patella was dislocated, and it usually reduced spontaneously. In patients who have not observed the dislocation the diagnosis can be difficult; such patients have usually felt that something got out of joint or that the knee gave way following minor trauma, for example during normal walking. Hemarthrosis may occur and when the blood contains fat, osteochondral fracture should be suspected (Scheller and Mårtenson 1974). In such cases radiographic identification of avulsion and/or osteochondral fracture may confirm the clinical suspicion that a dislocation had occurred (Ståhl 1950, Scheller and Mårtenson 1974); in 21 % of this material the diagnosis was confirmed in this way. However, identification of these fractures is not always easy and ususally requires an axial projection of the patellar articulation; this examination should be routine in the radiographic examination of all patients with knee problems (Ahlbäck 1968). The apprehensive test was positive in all but one of the 103 knees examined, and the test alone confirmed the history of patellar dislocation in only 16 % of the probands.

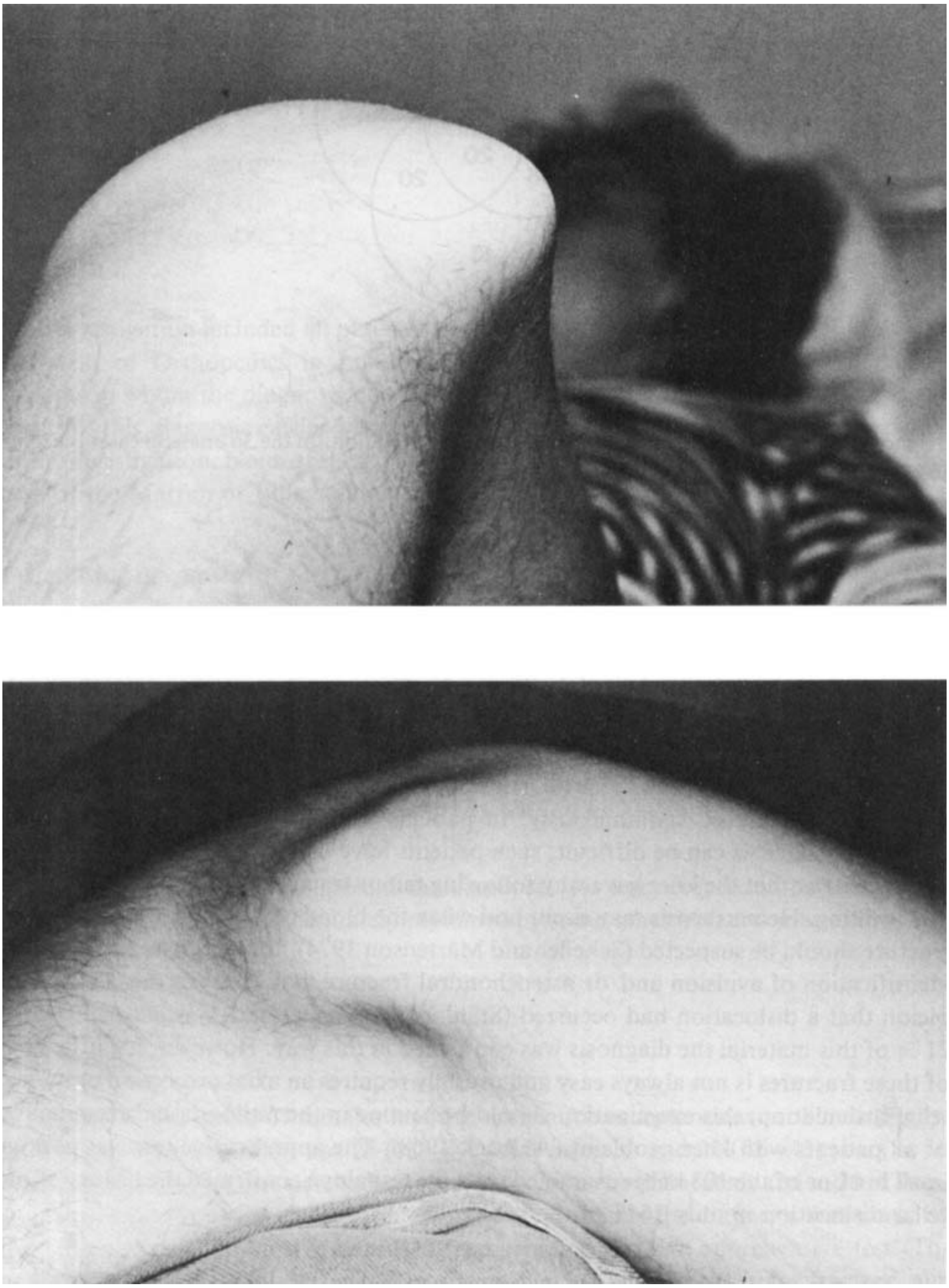


Figure 2. Dislocation of the patella (Case 10).

History

In minors the history was obtained also from the parent(s).

Age at the first dislocation

All probands could state the age when they first experienced dislocation of the patella. The age at onset was 15 (8—35) years in males and 13 (8—33) years in females.

Other joint disorders

Only non-traumatic disorders treated by an orthopedic surgeon were recorded. Seventeen males and 12 females had been treated. Seven males and 16 females had parents, siblings or own children with dislocation of the patella or congenital dislocation of the hip.

Bilateral dislocation

Bilateral dislocations occurred in 15 males and 21 females. The second knee dislocated 2 (0—16) years after the first.

Frequency of dislocations

The duration of symptoms due to a dislocating patella was two years or more in 97 probands for a mean observation time of 8 (2—25) years. Seven probands had had a stabilizing operation within two years of the first dislocation. Based on whether or not they had more than two dislocations per year the probands were divided into two groups. Forty-five probands had *frequent* dislocations; they often had a feeling of instability between the dislocation episodes. Fifty-two probands had *in-frequent* dislocations; they usually had a feeling of instability lasting only a couple of weeks after each frank dislocation. The total number of dislocations in probands with frequent dislocations could not be estimated; most of them had so many dislocations that they were not sure of the total number. Probands with in-frequent dislocations had had on average four dislocations. i.e. one dislocation every other year.

Trauma

Based on the physical activity and an estimate of the forces involved in the first dislocation episode the degree of trauma was estimated to have been either moderate or minor. Direct force against the patella or indirect forces associated with athletics or dance were labelled *moderate* in 57 probands. Indirect forces associated with every day activities, e.g. a slip or giving-way of the knee during walking, were labelled *minor* in 47 probands.

Clinical examination

The apprehensive test

Fairbank (1937) introduced the apprehensive test, and its importance has been generally accepted (Hughston 1968, Apley 1973, Ficat and Hungerford 1977, Larson 1979, Smillie 1979). The test was performed with the patient supine, relaxed and with extended knees (Figure 3). An attempt was made to dislocate the patella laterally with the thumb while bending the knee slightly. The test was judged positive when the patient recognized the uncomfortable sensation, usually pain, by character and location.

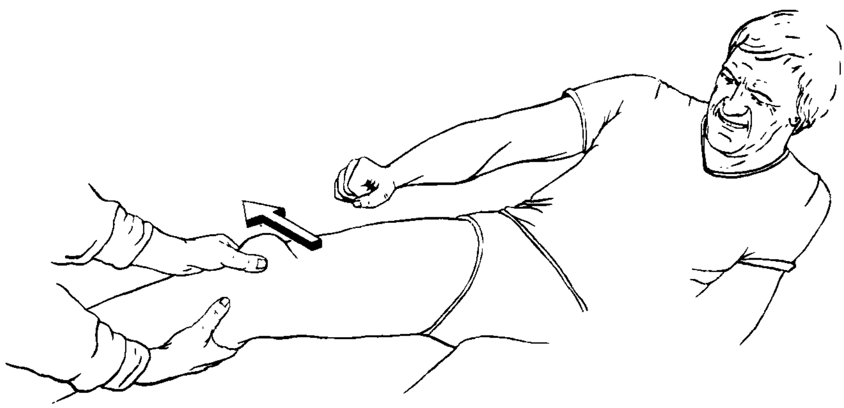


Figure 3. The apprehensive test.

Generalized joint laxity

All probands were examined for generalized joint laxity. Carter and Wilkinson (1964) have defined five tests, at least four of which have to be positive to permit the diagnosis.

(1) Hyperextension of the elbow >10°.
(2) Hyperextension of the knee joint >10°.
(3) Passive apposition of the thumb to the volar aspect of the forearm.
(4) Hyperextension of the fingers and the wrist so that the fingers are parallel with the dorsal aspect of the forearm.
(5) Dorsal hyperextension of the ankle >45°.

In this investigation I used only tests 1—3 (Figure 4) as I have found them easy to handle in clinical work. Elbow and knee extension were measured with a goniometre. To satisfy the diagnosis all three tests had to be positive. However, a distance of up to half a centimetre between the thumb and forearm was accepted as positive in the test of thumb apposition. The probands were compared with an age and sex matched *control*

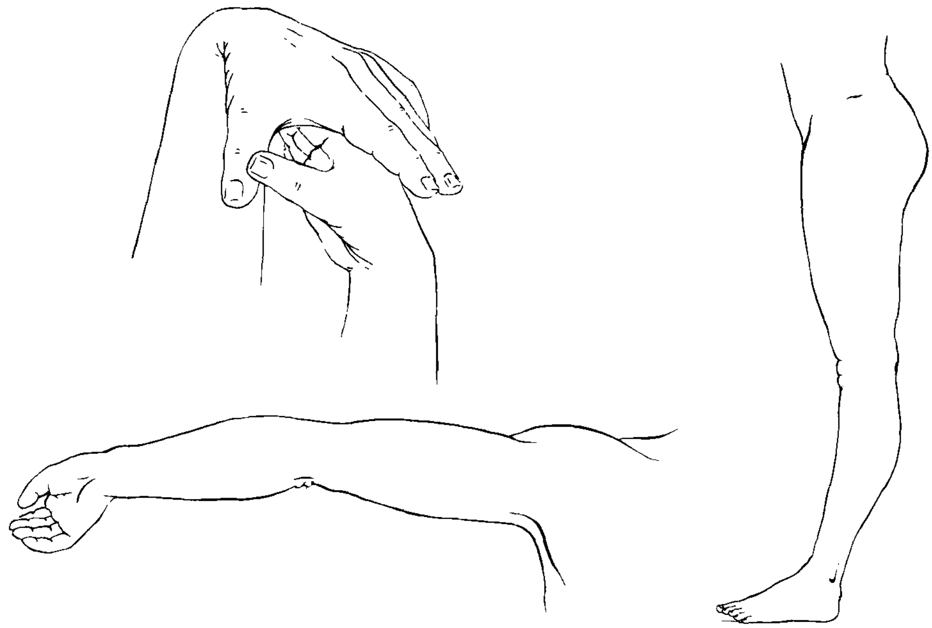


Figure 4. Tests for diagnosis of generalized joint laxity.

population consisting of 110 hospital personnel and school children without history of dislocation of the patella or other joint disorders.

Comments

In patients with generalized joint laxity the differential diagnosis between dislocation of the patella and ligamentous rupture(s) may be difficult; in lax patients the knee joint may be stable laterally only in hyperextension, and it may be so unstable sagitally that a rupture of the cruciate ligament(s) can be suspected. The patella may also be so unstable that the apprehensive test causes discomfort which, however, is not recognized by patients who have not had a dislocating patella. I usually tested apprehension at the end of the examination of the knee joints so that the patient would not react with apprehension to other clinical tests.

Radiographic examination

The dislocating knee joints were examined radiographically in antero-posterior, lateral, and oblique projections with an axial projection of the patellar articulation for identification of fractures. The anatomy of the patellar articulation in both knees was examined by special projections. The radiographic analysis was performed in collaboration with Dr. Niels Egund in the Department of Diagnostic Radiology in Lund.

The quadriceps tendon

The four muscles of the quadriceps converge into the patella and continue as the patellar ligament; in this investigation the patella and the patellar ligament were named the *quadriceps tendon*. The quadriceps tendon was examined with the patient in supine position with the knee in full extension with tight quadriceps (Norman et al 1983). The importance of the examination in maximal extension with tight muscles was explained and exercised before the examination. A support was placed under the heel to permit maximal extension of the knee. A lateral projection was now obtained with the central ray aimed at the anterior distal part of the patellar articulation, perpendicular to the long axis of the extremity (Figure 5); the Film Focus Distance was 100 centimetres and the filmcasette in direct contact with the knee. The radiogram of the quadriceps tendon permitted an analysis of the Insall and the Norman indexes.

The quadriceps tendon was examined (Norman et al 1983) in 91 *control patients* (57 males and 34 females) with meniscal injury, verified at operation (40 patients) and/or by arthrography; except for meniscal injury there was no evidence of other intraarticular abnormalities.

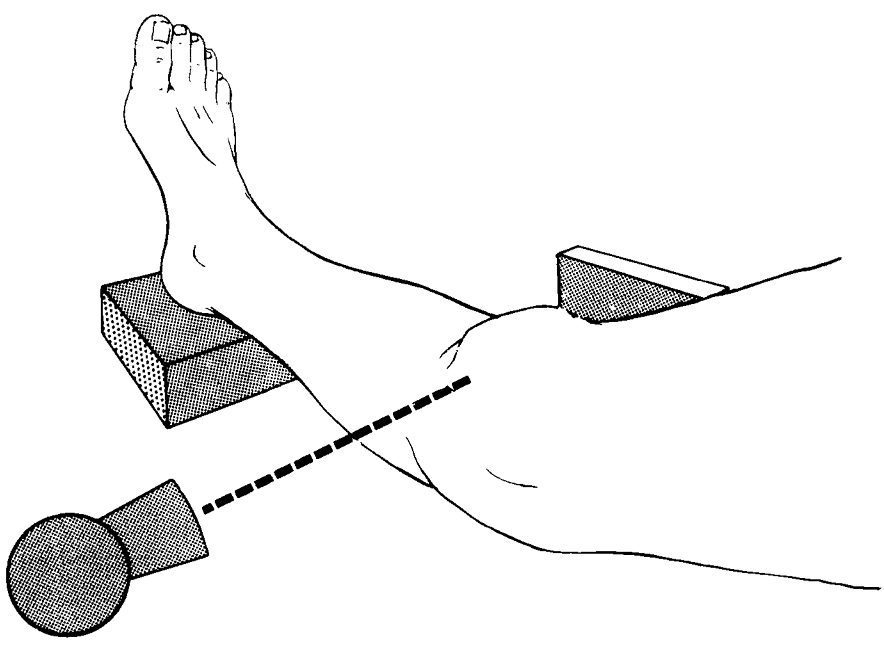


Figure 5. Position of the leg for examination of the quadriceps tendon.

The Insall index (Insall and Salvati 1971) expresses the relation between the ligamentous and the patellar portions of the quadriceps tendon (Figure 6). The length of the ligament was measured at the posterior aspect from the tuberosity to the apex of the patella. The length of the patella was measured diagonally from the apex to the proximal edge of the articulating surface of the patella.

The Norman index (Norman et al 1983) expresses the vertical position of the patellar articulating surface (Figure 6). The position of the patella was established by measuring the distance from the distal edge of the articulating surface of the patella to the distal plane of the femoral condyles i.e. a line perpendicular to the extension of a longitudinal line along the anterior straight part of the distal third of the femur. In both males and females the vertical position of the patella is normally related to the length of the body: the Norman index is the ratio of the vertical position/body length.

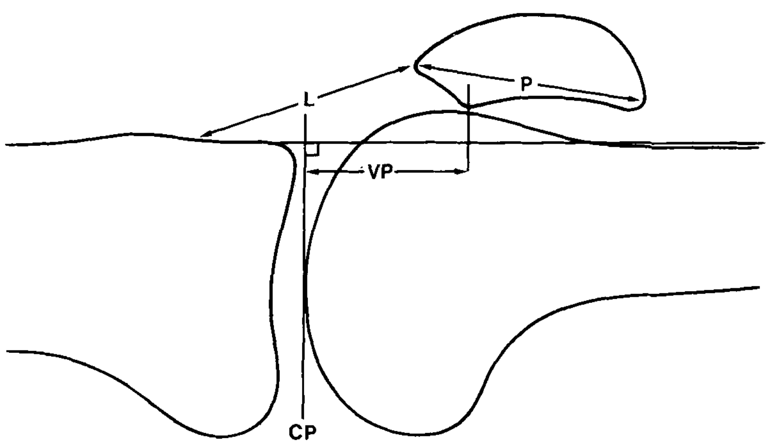


Figure 6. Determination of the Insall and Norman indexes.

The length of the ligament (L), the diagonal length of the patella (P) and the vertical position of the distal edge of the articulating surface of the patella (VP) in relation to the plane of the femoral condyles (CP).

Insall index L / P

Norman index $\frac{\text{VP (cm)} \times 10}{\text{body length (cm)}}$

The condylar angle

The condylar angle, an expression of the depth of the femoral condylar groove (Brattström 1964, Hepp 1982), was examined by vertical projection with the patient standing as described by Ahlbäck (1968). The knee was flexed 60° and the central ray was 45° against the long axis of the femur (Figures 7 and 8).

The condylar groove was examined in 40 *control patients* (20 males and 20 females) who had never had any complaints from the knees.

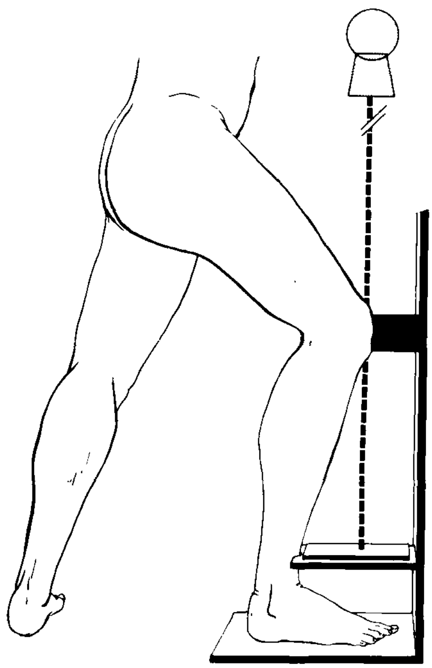


Figure 7. Examination of the condylar groove.

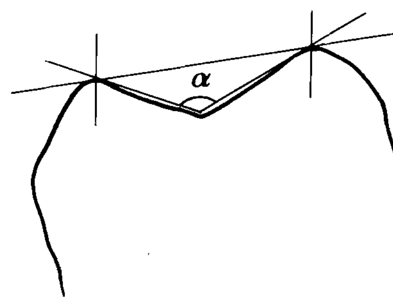


Figure 8. Measurement of the condylar angle (Brattström 1964).

A line was drawn tangentially to the femoral condyles and from these intersects lines were drawn to the bottom of the groove. The angle (α) between these lines describes the condylar angle, corresponding to the condylar groove.

Comments

The purpose of the radiographic examination was to identify fractures associated with dislocation of the patella, and to analyze the anatomy in the patellar articulation. The methods used followed routines established several years ago in Lund. For comparison with the probands of this investigation two control groups were examined.

The term quadriceps tendon was used to emphasize that the patella and the ligament form a functional unit in which both the Insall and the Norman indexes may vary. By using this definition bone fragments from the tuberosity in cases of Osgood-Schlatter disease were included in the length of the tendon.

The Insall index was intended to describe the vertical position of the patella (Insall and Salvati 1971), but the quadriceps tendon can be transferred vertically without changing the relation between the ligament and the patella. The Norman index was therefore used for determination of the vertical position of the articular surface of the patella; by this method the position of the patella is determined in its most proximal location.

The method described by Norman et al (1983) for examination of the quadriceps tendon is simple and reproducible. However, it is based on close cooperation between patient and examiner; the patient must understand and the examiner must check that the knee is examined in maximal extension with tight quadriceps musculature. If the patient is unable to tighten the quadriceps, e.g. because of pain, the radiogram shows that the ligament is not straight, and an extension defect becomes apparent compared to the contralateral knee; both knees should thus always be examined.

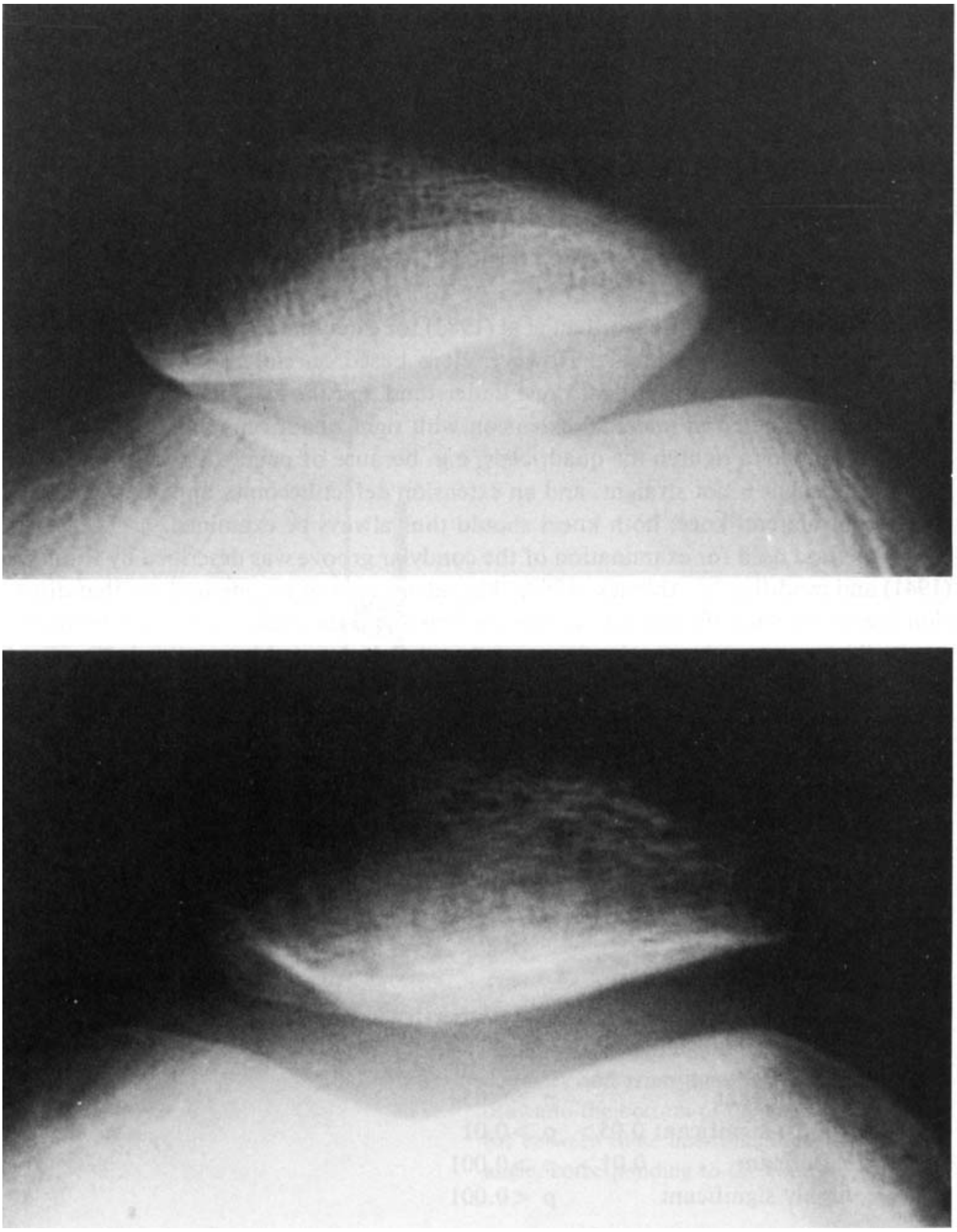
The method used for examination of the condylar groove was described by Knutsson (1941) and modified by Ahlbäck (1968). The advantages of the method are that distorsion is avoided since the central ray hits the film at a right angle, and a well defined reproducible aspect of the proximal part of the condylar groove is examined. The disadvantages of the method are that the patient may have difficulties to adapt his head and body to the equipment and that it may not always be possible to fully evaluate the patellar articulation; the patella will not be cut tangentially if located abnormally high or low (Figure 9). For the purpose of this investigation the method was sufficient to determine the condylar angle which in turn corresponds to the depth of the condylar groove (Hepp 1982).

Statistical methods

The Student's t-test, chi-square and the Fisher-Irwin tests were used and the levels of significance were indicated as follows:

ns	= insignificant		$p > 0.05$
*	= almost significant	$0.05 >$	$p > 0.01$
**	= significant	$0.01 >$	$p > 0.001$
***	= highly significant		$p < 0.001$

Statistical adviser: Klas Svensson, Department of Statistics, University of Lund.



A

B

Figure 9. Axial projection of the patellar articulation (case 78).

A. Norman index 0.30. The patella is not cut tangentially and no information is available concerning patellar dysplasia or the congruence between the patella and the groove.

B. The same patella after distal transfer to Norman index 0.21. The patella dysplasia and the congruence can now be determined.

Observations

Systemic arthropathy in patellar dislocation

It is well known that the incidence of joint dislocations is increased in patients with generalized joint laxity associated with the Marfan and Ehler-Danlos syndroms and with osteogenesis imperfecta (Smårs 1961, McKusick 1966). Even in the absence of other evidence of systemic disease, generalized joint laxity carries a disposition for dislocations (Hass and Hass 1958). Thus, generalized joint laxity is well known to be associated with congenital dislocation of the hip (Carter and Wilkinson 1964, Wynne Davies 1970, Fredensborg 1975) and dislocation of the patella (Heywood 1961, Savastano and Cronin 1975, Janssen 1978 and Macnab and Macnab 1978). In congenital dislocation of the hip the incidence of other joint disorders is high (Wynne Davies 1970), as has been described also in cases of dislocation of the patella (Andersen 1955, Rütt 1976). These latter observations were, however, not correlated to the incidence of generalized joint laxity.

The hereditary disposition for patellar dislocation is well known; some 10—28 percent of relatives are affected (Andersen 1955, Carter and Sweetnam 1958, Brattström 1964, Crosby and Insall 1976). Carter and Sweetnam (1958) have suggested that general joint laxity be a possible factor in the hereditary disposition for patellar dislocation.

In this investigation evidence for generalized joint laxity and heredity was analyzed to clarify to what extent patellar dislocation could be an expression of a systemic disorder.

Generalized joint laxity

In the control material (p 14) the incidence of laxity was 12/110 with no difference between males and females (Table I). In the probands, laxity was found in 21/37 males and in 46/67 females. The incidence of generalized joint laxity was thus six times higher *** than normal in both males and females with patellar dislocation.

Table I. Incidence of generalized joint laxity in patellar dislocation compared to a control population.

	Patellar dislocation		Control	
Joint laxity	Males	Females	Males	Females
No	16	21	36	62
Yes	21	46	4	8
Total	37	67	40	70

Other arthropathies

In probands *without laxity* one of 16 males and one of 21 females had had previous orthopedic treatment for flat feet (Table II). In probands *with laxity* 12/21 males and 17/46 females had had previous orthopedic treatment; 4 for congenital dislocation of the hip; one of the latter had also been treated for scoliosis, 20 for flat feet and 2 for equinus feet. Previous orthopedic treatment was also more frequent* in probands with *bilateral* (17/27) compared with *unilateral* (12/40) dislocations (Figure 10).

Table II. Arthropathies in patellar dislocation.
Orthopedically treated conditions in probands with and without generalized joint laxity.

Condition	No joint laxity		Joint laxity	
	Males	Females	Males	Females
Scoliosis	—	—	—	1[a]
Congenital dislocation of the hip	—	—	—	4[a]
Osgood-Schlatter disease	—	—	2	1
Pes plano valgus	1	1	8	12
Pes equino varus	—	—	2	—
Probands with arthropathy	1	1	12	17
Probands without arthropathy	15	20	9	29
Total	16	21	21	46

a. Proband with both scoliosis and congenital dislocation of the hip.

Arthropathy in relatives

Eighteen probands had relatives with patellar dislocation, and five probands had relatives with congenital dislocation of the hip. Relatives with orthopedic abnormality were identified in 22/67 and 1/37 probands with and without generalized joint laxity, respectively.

Comments

In a population of school children, Carter and Wilkinson (1964) found an incidence of generalized joint laxity of 7 % in both boys and girls. For the purpose of the present investigation their criteria for the diagnosis of joint laxity were slightly modified but the incidence in the control material was in the same range. In agreement with previous authors the incidence of generalized joint laxity in the probands with dislocation of the patella was abnormally high with two-thirds affected.

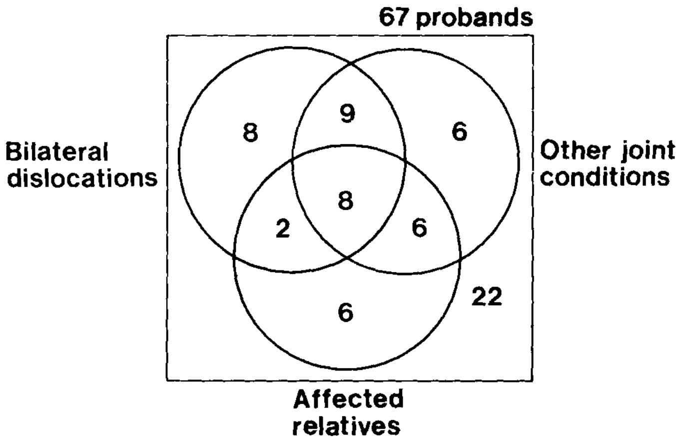


Figure 10. Coexistence of bilateral patellar dislocations, other joint conditions, and affected relatives in 67 probands with joint laxity.

Other joint conditions are shown in Table II; 5 probands had relatives with congenital dislocation of the hip and 17 probands had relatives with dislocation of the patella.

Generalized joint laxity was associated with a high incidence of other arthropaties. The many orthopedically treated flat feet in the probands may reflect a former policy to treat also non-symptomatic flat feet, but Finsterbush and Pogrund (1982) reported that half of their patients with generalized joint laxity had symptomatic flat feet. Even if flat feet and Osgood-Schlatter disease were excluded (Table II) 6/67 probands with laxity and none without laxity had other joint conditions of the types described by Key (1927) and by Andersen (1955) in subjects with dislocation of the patella.

The majority of probands with affected relatives had joint laxity, and of these two-thirds had orthopedically treated conditions other than dislocation of the patella. In probands with generalized joint laxity dislocation of the patella, often bilateral, was thus usually not an isolated condition but rather a painful symptom of generalized joint abnormalities, often with a hereditary disposition.

Anatomy of the patellar articulation

The anatomic conditions which determine the stability of the patella can be described with the aid of several radiographic parametres such as the size of the patella, its location in relation to the condylar groove, and the depth of the condylar groove. Patellar instability occurs when the ligamentous part of the quadriceps tendon is longer than the patella (Insall et al 1972), when the patella is located abnormally high, i.e. patella alta (Blumensaat 1938), and when the condylar angle is increased (Brattström 1964). However, these parametres have usually been studied separately, and it is not known how they may interrelate to cause patellar instability.

In order to clarify these anatomic conditions the Insall and Norman indexes and the depth of the condylar groove were examined in a control group to permit comparison with the probands. The anatomy of the dislocating patellar articulations was also correlated to the presence or absence of generalized joint laxity.

The normal patellar articulation

The Insall and Norman indexes and the condylar angle were determined in the control groups (p 19). The mean value for the *Insall index* was 1.0 ± 0.15 with lower ** values in males (0.98 ± 0.13) than in females (1.08 ± 0.15). In males the Insall index was less than 1.0 in 28/57 knees and in females in 12/34 knees. — The mean value for the *Norman index* was 0.21 ± 0.02 in both males and females. — The mean value for the *condylar angle* was 138° ± 3.5 in both males and females.

On the basis of mean values ± 2 standard deviations *the normal patellar articulation* was defined as follows.

Insall index	0.70 – 1.3;
Norman index	0.17 – 0.25;
condylar angle	131° – 145°.

The dislocating patellar articulation

Of 68 probands with unilateral dislocations, the dislocating knee was examined in 64. The other knee was examined in 4 probands because the dislocating knee had had a quadriceps transfer; no difference was observed as regards the Insall index and the condylar angle in these four pairs of knees. In probands with bilateral dislocations the first dislocating knee was examined in 27 and the second knee in 9 as the first had had a quadriceps transfer.

As compared with normal the *Insall index* was increased to the same extent in probands with and without laxity, and no sex differences were observed; the mean value was 1.3, and all 104 knees had an Insall index greater than 1.0 (Table III).

The mean value for the *Norman index* was also abnormally high. In probands without laxity the index was lower ** than in probands with laxity. In probands with laxity the Norman index was slightly higher * in males than in females, but in probands without laxity no sex difference was observed.

The *condylar* angle was increased when compared with normal without differences related to sex or joint laxity.

Table III. Anatomy of the dislocating patellar articulation.

No laxity	n	Insall index (mean ± SD)	Norman index (mean ± SD)	Condylar angle (mean ± SD)
Males	16	1.27±0.14	0.23±0.02	148±5.9
Females	21	1.29±0.14	0.24±0.03	148±5.8
Difference		ns	ns	ns
Total	37	1.28±0.14	0.23±0.03	148±5.8
Laxity	**n**	**Insall index (mean ± SD)**	**Norman index (mean ± SD)**	**Condylar angle (mean ± SD)**
Males	21	1.35±0.17	0.27±0.03	146±7.8
Females	46	1.29±0.14	0.25±0.03	146±5.5
Difference		ns	*	ns
Total	67	1.31±0.15	0.25±0.03	146±6.3

Probands without joint laxity. In non-lax probands the patellar articulation was abnormal in at least one of the three parametres in 36 of the 37 knees examined (Figure 11). The one exception was a male with 30° hyperextension of his elbows who had previously been treated for flat feet (Case 4). The Insall index was abnormally high in 20 knees, and 13 of these had a normal Norman index. In 16 knees at least 2 parametres were abnormal.

No difference in condylar angle with relation to normal and abnormal Insall index could be observed, but the groove was more shallow ** when the Norman index was normal than when it was abnormal (Table IV).

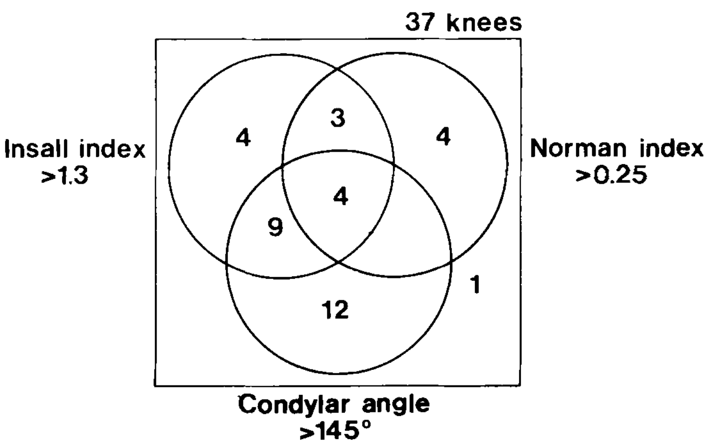


Figure 11. Anatomy of the patellar articulation in 37 knees in probands without joint laxity.

Probands with joint laxity. In lax probands the patellar articulation was abnormal in 54 of the 67 knees examined, and in 29 at least 2 parametres were abnormal (Figure 12). The Insall index was abnormally high in 31 knees, and 12 of these had normal Norman index.

The condylar groove was more shallow when the Insall *** and the Norman ** indexes were abnormal (Table IV).

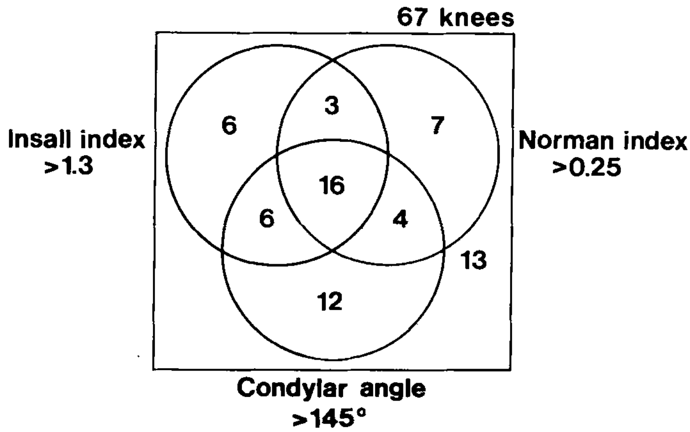


Figure 12. Anatomy of the patellar articulation in 67 knees in probands with joint laxity.

Table IV. Correlation of condylar angle and the Insall and Norman indexes.

	Insall index				
		≤1.3		>1.3	
	n	(mean ± SD)	n	(mean ± SD)	
No laxity	17	148±5.5	20	149±6.3	ns
Laxity	36	143±6.5	31	149±5.0	***
Total	53	145±6.5	51	149±5.3	***

	Norman index				
		≤0.25		>0.25	
	n	(mean ± SD)	n	(mean ± SD)	
No laxity	26	150±5.4	11	145±4.9	**
Laxity	37	144±5.6	30	148±6.6	**
Total	63	147±6.5	41	147±6.4	ns

Comments

In the majority of the dislocating articulations the instability of the patella was a result of changes in the quadriceps tendon and/or in the condylar groove, often associated with joint laxity. Patellar dislocation was not observed in the absence of predisposing factors. The different relationships observed between the quadriceps tendon and the depth of the condylar groove in probands with and without joint laxity suggest that the development of the patellar articulation might be influenced by joint laxity. The results confirm the observations of several authors, e.g. Andersen (1955) Brattström (1964), Hughston (1968), Ficat and Hungerford (1977) and Larson (1979) that patellar dislocation is associated with changes in the patellar articulation.

Recurrent patellar dislocation

Andersen (1955) and Heywood (1961) found that 19 % and 15 %, respectively, of their patients were free from symptoms following the first dislocation. Cofield and Bryan (1977) found that half of their patients did not have recurrent dislocations, and they proposed that only 25 % of patients with dislocated patellas need operative treatment. Crosby and Insall (1976) made the same observation, and they also found that the risk of dislocation decreased with increasing age. However, none of these authors have specified which patients have such a low risk of recurrent dislocation that they do not require operation. Based on the anatomy in the patellar articulation Brattström (1964) and McManus et al (1979) could not establish any correlation between the degree of dysplasia and patellar instability.

The stability of the patella was studied on the basis of dislocation frequency, incidence of bilateral dislocations, the anatomy of the patellar articulation, and the incidence of joint laxity. In 97 probands observed for more than two years, 45 had frequent dislocations, and bilateral dislocations occurred in 36 probands. In all but one proband with bilateral dislocations the frequency of dislocations was examined in the first dislocating knee; one knee was operated acutely for fracture at the first dislocation.

Dislocation frequency

In *non-lax* probands 14/35 knees had frequent dislocations (Table V). The Insall index was abnormally high in 12/14 in frequently dislocating knees ** versus 8/21 in infrequently dislocating knees; there was no difference between the groups as regards Norman index and condylar angle.

In probands *with joint laxity* 31/62 knees dislocated frequently. The Insall index and the condylar angle were increased *** in knees with frequent dislocations.

Table V. Dislocation frequency and anatomy of the patellar articulation.

	Frequent dislocations	Insall index >1.3	Norman index >0.25	Condylar angle >145°	Total number of knees
No laxity	Yes	12	3	11	14
	No	8	7	12	21
	Difference	**	ns	ns	
Laxity	Yes	23	18	24	31
	No	8	12	11	31
	Difference	***	ns	***	

Bilateral dislocations

In *non-lax* probands 9/35 had bilateral dislocations (Table VI). There was no appreciable difference in the Insall and Norman indexes and in the condylar angle between the knees with bilateral as compared with unilateral dislocations.

In probands *with joint laxity* 27/62 had bilateral dislocations. The anatomical parametres were more often abnormal in those with bilateral compared to unilateral dislocations, especially the Insall index which was abnormally high in 21/27 probands with bilateral dislocations *** versus 10/35 with unilateral dislocations.

Table VI. Bilateral dislocations and anatomy of the patellar articulation.

	Bilateral dislocations	Insall index >1.3	Norman index >0.25	Condylar angle >145°	Total number of knees
No laxity	Yes	7	4	6	9
	No	13	7	17	26
	Difference	ns	ns	ns	
Laxity	Yes	21	17	21	27
	No	10	13	15	35
	Difference	***	ns	*	

Comments

Patellar instability, expressed as the incidence of frequent and bilateral dislocations, respectively, was closely correlated to an abnormally high Insall index and generalized joint laxity (Figure 13). The degree of instability was lowest in non-lax probands with a normal Insall index. It was higher in those who had either joint laxity or an increased Insall index, and it was highest in probands who had both.

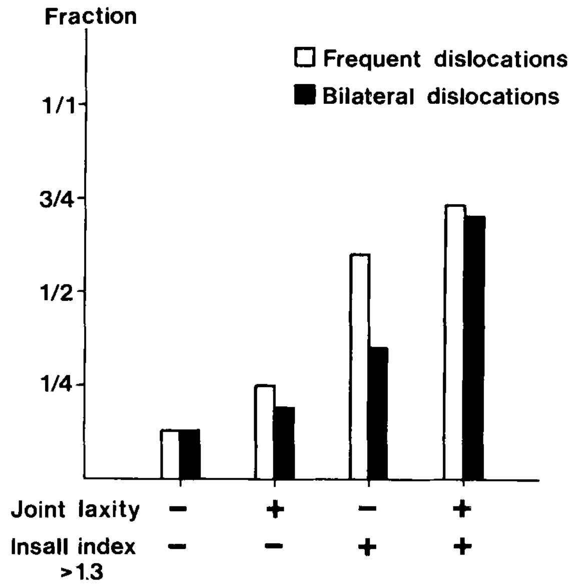


Figure 13. Correlation of frequent and bilateral patellar dislocations with joint laxity and Insall index.

Trauma and age at onset in patellar dislocation

Except in the rare cases of permanent dislocation of the patella the condition is always associated with some kind of trauma. The degree of trauma may vary from severe direct forces against the patella to a slight twist during walking. Trauma as the only cause of patellar dislocation is rare; Andersen (1955), Heywood (1961) and Savastano and Cronin (1975) found that in only 6—10% of dislocations of the patella no other cause of the condition could be found but trauma.

Dislocation of the patella usually occurs for the first time in puberty (Brattström 1964), i.e. at about 15 years in girls and a year later in boys. In the different types of dislocations of the patella which Andersen (1955) described as having a congenital, acquired, or traumatic origin, the age at onset was 12, 22 and 33 years, respectively. These observations suggest that age at onset is associated with the degree of patellar stability.

The importance of trauma as an etiologic factor in dislocation of the patella as well as the age at onset of the condition were studied in relation to the presence of joint laxlaxity and an abnormally high Insall index.

Trauma

Of the 104 probands, 57 were judged to have moderate trauma, and 47 minor trauma at the first dislocation. The degree of trauma (Table VII), expressed as the incidence of moderate trauma, was highest in the absence of both joint laxity and abnormally high Insall index, lower in the presence of one of them, and lowest when both were present.

Table VII. Moderate trauma and age at onset in 104 probands with patellar dislocation.

Joint laxity	Insall index >1.3	Age at onset (range)	Moderate trauma	Total number of knees
—	—	19 (11—33)	13	17
+	—	15 (8—35)	25	36
—	+	15 (8—28)	11	20
+	+	13 (10—33)	8	31
Total		15 (8—35)	57	104

Age at onset

The median age at onset of patellar dislocation was highest in the absence of both joint laxity and abnormally high Insall index, lower in the presence of one of them, and lowest when both were present (Table VII).

Comments

Truly traumatic dislocation, i.e. dislocation without any predisposing factor, was not observed in this material. Trauma as an etiological factor in dislocation of the patella was inversely proportional to patellar instability (Figure 14). The importance of trauma as an etiologic factor in dislocation of the patella was thus contributory rather than exclusive or, as expressed by Savastano and Cronin (1975), more indirect than direct. The age at onset showed the same relationship; an early onset was often associated with more pronounced instability. The importance of trauma as an etiologic factor was less in cases with an early onset of dislocation, as shown by Larsen and Lauridsen (1982).

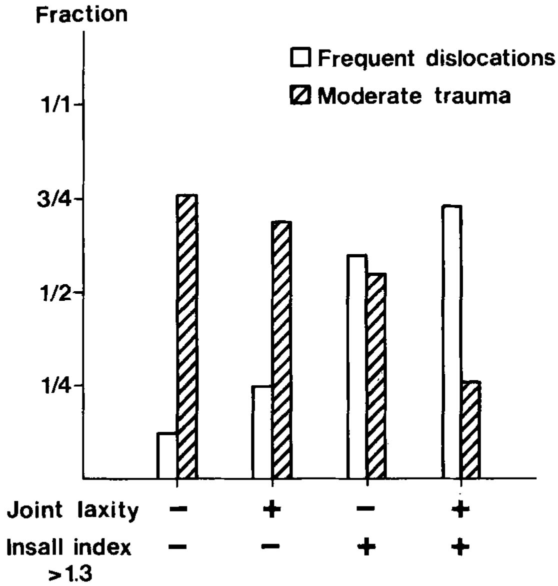


Figure 14. Correlation of moderate trauma and frequent patellar dislocations with joint laxity and Insall index.

Fractures in patellar dislocation

Patellar dislocation can be confirmed radiographically by identification of an avulsion fracture at the medial margin of the patella, or an osteochondral fracture at the patella or at the lateral femoral condyle (Ståhl 1950, Scheller and Mårtenson 1974). The avulsion fractures are caused by tear of the capsule, and they do not involve the articular surface. The osteochondral fracture of the patella is usually located at the medial facet, and that of the lateral femoral condyle peripherally at the edge of the articular surface (Scheller and Mårtenson 1974). Trauma need not be severe for dislocation of the patella to be associated with avulsion or osteochondral fractures; Scheller and Mårtenson (1974) found that more than half of their cases had a history of rather insignificant trauma.

In this investigation fractures associated with patellar dislocation were studied in relation to joint laxity and the Insall index.

Fracture types

In the description of fractures associated with patellar dislocation it is important to distinguish between avulsion and osteochondral fractures. The avulsion fracture fragment is located in the medial capsule and does not lie free in the joint (Figure 15). The osteochondral fracture of the patella often causes loose fragments (Figure 16) whereas those at the lateral femoral condyle may be either impression fractures or result in free fragments (Figure 17).

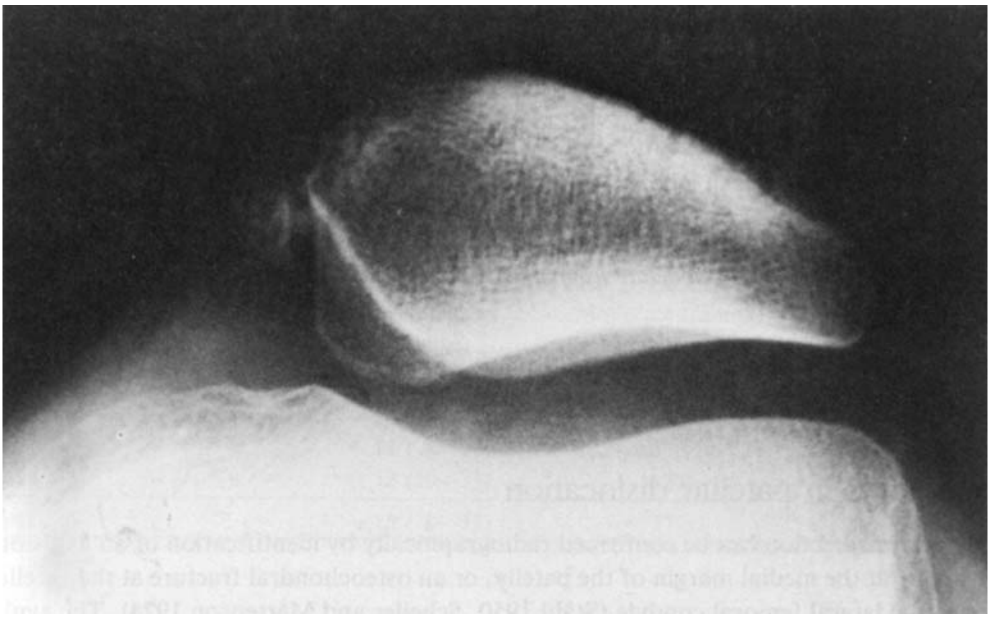
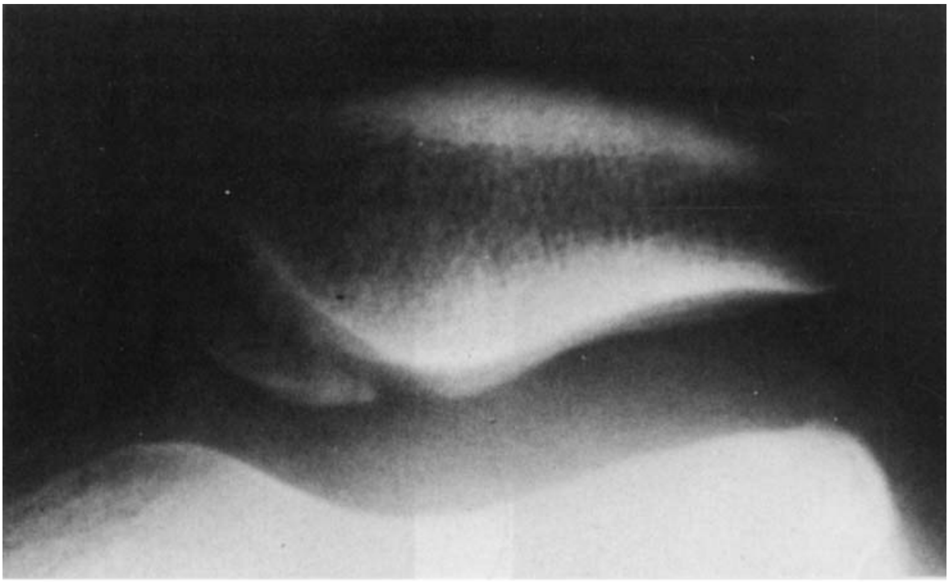
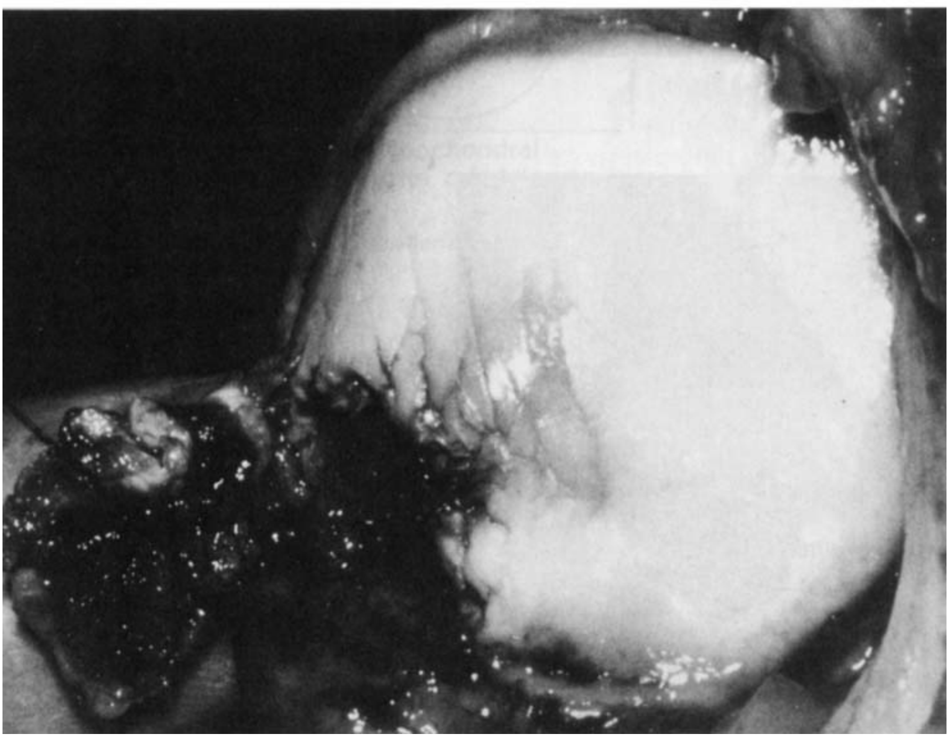


Figure 15. Avulsion fracture of the patella (case 36).



A



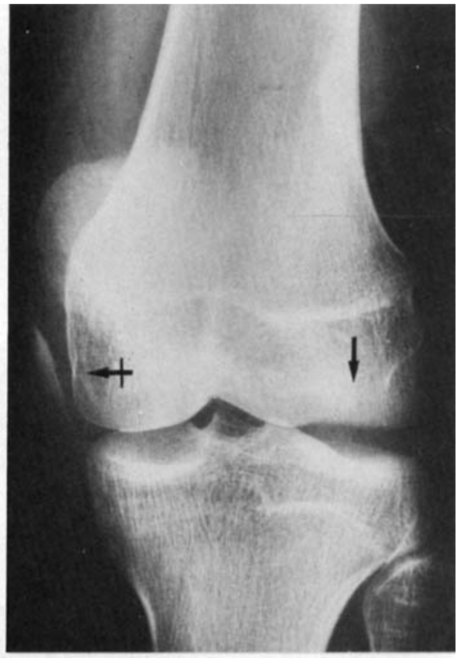
B

Figure 16. Osteochondral fracture of the patella.

A. Axial radiogram.

B. Operation photograph. The fracture fragment is attached to the medial margin of the patella. The fracture was thus caused by the dislocation rather than the reduction of the patella.

A



B

Figure 17. Osteochondral fracture of the lateral femur condyle.

A. Lateral projection → indicates the place of the fracture;

B. Oblique projection. The fracture fragment +→ is located at the medial femoral condyle.

C. Operation photograph. The fracture engages the edge of the articulating surface of the lateral condyle.

Fractures were found in 46 of the 140 dislocated knees in 104 probands (Figure 18). Avulsion fractures occurred in 30 knees, 14 of which were operated. Osteochondral fracture of the patella occurred in 12 knees, 9 operated. Osteochondral fracture of the lateral femoral condyle occurred in 12 knees, 9 operated. The avulsion fracture was associated with osteochondral fracture at the lateral femoral condyle in 6 knees, but was not observed in combination with osteochondral fracture at the patella. Simultaneous osteochondral fractures of the patella and the lateral femoral condyle occurred in 2 knees. Isolated osteochondral fractures of the patella thus occurred in 10 knees and at the condyle in 4 knees.

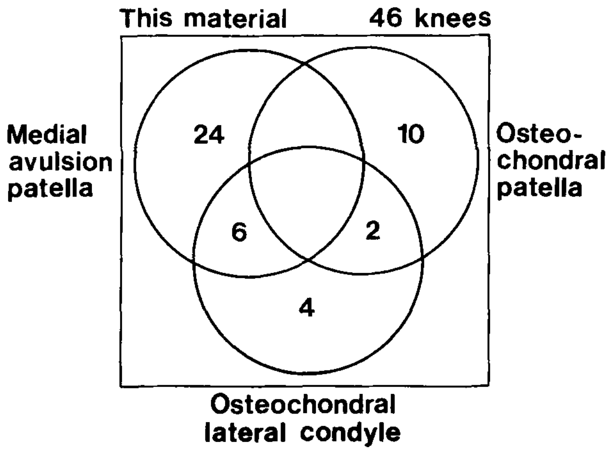


Figure 18. Distribution of fractures in patellar dislocation.

Location of osteochondral fractures

The osteochondral fracture of the patella mainly involved the distal half of the medial facet. In three knees, the fracture mainly involved the ridge between the facets and did not result in a loose fracture fragment. In 9 knees the fracture at the lateral femoral condyle was located in the area where the central axis of the distal third of the femur transects the condyle; the three other fractures were located more proximally in the groove.

Fracture incidence

The incidence of fractures, both avulsion and osteochondral, was highest in the absence of both joint laxity and abnormally high Insall index, lower in the presence of one of them, and lowest in the presence of both (Table VIII). Avulsion fractures were twice as common * in knees without joint laxity, and osteochondral fractures were almost five times more common *** in knees with normal as compared to increased Insall index.

Table VIII. Fractures in 140 knees with patellar dislocation.

Joint laxity	Insall index >1.3	Avulsion fractures	Avulsion and osteochondral fractures	Osteochondral fractures	Total frac-tures	Total number of knees
—	—	3	4	5	12	19
+	—	8	1	7	16	42
—	+	7	1	1	9	27
+	+	6	—	3	9	52
Total		24	6	16	46	140

Comments

In this material avulsion and osteochondral fractures of the patella were not observed simultaneously. Scheller and Mårtenson (1974) have described 59 knees with fractures associated with dislocation of the patella; their case histories permit an analysis of the relationships between the different types of fractures. The distribution agrees well with that in the present investigation (Figure 19); no knees were described to have simultaneous avulsion and osteochondral fractures at the patella. They reported, however, that the osteochondral fracture in seven knees involved the medial margin of the patella, but they did not observe simultaneous separate avulsion of a fracture fragment at the insertion of the capsule and an osteochondral fracture of the patella. Simultaneous avulsion and osteochondral fracture of the patella is thus quite uncommon; no case was found among the 105 knees of the combined materials.

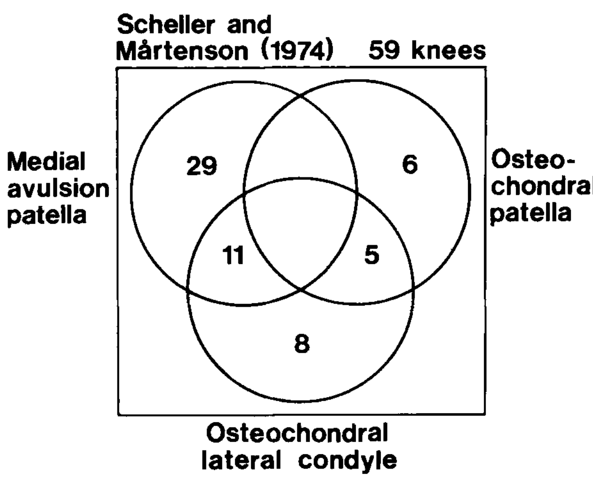


Figure 19. Distribution of fractures in patellar dislocation.

Data from Scheller and Mårtenson (1974).

One explanation for the rarity of simultaneous avulsion and osteochondral fracture of the patella may be that the fractures have different etiologies. The avulsion fracture represents a tear of the capsule and is generally described to be caused by the dislocation whereas the osteochondral fracture may be caused by the reduction of the dislocated patella (Smillie 1970, Scheller and Mårtenson 1974, Larson 1979). An intact medial capsule seems to be a prerequisite for an isolated osteochondral fracture of the patella but is apparently less important in fractures at the lateral femoral condyle. However, the osteochondral fracture can also occur at the dislocation of the patella (Figure 16); some of the osteochondral fractures which involved the medial margin of the patella in the Scheller and Mårtenson (1974) material may well have been fractures of the same etiology.

However, an alternative explanation for the observation that avulsion and osteochondral fractures of the patella did not occur simultaneously may be that they occur in different types of knee. The avulsion fractures were more common in knees without evidence of joint laxity; this fracture may be an expression of relative inelasticity of the medial capsule. The osteochondral fractures were observed more often when the Insall index was within normal limits; a normal quadriceps tendon seems to predispose to osteochondral fractures.

The incidence of both osteochondral and avulsion fractures was closely correlated to the presence of joint laxity and increased Insall index; they were four times more common in the absence than in the presence of both. The incidence of knees with fractures thus inversely proportional to frequent dislocation (Figure 20). The occurrence of fracture was an expression of relative stability, and trauma was then often a contributing etiologic factor.

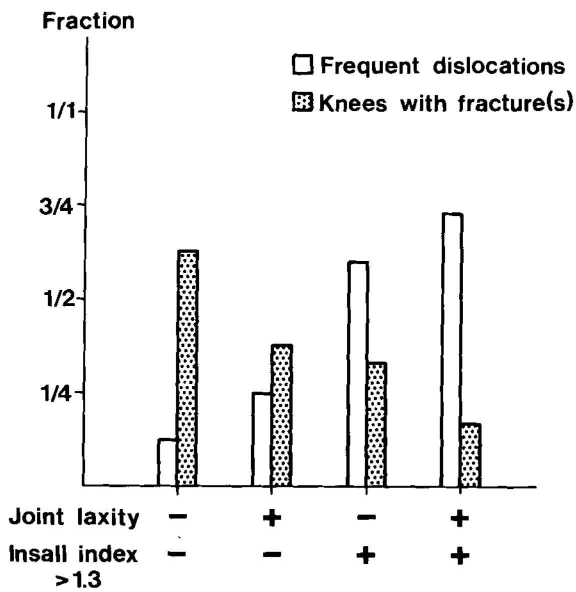


Figure 20. Correlation of fractures and frequent patellar dislocations with joint laxity and Insall index.

Discussion

Main causes of patellar dislocation

This investigation has clearly confirmed the multifactorial etiology of patellar dislocation. Such factors may be *external* or *internal.* Trauma is, at least partly, an external factor, and anatomic abnormality and generalized joint laxity are internal factors, one *local* and the other *systemic.* It is easy to identify cases, albeit rare, where one of these factors clearly dominates, be it trauma in traffic accidents, abnormal anatomy in permanent dislocation or systemic disease like Ehlers-Danlos syndrome. It is quite another matter to evaluate the relative significance of each of these factors in the etiology of the vast majority of patellar dislocations. Few writers have classified the factors, and no system of classification has been widely accepted. However, the observations reported here have definite numeric associations, notably of trauma and dislocation incidence, which suggest that the material should be suitable for logic analysis.

Feinstein (1963, 1967) has drawn attention to the general area of analytic synthesis and medical taxonomy. Bauer and his associates have demonstrated how rigid formal analysis may be a powerful tool for evaluation of etiology, prognosis and therapy in clinical orthopedics, for example femoral neck fracture (Alffram 1964, Ceder 1978), tibial shaft fracture (Edwards 1965, Önnerfält 1978), gonarthrosis (Ahlbäck 1968, Bauer et al 1969, Hagstedt 1974, Tjörnstrand 1981), and occlusive vascular disease (Liedberg 1982). By application of a similar analytic model to the dislocating patella, the interaction of external, local and systemic factors will now be explored. With reference to the Venn-diagram of Figure 21 three main sets will first be discussed.

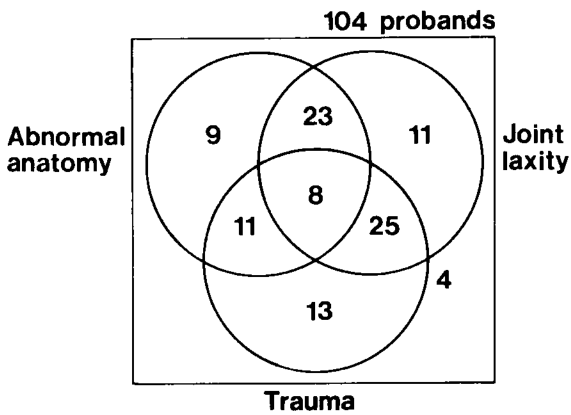


Figure 21. Correlation of etiologic factors in patellar dislocation.

An abnormal Insall index (> 1.3) indicates abnormal anatomy, and moderate trauma is labelled trauma.

Anatomic abnormality

Patellar instability may be caused by several anatomic factors, most of which can be classified as affecting either the lateral vector of the forces acting on the patella or the patellar articulation locally. The valgus vector increases with the Q-angle, i.e. the lateral angle between the quadriceps muscle and tendon. The Q-angle is increased in genu valgum, femoral and tibial torsion (Brattström 1964), and in outward rotation of the tibia during extension and flexion of the knee (Helfet 1974). The medial, stability vector is decreased by weakness of the oblique portion of the medial vastus muscle, a medial capsule defect and when the lateral capsule is abnormally tight. Local anatomic abnormalities in the patellar articulation may cause instability, notably abnormally high Insall and Norman indexes and a shallow condylar groove. In the analysis discussed here, an abnormally high Insall index was chosen as indicator for an anatomic abnormality; the Insall index was closely associated with instability, notably frequent and bilateral dislocations (Figure 13). The Insall index describes the relation between the ligamentous and the patellar portions of the quadriceps tendon; everything else equal the range of sidewise motion of the patella increases with the Insall index. In agreement with Marks and Bentley (1978) the patella was often longer than the ligament in normal males but not in females. In all dislocating knees, however, the patellar share of the quadriceps tendon was smaller than that of the ligament, and no sex difference was observed.

This investigation confirmed the observations of Insall et al (1972) and Lancourt and Cristini (1975) of a correlation between the patellar portion of the quadriceps tendon and instability of the patella (Table IX). Dislocation of the patella did not occur when the Insall index was less than unity, i.e. when the patella constituted more than half of the quadriceps tendon; in the control materials the Insall index was less than unity in about one third of the knees. Furthermore, the Insall index was above 1.3 in only 2 % of the control knees but in as many as 41 % of the dislocating knees. The importance of the Insall index as a factor in patellar instability was further emphasized by the fact that frequent and bilateral dislocations were three times more common when this index was abnormally high than when it was within normal limits.

Table IX. Insall index in patellar dislocation and in normal knees.

	Patellar dislocation				Controls			
Insall index	Insall et al (1972)	Lancourt & Cristini (1975)	This investigation	Total	Insall et al (1972)	Lancourt & Cristini (1975)	This investigation	Total
<1.0	—	—	—	—	25	19	40	84
1.0—1.3	55	19	46	120	86	60	48	194
>1.3	22	9	51	82	3	1	3	7
Total	77	28	97	202	114	80	91	285

Generalized joint laxity

The importance of systemic joint laxity in the etiology of patellar dislocations has been shown by several authors (Heywood 1961, Savastano and Cronin 1975, Janssen 1978, Macnab and Macnab 1978); Zimbler et al (1980) have demonstrated the association of this condition with bilateral dislocations. The importance of the systemic nature of generalized joint laxity was demonstrated in this material by the finding that probands with this condition often had other arthropathies and affected relatives. Like Macnab and Macnab (1978) I have observed that probands with joint laxity, operated for patellar dislocation, often had thin and wide operation scars. The patients with generalized joint laxity thus constitute a sub-set in whom dislocation of the patella may be one of many expressions of a systemic disorder of connective tissue.

Trauma

In the individual patient it is often very difficult to evaluate the importance of external trauma as the cause of patellar dislocation. In the aggregate material of this investigation, however, it was clear that the degree of trauma was inversely related to joint laxity and anatomic abnormality (Figure 14). Also, the harmonious distribution of the cases in the different sub-sets of the Venn-diagram (Figure 21) shows that trauma definitely is an important etiologic factor. A more precise analysis of the role of trauma for patellar dislocation will be attempted below on the basis of different types of anatomic abnormality; trauma is clearly not an independent factor in the etiology of patellar instability.

Classification of patellar instability

A classification of patellar instability based on the two independent variables, one local, abnormally high Insall index, and the other systemic, generalized joint laxity, will by definition have four steps from Grade I with absence of both factors, to Grade IV with presence of both. Grades II and III will have presence of one and absence of the other. The numerical order of the two mid-grades is immediately decided by Table X which lists the observations associated with each of the four grades; the decision is based on the incidence of frequent and bilateral dislocations in particular, but also on the numerical order of the incidence of moderate trauma and fractures. Grade II thus contains probands with generalized joint laxity and knees with Insall index higher than 1 but less than 1.3 while Grade III is the complement sub-set.

From the look of Table X these four grades seem appropriate; they contain relatively equal shares of the total material; the five sets of observations in each grade are neatly ordered numerically. The impression of logic harmony is strengthened by a numerical instability score based on the allocation of one point to each of the following seven instability factors studied in 97 probands, observed for more than 2 years after the initial dislocation: (1) age at onset less than 16 years, (2) frequent and (3) bilateral dislocations, (4) abnormally high Norman index and (5) condylar angle, and the absence of

Table X. Classification of patellar instability.

Instability Grade	Joint laxity	Insall index >1.3	Percent of total material	Age at onset (years)	Frequent dislocations (Fraction)	Bilateral dislocations (Fraction)	Moderate trauma (Fraction)	Fracture(s) (Fraction)	Instability score (Figure 22)
0	—	—	—	—	—	—	—	—	—
I	—	—	16	19	0.13	0.13	0.76	0.63	2.1
II	+	—	35	15	0.26	0.19	0.69	0.38	2.7
III	—	+	19	15	0.60	0.35	0.55	0.33	3.6
IV	+	+	30	13	0.74	0.68	0.26	0.17	5.0
Total material			100	15	0.46	0.37	0.55	0.33	3.6

Comments on anatomic factors

Grade 0	Normal groove and Norman index or Insall index <1.0
Grade I	Shallow groove or high Norman index
Grade II	One third of the knees had a normal patellar articulation
Grade III	One fifth of the knees had a shallow groove and high Norman index
Grade IV	Half of the knees had a shallow groove and high Norman index

(6) moderate trauma and (7) fracture(s) (Figure 22). The mean scores ranged from 2.1 for Grade I to 5.0 for Grade IV.

Trauma and anatomy. In the absence of both internal factors (Grade I) trauma definitely has a role in patellar dislocation. The importance of trauma was reduced in the presence of either the local or the systemic factor, and it was highly reduced in the presence of both (Grade IV). Trauma alone, however, did not fully explain dislocation in Grade I patellar instability; relatively forceful trauma had hit knees with either a shallow groove or a high Norman index, see the comments in Table X. When also these factors were absent, or when the Insall index was below unity, dislocations apparently hardly ever occur, i.e. the patella is stable (Grade 0). The dislocations in Grade II were observed in relatively normal patellar articulations; the three anatomic parametres examined were within normal limits in one third of the knees, and in two thirds only one abnormal anatomic parametre was observed. The interaction of trauma and the pattern of anatomic abnormality were further expressed in Grades III and IV. The fraction of moderate rather than insignificant trauma dropped to 0.55 and 0.26 respectively, and half of the knees in Grade IV were abnormal in all three anatomic parametres versus only one fifth in Grade III.

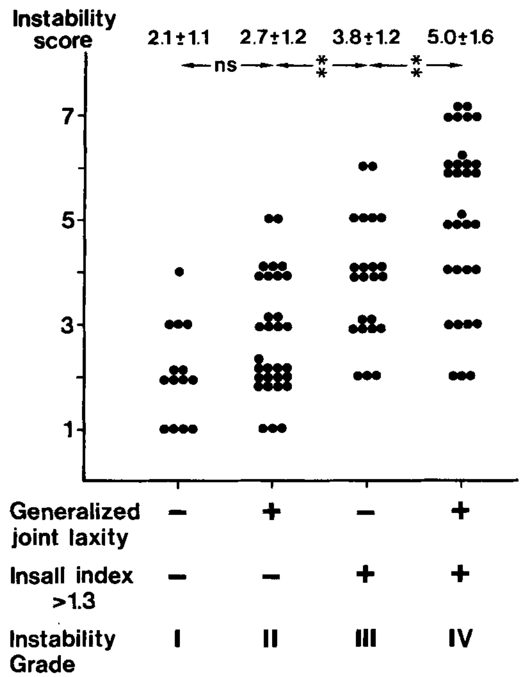


Figure 22. Instability score in the four grades of patellar instability.

The quadriceps tendon. Evaluation of the role of the anatomy of the quadriceps tendon in patellar dislocation requires analysis of both the Insall and the Norman indexes (Figure 23); the latter was often abnormally high in probands with joint laxity. On the other hand half of the knees with high Insall index had a normal Norman index, and these knees may give a false impression of patella alta; Blumensaat (1938) coined this expression for a patella with a long ligament and a high vertical position. However, this condition, i.e. both indexes high, was not observed in more than one fourth of this material; it occurred twice as often in probands with joint laxity (Figure 12) as compared to probands without laxity (Figure 11). In spite of Andersen's (1955) report that patellar dislocation was associated with a 75 per cent incidence of patella alta, it is concluded that this condition was not often a decisive factor in patellar instability. This seems to explain why the use of an abnormal Insall index alone as indication for transfer of the quadriceps tendon distally may be associated with failures as described by Crosby and Insall (1976).

The condylar groove. In agreement with Brattström (1964) and others a shallow condylar groove contributed to patellar instability both in the presence of a normal quadriceps tendon and in association with patella alta. Hvid et al (1983) have recently shown that an abnormally high Insall index is closely associated with a shallow condylar groove. In this material, also, this relation was observed, but only in probands with

Insall index	Norman index	
1.21	0.21	A
1.42	0.22	B
1.28	0.29	C
1.44	0.29	D

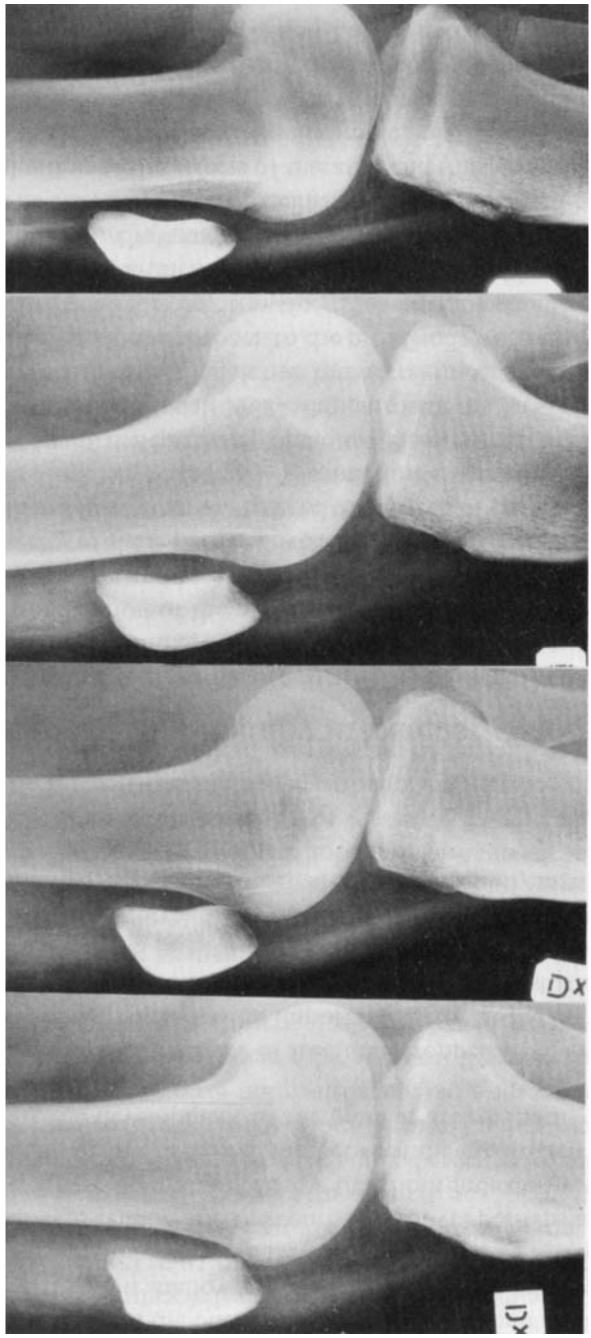


Figure 23. Covariation of the Insall and Norman indexes.

A. Both indexes normal (case 2)
B. Abnormal Insall and normal Norman indexes (case 20)
C. Normal Insall and abnormal Norman indexes (case 51)
D. Both indexes abnormal (case 84).

joint laxity. On the other hand a normal Norman index in knees without laxity was associated with a shallow groove and the reverse relation was observed in knees without laxity. Apparently generalized joint laxity has an influence on the relations between the quadriceps tendon and the condylar groove, perhaps an effect of hyperextension of the knee. These observations show that both indexes must be taken into consideration in the analysis of the interaction between the quadriceps tendon and the condylar groove during the development of the patellar articulation.

Fractures. The incidence of fractures dropped from Grade I to Grade IV patellar instability, and trauma was an important factor in the etiology of fractures as pointed out previously by Scheller and Mårtenson (1974); most fractures occurred in the absence of the two internal factors. However, trauma was a contributing rather than exclusive factor to the occurrence of fractures. In the absence of joint laxity avulsion fractures dominated, and, in the absence of an abnormally high Insall index, osteochondral fractures were most common.

Prognosis and therapy in patellar dislocation

The treatment of the dislocating patella is a highly controversial subject. Smillie (1970), Helfet (1974) and Scheller and Mårtenson (1974) have stressed the importance of surgical stabilization of the patella to prevent recurrence after the first dislocation. By contrast, Crosby and Insall (1976) and Cofield and Bryan (1977) have proposed that only a minority of these patients need surgery. However, this conservative approach seems to be based less on an analysis of the degree of patellar instability and more on trial and error, first physiotherapy, second, soft tissue realignment, and third, as a last resort, transfer of the quadriceps tendon (Ficat and Hungerford 1977, Larson 1979, Kettelkamp 1981 and Insall 1982). Patients with the most unstable patellas will thus lose time spent on unrewarding conservative treatment or soft tissue operations. On the other hand a cautious approach to the problem is well motivated by the risk of complications following quadriceps transfer, such as retropatellar pain, loss of motion, and even serious compartment syndromes necessitating amputation (Wiggins 1975, Crosby and Insall 1976, Chrisman et al 1979 and Wall 1979).

The classification of patellar instability proposed here should permit a more precise evaluation of the effects of therapy, and thus, eventually, provide a predictive basis for the choice of therapy. For example, plaster fixation after the first dislocation can hardly influence the factors active in causing patellar instability, and failures to prevent recurrence by plaster fixation have consequently been reported by Andersen (1955), Cofield and Bryan (1977) and Larsen and Lauridsen (1982). The main indication for plaster fixation will thus be limited to the relief of pain during the immediate post-dislocation period.

The observation of avulsion and/or osteochondral fractures after the first dislocation merely confirms the diagnosis and does not in itself constitute an indication for stabilizing surgery. At any rate, it has not been shown that capsular repair following an avulsion fracture can reduce the risk of recurrence and Ahstrom (1965) has shown that the patella may well be stable after mere excision of osteochondral fracture fragments and shaving of injured cartilage. The indication for surgery in dislocations associated with fracture(s) should perhaps mainly be the removal of intraarticular fragments. The effects of stabilizing procedures should be evaluated with reference to the grade of instability and analysis of the anatomy of the patellar articulation.

The classification proposed here permits prediction of the risk and even frequency of recurrent dislocations. In the more stable Grades I and II the risk for frequent dislocations is low. Most patients can accept a patellar dislocation every other year when they are told that the dislocation rate will decrease with age. The indications for a stabilizing procedure is obviously strengthened with the increasing instability of Grades III and IV.

In my personal experience (to be published) soft tissue realignment is usually more successful in the more stable knees, whereas a soft tissue operation often fails in Grade IV knees, which have the highest need for improved stability. In cases of patella alta in Grade IV mature knees, transfer of the quadriceps tendon distally and also medially for correction of an abnormal Q-angle may be necessary to achieve a stable and painless knee. Realignment by soft tissue operations or quadriceps tendon transfer has a thin margin of safety, however, and it is difficult to put the patella in an optimal position relative to the condylar groove.

Prevention of patellar instability

Unfortunately the patellar articulation has usually reached its final, often abnormal, shape by the time dislocations occur, and the therapy offered is similar to that offered to patients with untreated congenital dislocation of the hip. The purpose in both situations is to correct the abnormal anatomy rather than to prevent the development of the condition. Our efforts to stabilize the dislocating patella will continue to be relatively ineffective as we cannot counteract joint laxity and do relatively little to improve established anatomic abnormality. Perhaps, in the future, as we know more about the association of patellar instability in the young and degenerative arthrosis of the patellar articulation in the elderly (Ahlbäck and Mattsson 1978) it may prove rewarding to look for patellar instability long before some of those affected have symptoms.

Summary

The material of this investigation consisted of 104 patients (37 males and 67 females), treated for dislocation of the patella at the Department of Orthopedics in Lund during 1975—1977. The patients were examined clinically and radiographically in order to identify the etiologic importance of trauma, generalized joint laxity, and an anatomically abnormal patellar articulation. All patients were examined for generalized laxity, other orthopedic conditions, relatives with patellar dislocation or congenital dislocation of the hip, dislocation frequency, bilateral patellar dislocation, age and the nature of the trauma at initial dislocation, incidence and type of articular fractures associated with patellar dislocation, and three radiographic parametres of anatomically abnormal patellar articulations.

Generalized joint laxity was observed in two thirds of the patients, frequent dislocations in one half and bilateral dislocations in one third. In half of the patients the initiating trauma was insignificant, and one third had avulsion or osteochondral fractures. The majority had definite anatomic abnormalities but patella alta was observed in only one fourth of the patients.

The material was subjected to an analysis of the covariation of etiologic factors operating in patellar dislocation. On this basis the material was classified in four grades of increasing patellar instability, from Grade I with neither laxity, nor increased Insall index, to Grade IV with both these factors. With increasing patellar instability the frequency of recurrent and bilateral dislocations increased whereas the degree of trauma and incidence of fractures decreased. The type and degree of anatomic abnormalities were correlated to the different grades of patellar instability.

The classification of patellar instability proposed here should permit more precise evaluation of treatment of patellar instability, and, eventually, provide a basis for the choice of therapy in patellar dislocation.

Appendix

Key to data

A Case number
B Sex
C Age at onset
D Age at examination
E Dislocation observed
F Avulsion fracture
G Osteochondral fracture of the patella
H Osteochondral fracture of the lateral femoral condyle
I Generalized joint laxity
J Affected relatives
K Other arthropathies
L Moderate trauma
M Frequent dislocations
N Bilateral dislocations
O Insall index
P Norman index
Q Condylar angle
R Instability score
S Operation
1. excision of fracture fragment without stabilization
2. soft tissue realignment operated acutely
3. soft tissue realignment operated within 2 years
4. soft tissue realignment operated later than 2 years
5. quadriceps transfer

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
001	M	15	18	+	+	−	+	−	−	−	+	−	−	1.16	0.21	149	2	4
002	M	21	23	−	+	−	−	−	−	−	−	−	−	1.21	0.21	147	2	
003	M	26	26	−	−	+	−	−	−	−	+			1.10	0.23	147	—	2
004	M	20	25	−	−	+	−	−	−	+	−	−	−	1.08	0.21	140	1	1,4
005	M	24	29	+	−	+	−	−	−	−	+	−	−	1.26	0.27	137	1	
006	M	19	27	+	∓	=	±	−	−	−	+	−	+	1.25	0.26	145	2	4,5
007	M	19	22	+	−	−	−	−	−	−	−	−	−	1.20	0.23	148	3	
008	M	33	37	+	−	−	−	−	−	−	+	−	−	1.12	0.24	148	2	4
009	M	19	26	−	−	+	−	−	−	−	+	−	−	1.12	0.22	147	1	1,4
010	F	15	17	+	+	−	−	−	−	−	+			1.05	0.18	156	—	3
011	F	18	20	−	−	+	−	−	−	−	−	−	−	1.08	0.20	150	2	
012	F	20	23	−	+	−	+	−	−	−	+	−	−	1.02	0.19	152	1	
013	F	32	35	+	−	−	−	−	−	−	+	−	−	1.22	0.27	138	2	5
014	F	12	17	+	−	−	−	−	+	+	+	−	−	1.17	0.17	156	3	
015	F	27	35	+	−	−	−	−	−	−	+	+	−	1.16	0.23	152	3	4
016	F	16	26	+	−	−	−	−	−	−	+	+	+	1.12	0.25	151	4	4,5
017	F	14	20	−	+	−	+	−	−	−	+	−	−	1.22	0.27	145	2	1,4
018	M	17	40	+	+	−	−	−	−	−	+	+	+	1.38	0.26	148	4	5
019	M	11	13	+	−	−	−	−	−	−	+	+	−	1.37	0.21	156	4	
020	M	15	20	−	+	−	+	−	−	−	−	+	−	1.42	0.22	158	4	4
021	M	15	19	−	+	−	−	−	−	−	+	−	−	1.34	0.24	143	2	4
022	M	28	30	+	−	−	−	−	−	−	+	−	−	1.56	0.26	145	3	
023	M	17	21	+	−	+	−	−	−	−	+	+	−	1.40	0.26	151	3	
024	M	8	22	+	−	−	−	−	−	−	+	+	+	1.37	0.22	159	5	4
025	F	11	38	+	−	−	−	−	−	−	−	+	+	1.48	0.30	143	6	4,5
026	F	20	43	+	+	−	−	−	−	−	−	+	−	1.40	0.24	148	2	4
027	F	15	31	+	+	−	−	−	−	−	−	+	−	1.44	0.25	149	3	
028	F	13	33	+	−	−	−	−	−	−	−	+	+	1.33	0.23	141	5	4
029	F	9	15	−	−	−	−	−	−	−	−	+	−	1.35	0.24	143	4	
030	F	13	15	+	−	−	−	−	−	−	−	−	+	1.46	0.25	152	6	
031	F	12	14	+	−	−	−	−	−	−	+	−	−	1.48	0.28	148	4	
032	F	15	20	+	−	−	−	−	−	−	−	−	−	1.33	0.24	143	3	4
033	F	12	20	+	−	−	−	−	−	−	−	−	−	1.33	0.22	159	4	
034	F	15	17	−	+	−	−	−	−	−	+	−	−	1.32	0.25	152	2	5
035	F	15	26	+	−	−	−	−	−	−	+	+	+	1.35	0.26	152	4	5
036	F	15	22	−	∓	=	=	−	−	−	+	+	+	1.42	0.21	152	4	4,4
037	F	15	26	+	−	−	−	−	−	−	+	−	−	1.48	0.28	140	3	
038	M	20	37	+	+	−	−	+	+	−	+	−	+	1.26	0.27	144	2	4,5
039	M	13	17	+	−	−	−	+	−	−	+	−	−	1.22	0.27	137	3	
040	M	19	21	+	−	−	−	+	−	+	+	−	−	1.15	0.26	135	2	
041	M	8	25	+	∓	=	=	+	−	+	−	−	+	1.15	0.26	137	4	
042	M	10	27	+	−	−	−	+	−	−	+	−	−	1.27	0.22	140	2	
043	M	21	24	+	−	−	−	+	−	+	+	−	+	1.18	0.24	147	3	4
044	M	17	27	−	−	−	−	+	−	−	+	−	−	1.26	0.24	141	1	
045	M	17	17	−	−	+	+	+	+	−	+			1.20	0.23	150	—	2
046	M	18	20	+	+	−	−	+	−	+	+	−	−	1.20	0.26	137	1	
047	M	18	20	+	−	−	−	+	−	−	+	−	−	1.26	0.23	147	2	
048	M	13	18	−	−	+	−	+	−	−	−	−	−	1.25	0.23	132	2	4
049	F	13	15	+	−	+	−	+	−	−	−	−	−	1.18	0.26	152	4	
050	F	15	17	+	+	−	+	+	+	−	+		−	1.14	0.25	146	—	3

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
051	F	15	38	+	−	+	−	+	−	−	−	+	−	1.28	0.29	145	4	4
052	F	15	15	−	−	+	−	+	−	−	+			1.15	0.20	141	—	2
053	F	15	15	−	−	−	+	+	+	−	+			1.09	0.23	149	—	2
054	F	27	27	−	−	+	+	+	−	−	−			1.11	0.22	146	—	2
055	F	10	16	+	+	−	−	+	−	−	+	−	−	1.19	0.24	148	2	
056	F	8	14	−	+	−	−	+	−	+	−	+	+	1.25	0.28	159	5	4
057	F	12	14	−	+	−	−	+	+	−	+	+	−	1.25	0.25	155	3	
058	F	21	24	−	+	−	−	+	−	−	−	−	−	1.07	0.23	147	2	
059	F	12	20	+	−	−	−	+	+	+	+	−	−	1.29	0.26	142	3	
060	F	15	17	−	−	−	−	+	+	+	−	−	−	1.28	0.26	147	4	
061	F	15	20	+	−	−	−	+	−	−	+	−	−	1.21	0.24	131	2	5
062	F	20	23	−	−	−	−	+	−	+	+	−	−	1.19	0.24	145	1	
063	F	15	23	+	−	−	−	+	−	−	+	−	−	1.23	0.24	141	2	
064	F	17	19	+	−	−	−	+	−	−	+	−	−	1.10	0.23	138	1	
065	F	18	23	+	−	−	−	+	−	−	−	−	−	1.07	0.21	135	2	
066	F	15	20	−	−	−	−	+	−	−	+	+	−	1.14	0.23	138	3	4
067	F	35	38	−	−	−	−	+	+	+	−	+	+	1.24	0.24	137	4	4
068	F	8	15	+	−	−	−	+	+	+	+	+	+	1.21	0.22	146	5	
069	F	18	22	+	−	−	−	+	−	+	+	+	−	1.09	0.23	149	3	5
070	F	15	22	+	−	−	−	+	−	−	+	−	−	1.15	0.19	135	2	
071	F	15	17	+	−	−	−	+	−	−	+	+	−	1.28	0.24	150	4	
072	F	20	30	+	−	−	−	+	−	−	−	−	−	1.28	0.26	147	4	4
073	F	9	12	−	−	−	−	+	−	+	+	−	−	1.20	0.21	139	2	
074	M	15	47	+	+	−	−	+	+	+	−	+	+	1.44	0.26	149	6	
075	M	12	15	+	−	−	−	+	+	+	−	+	+	1.40	0.26	150	7	4
076	M	12	27	−	±	=	=	+	+	−	−	+	+	1.40	0.27	155	6	
077	M	15	18	+	−	−	−	+	−	+	−	+	+	1.43	0.27	158	7	4
078	M	17	20	−	−	−	+	+	−	+	+	+	+	1.40	0.30	149	4	2,4
079	M	20	22	−	−	−	−	+	−	+	−	+	+	1.58	0.33	149	6	4,4
080	M	13	15	+	−	−	−	+	+	+	+	+	+	1.65	0.32	159	6	
081	M	13	16	−	−	−	−	+	−	−	−	+	+	1.40	0.30	156	7	
082	M	12	24	+	−	−	+	+	+	+	−	−	−	1.49	0.24	149	3	4
083	M	12	16	+	−	−	−	+	−	+	+	+	+	1.78	0.36	152	6	4
084	F	15	39	+	−	−	+	+	+	−	−	+	−	1.44	0.29	141	4	
085	F	12	14	+	+	−	−	+	−	+	−	+	+	1.40	0.25	147	5	4
086	F	13	25	−	+	−	−	+	−	−	−	+	+	1.40	0.24	148	5	5
087	F	11	14	+	+	−	−	+	+	+	−	+	+	1.41	0.28	142	5	4
088	F	15	25	−	−	−	−	+	+	+	−	+	+	1.34	0.23	148	6	4
089	F	13	15	+	−	−	−	+	−	−	−	−	−	1.33	0.23	142	3	
090	F	12	17	−	−	−	−	+	−	−	+	−	−	1.34	0.24	138	2	
091	F	12	26	+	−	−	−	+	−	−	−	+	+	1.42	0.23	150	6	5
092	F	12	20	+	−	−	−	+	−	−	−	+	+	1.35	0.29	152	7	4
093	F	15	23	−	−	−	−	+	−	−	−	+	+	1.44	0.24	147	6	5
094	F	33	38	−	−	−	−	+	+	+	−	+	−	1.40	0.30	147	5	4
095	F	35	38	−	−	−	−	+	−	−	−	+	+	1.50	0.25	142	4	4
096	F	15	34	+	−	−	−	+	+	−	+	−	−	1.31	0.25	144	2	4
097	F	23	25	−	−	−	−	+	−	−	−	+	+	1.34	0.21	145	4	4
098	F	19	37	+	−	−	−	+	+	+	+	−	−	1.35	0.25	148	2	4
099	F	11	14	+	−	−	−	+	−	−	−	+	+	1.38	0.26	146	7	4
100	F	19	38	+	−	−	−	+	−	−	+	−	−	1.35	0.29	152	3	
101	F	16	40	+	−	−	−	+	−	+	−	+	+	1.39	0.28	153	6	
102	F	10	22	+	−	−	−	+	+	+	+	−	−	1.60	0.29	145	3	
103	F	10	14	+	−	−	−	+	+	+	−	+	+	1.70	0.31	154	7	
104	F	10	12	−	−	−	−	+	−	+	−	−	−	1.54	0.29	150	5	

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