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# THE VERTICAL POSITION OF THE PATELLA

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A new radiographic method for estimation of the vertical position of the patella in extension is presented. The vertical position of the patella determined by this method and the length of the ligament, patella and its surface were all found to be related to body-height. The vertical position of the patella may thus be expressed as its ratio to body-height: the vertical index of the patella.

*Key words:* knee joint; patella; patella alta; radiography

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Patella alta is the clinical expression generally used for an abnormally high position of the patella in relation to the femoral condylar groove and is estimated by radiographic examinations. As the condylar groove is difficult to define radiographically, the few methods which are available either directly or indirectly relate the position of the patella to other anatomical structures of the femoral condyles. However, none of the results of the radiographic methods available are comparable and therefore the definition of patella alta has to be related to each specific method.

The first direct method was presented by Boon-Itt (1930), who determined the position of the patella in relation to the femur but without reference to the degree of flexion of the knee. The method needs geometric calculations and nomograms and is too complicated for routine clinical use.

Another direct method is that of Blumensaat (1938). He described the position of the patella in relation to the condylar groove as the distance between the apex of the patella and a line through the roof of the intercondylar fossa. However, he did not clearly define how to obtain the exact degree of flexion of the knee. In addition, the angle between a line following the intercondylar notch and the long axis of the femur may vary as much as 30° (Brattström 1970). This may lead to a false impression of the vertical position of the patella.

Indirect assessment of the patellar position based on the ratio between the length of the ligamentum patellae and the patella (Insall & Salvati 1971) has been used as the radiograph method of choice in clinical practice (Insall et al. 1972, Lancourt & Cristini 1975, Ahlbäck & Mattson 1978). The ligament/patella ratio does not describe the vertical position of the patella in relation to the femus, but most important is that the whole ligament/patella complex can be transferred both proximally or distally without changing this ratio.

Blackburne & Peel (1977) described the patellar position indirectly by a ratio; e.g. distance between the distal edge of the articular surface of the patella and the tibial plateau divided by the length of the articulating surface of the patella. This method, however, implies that there are no individual anatomical variations in the inclination of the tibial plateau.

Norman & Ekelund (1976) introduced a radiographic method in which the patella is

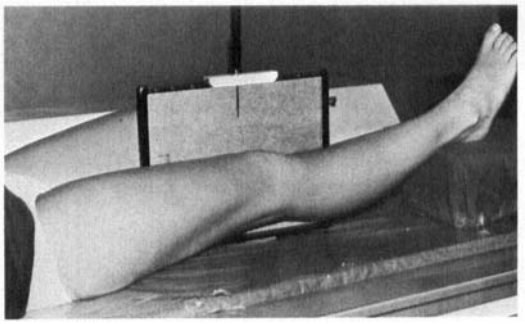

*Figure 1. Position of the patient for roentgenographic measurement of the vertical position of the patella. The elevated heel allows extension of the knee.*

examined in its most proximal position during maximal extension. The present paper deals with our experience of this method and the different factors which influence the vertical position of the patella, and its relation to body height.

## PATIENTS AND METHODS

### *Method*

The patient is placed on the examination table in the supine position with the knee extended (Figure 1). The leg is raised, supported at the heel to allow maximum extension; the foot is rotated outward about 10–15 degrees to bring the dorsal facets of both the femoral condyles into the horizontal plane. The need for maximal extension of the knee is explained to the patient who is trained to contract the quadriceps muscle adequately before the examination. A lateral radiogram is obtained with a horizontal beam, the central ray directed at the ventral aspect of the joint space. (Roentgenologic data: FFD 100 cm, film size 24 × 30 cm.)

The following radiographic parameters were recorded (Figure 2).

*Length of the ligament (LL).* The length of the posterior aspect of the ligamentum patellae from the insertion into the tuberositas tibiae to the apex of the patella.

*Length of the patella (LP).* The greatest diagonal length of the patella.

*Length of the articular surface of patella (PA).* The distance between the distal and proximal edges of the articulating surfaces.

*Femoral condylar plane (CP).* A plane, perpendicular to a longitudinal line following the anterior aspect of the distal third of the femur and passing through the point midway between the medial and lateral condyles.

*Vertical position of the patella (VP).* The perpendicular distance from the distal edge of the articular surface of the patella to the femoral condylar plane.

All measured parameters were expressed in relation to body height:

$$\frac{\text{measured length (cm)}}{\text{body height (cm)}} \times 10 = \text{relative length}$$

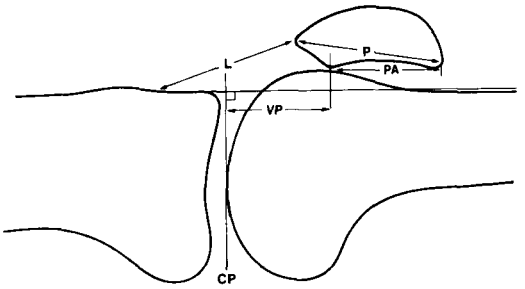


*Figure 2. Studied parameters affecting the vertical position of the patella. For abbreviations and definitions, see text.*

### *Patients*

The study presents results from 91 patients (34 females and 57 males) with meniscus lesions. The diagnosis was verified at operation in 41 of the 91 patients; besides the meniscus lesion, there were no other intraarticular abnormalities. Fifty patients had a history and clinical signs of a meniscus lesion only, and this was confirmed by arthrography. For both sexes the average age was 33 (15–65) years. There was no age difference between patients with meniscus lesions, verified at operation, and those cases verified by arthrography. The average height of females was 155 (150–176) cm and that of males 177 (167–190) cm.

Both the right and the left knee were examined in each patient, but only the results from the right knee are reported.

## RESULTS

The absolute lengths obtained for all parameters were greater in males than in females (Table 1). In both sexes there was a significant correlation

*Table 1. Length of studied parameters in mm (males n = 57, females n = 34)*

| | Sex | m̄ | Range | ± S.D. | Difference |
|---|---|---|---|---|---|
| Vertical position of patella | M | 37.1 | 30–46 | 3.7 | |
| | F | 34.6 | 27–41 | 3.7 | ** |
| Ligament | M | 50 | 40–65 | 5.1 | |
| | F | 46.5 | 38–56 | 5.0 | ** |
| Patella | M | 51.1 | 45–60 | 3.6 | |
| | F | 43.5 | 39–50 | 3.3 | *** |
| Articular surface of patella | M | 37.4 | 31–43 | 2.4 | |
| | F | 33.0 | 30–38 | 2.1 | *** |

*Table 2. Studied parameters in relation to the body length (males n = 57, females n = 34)*

| | Sex | m̄ | Range | ± S.D. | Difference |
|---|---|---|---|---|---|
| Vertical position of patella | M | 0.21 | 0.17–0.26 | 0.02 | |
| | F | 0.21 | 0.17–0.26 | 0.02 | ns |
| Ligament | M | 0.28 | 0.23–0.34 | 0.03 | |
| | F | 0.28 | 0.24–0.34 | 0.03 | ns |
| Patella | M | 0.29 | 0.25–0.33 | 0.02 | |
| | F | 0.26 | 0.23–0.30 | 0.02 | *** |
| Articular surface of patella | M | 0.21 | 0.17–0.24 | 0.02 | |
| | F | 0.20 | 0.17–0.23 | 0.01 | * |

*Table 3. Insall index in females (n = 34) and males (n = 57)*

| | Sex | m̄ | Range | ± S.D. | Difference |
|---|---|---|---|---|---|
| Insall index | F | 1.08 | 0.84–1.38 | 0.15 | |
| | M | 0.98 | 0.72–1.35 | 0.13 | ** |

between the absolute length of all parameters and body height (Figure 3).

The relative length of the patellar ligament was the same in both sexes, but the relative length of the patella was shorter in females than in males (Table 2). The ligament/patella ratio, i.e. the *Insall index*, was greater in females than in males (Table 3).

The relative length of the articulating surface of the patella was shorter in females than in males (Table 2). The relative length of the vertical position of the patella was the same in both sexes (Table 2). The vertical position of the patella could thus be expressed as the vertical index of the patella (mean value 0.21 ± 0.02).

No difference of the studied parameters was observed between the right and left knee.

## DISCUSSION

The proposed method is technically simple and reproducible. The patella is examined in its most proximal position since the quadriceps is tightened and the knee is in maximal extension. The method thus takes into account the presence of

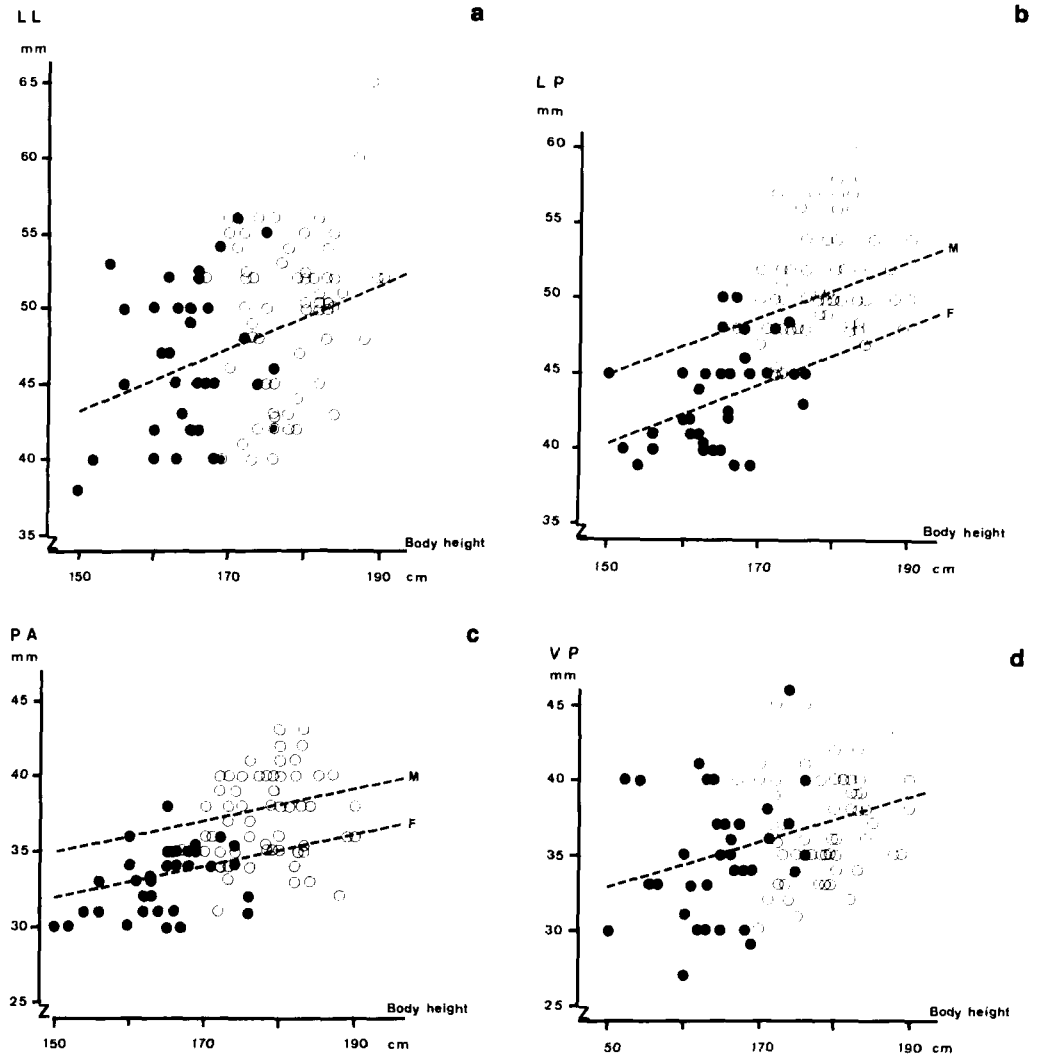


*Figure 3. Relation between the absolute length of the ligament, the patella, the articulating surface of the patella, the vertical position of the patella, and the body height. (● females, ○ males) (a) length of ligament (LL) f(x) 11.7 + 0.21x r 0.35***. (b) length of patella (LP) females 10.3 + 0.20 × $R^2$ 0.57***, males 15 + 0.20x $R^2$ 0.57***. Difference ***. (c) length of the articulating surface of the patella (PA) females f(x) 17 + 0.10x $R^2$ 0.11*, males 20 + 0.10 × $R^2$ 0.11*. Difference ***. (d) vertical position of the patella (VP), f(x) 8.7 + 0.16x r 0.34***.*

hyperextension, which is important for the biomechanics of the knee (Smillie 1974). Previous authors have used lateral radiograms of the knee in flexion, with the ligament straightened, but have overlooked the importance of hyperextension (Figure 4). The distance between the distal edge of the articulating surface of the patella and the distal part of the femoral condyles is a direct assessment of the vertical position of the patella in relation to the condylar groove. This measurement can be made with accuracy since both the femoral condylar plane and the distal edge of the articular surface of the patella are well defined in the radiograph. It is important to ensure that the knee is in maximal extension and that the ligament is tight; this can be checked

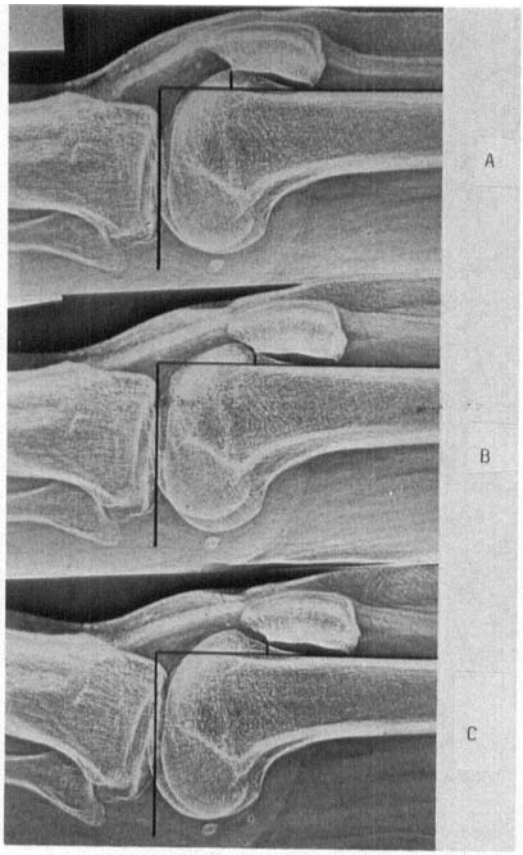


*Figure 4. The vertical position of the patella. (a) relaxed quadriceps, VP 30 mm. (b) tightened quadriceps, VP 40 mm. (c) maximal hyperextension and tightened quadriceps, VP 46 mm.*

by comparison with the contralateral knee, and both knees should thus always be examined.

Outerbridge (1964) stated that there was no correlation between the length of the ligament and body height. This conclusion was based upon examination of a heterogeneous group of patients with chondromalacia of the patella. In the present investigation of normal knee joints, not only the length of the ligament, but also the patella, its articular surface, and vertical position were found to be related to the body height.

Our results confirm those of Insall & Salvati (1971), Lancourt & Cristini (1975) and Marks & Bentley (1978) that in the normal male knee the length of the ligament is approximately equal to the length of the patella and that this ratio is greater in females. This sex difference can be explained by our observation that the patella was shorter in females.

Blackburn & Peel (1977) found no sex difference in the normal ratio of the patellar height above the tibial plateau and the length of the articular surface of the patella. Unfortunately, they reported only the ratios and did not study the parameters *per se*, and therefore their results are difficult to evaluate.

We believe that both the vertical index of the

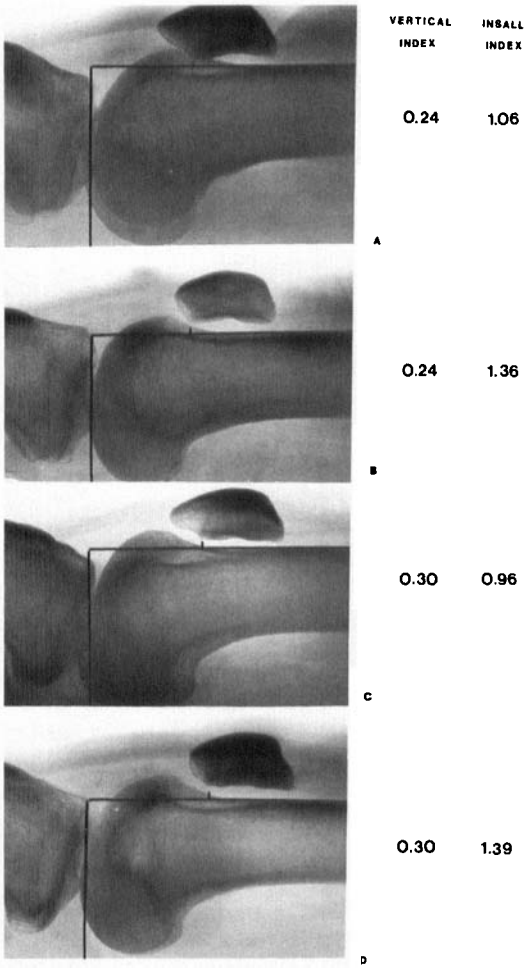


*Figure 5. Covariation of the vertical and Insall indexes. (a) both indexes normal. (b) vertical index normal, Insall index increased. (c) vertical index increased, Insall index normal. (d) both indexes increased.*

patella and the Insall index are of clinical significance and useful in the analysis of the biomechanics of patellar articulations (Rünow 1983). We also believe that our results will diminish some of the confusion concerning the definition of patella alta. The Insall index can be both normal and increased at the same vertical index, and the vertical index can be both normal and increased at the same Insall index (Figure 5).

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