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THE VERTICAL LOCATION OF THE PATELLA

Fundamental Views on the Concept Patella Alta, using a Normal Sample

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Patella alta, p.a., high riding patella, is a purely morphological concept. To what extent p.a. has an influence on disorders or complaints of the knee joint is still under discussion and not yet clarified.

Even as a morphological concept, p.a. is not exactly defined. The establishment of a diagnosis of high location of the patella is only possible with certainty if one knows the limits of the normal variation. As far as we know, an investigation of the vertical position of the patella in persons without any knee joint complaints has not hitherto been carried out.

Blumensaat (1938) has given the most commonly used definition: At a knee flection of 30 degrees (the 150 degree position) the apex of the normally located patella will touch the extension of a condensed line, which on the lateral radiograph of the knee is seen in the condylar *massif* of the femur and represents the "roof" in the intercondylar fossa; the line of Blumensaat, I. Bl. A patella with any higher position will be named a p.a. However, Blumensaat's suggestion is only a rough estimate; no exact measurements are given as reason for this definition: "Bei einem Beugungswinkel von etwa 150 Grad nun pflegt, wie wir uns stets überzeugen konnten, die gedachte Verlängerung dieser interkondylären Begrenzungslinie nach vorne mit dem unteren Kniescheibepol zusammenzufallen".

On the basis of 200 lateral radiographs of knee joints, Boon-Itt (1930) proposed an index for the patellar position by means of a geometric system. For clinical use, this method is too cumbersome, without affording a guarantee of exact values. Moreover, the material

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is weighted by the fact that a part of it comprises patients with complaints in the knee joints.

Insall & Salvati (1971) approached a clarification of the problem, when they examined a series of 44 knees with isolated meniscus injuries (operatively verified), and measured the position of the patella in relation to the l. Bl. at 30 degrees of knee flection. This investigation showed that the patella was located considerably higher than suggested by Blumensaat. We are of the opinion that this material is not necessarily representative as a normal material concerning the position of the patella, as the possibility exists that a relatively high location of the patella in these patients may have been predisposing for a meniscus lesion in the joint.

For that reason we have examined a series of persons who have never had any lesions, medical diseases or complaints in their knee joints.

Table 1. The age and sex distribution in the material.

Age	Women	Men	Total
20–30	21	21	42
31–52	3	5	8
20–52	24	26	50

MATERIAL AND METHOD

The material comprises the lateral radiographs of 100 knees from 50 persons, 26 men and 24 women, who have never had any lesions, joint diseases or complaints in the knee joints, and whose knees have been found sound on clinical examination. On the basis of this examination, we excluded subjects who showed atrophy of the quadriceps muscle, effusion in the knee joint, thickening of the capsule, reduction of movements in the joint, lateral looseness, rotary looseness and drawer sign, tenderness of the joint line as well as marked laxity of the posterior capsule. Thus, we excluded persons with a possibility of extension in the knee that exceeds the 195 degree position (measured on the fibular side of the lower extremity from the point of the malleolus to the epicondylus femoris and the point of the greater trochanter). Moreover, persons with a valgus deformity of the knee joints which exceeds 10 degrees were excluded, as Thestrup Andersen (1955) in a material of persons with sound knees found a variation of the angle between the femur and the tibia in the frontal plane between 0 and 10 degrees. All the radiographs are without pathological findings. The length of the lower extremity has been measured from the point of the greater trochanter to the point of the fibular malleolus.

The age and sex distribution appears in Table 1. The participating persons are students, physicians, nurses and hospital porters. Nearly all of them participate in some kind of sport, but only one in competitive athletics.

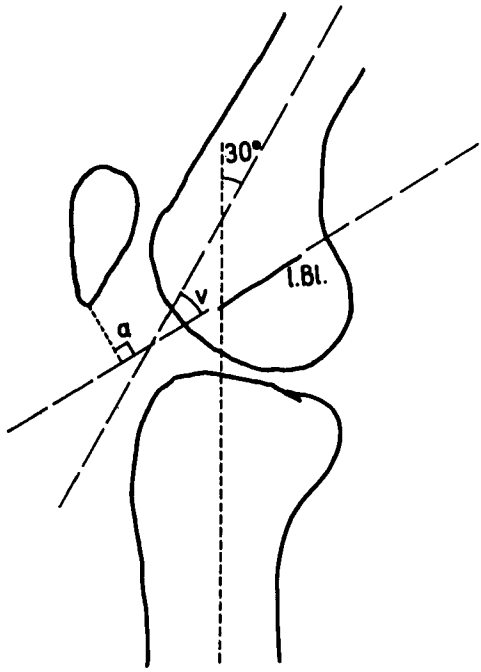

Figure 1. Diagram showing the distance, a, from the apex of the patella perpendicular to the extension of the line of Blumensaat, l. Bl., and the angle, v, between the axis of the shaft of the femur and the l. Bl. Knee flection: 30 degrees.

The lateral radiographs have been obtained with the knees in exactly 30 degrees of flection (the 150 degree position) by means of a special fixation. The angle between the axes of the femoral and tibial shafts was checked on the radiograph before the procedure was ended. The graphs have been made with a raster in the plate holder to obtain parallel rays and the magnification varies between 1.06 and 1.12.

The distance, a, from the apex of the patella is measured at right angles to the extension of the l. Bl. (Figure 1) by means of a Vernier scale on a transparent template with perpendicular vertical and horizontal lines placed over the radiograph in a horizontally placed illuminated viewing box. The measurements are carried out to an accuracy of 1 mm.

The angle, v, between the axis of the femoral shaft and the l. Bl. (Figure 1) has been measured as proposed by Brattström (1970).

As radiographs of the knee in the exact 150 degree position are difficult to obtain without a special fixation and careful technique, Insall & Salvati (1971) have proposed the following index: LT/LP. The greatest diagonal length of the patella is LP and the length of the patellar tendon LT. The length of the patellar tendon is measured from the apex patellae to the small notch just proximal to the tibial tuberosity on the lateral radiograph.

This index has been calculated as well.

Table 2. Distribution of the measured values of the distance a from the apex patellae to the line of Blumensaat.

a, mm	Right	Left	Total	Men	Women
0–5	0	0	0	0	0
6–10	5	8	13	3	10
11–15	18	18	36	16	20
16–20	8	14	22	14	8
21–25	14	6	20	10	10
26–30	4	4	8	8	0
31–35	1	0	1	1	0

RESULTS

The distribution of the distance, a, in the material is given in Table 2. The mean of a is 17 mm for the total material. The median is 16 mm. The 2½ per cent percentile is 7 mm and the 97½ per cent percentile is 29 mm. From this it follows that 95 per cent of the material has a distance, a, in the interval from 7 to 29 mm.

As the question concerned is the high location of the patella, p.a., especially the upper limit, the 97½ per cent percentile is of interest. A reasonable upper limit for the normal location of patella will thus

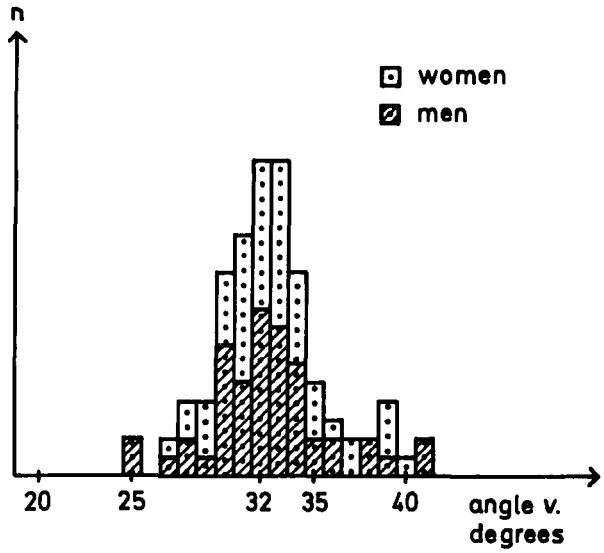

Figure 2. The distribution in the material of the values of the angle v.

Figure 3 a. Lateral radiograph of the right knee of a normal person. 30 degrees of knee flection. Note that the extension of the line of Blumensaat is well below the apex patellae.

Figure 3 b. Lateral radiograph of the same knee as in Figure 3 a. 40 degrees of knee flection. Note that the extension of the line of Blumensaat is very close to the apex patellae.

be 30 mm. In our material (Table 2), only one knee has a distance a, which exceeds this limit.

The average value of a, the mean, is 18.9 mm for men and 15.5 mm for women. The difference is statistically significant on a one per cent level ($P = 0.01$).

The average length of the lower extremity, measured from the point of the greater trochanter to the point of the fibular malleolus, is 86

cm for men, and 79 cm for women. If the value 79/86 is used as a corrective factor, the mean for men will be reduced to 17.4 mm. If all the male values of a are multiplied with this corrective factor there will no longer be a statistically significant difference between female a-values and corrected male a-values. This means that the greater male distance a is presumably due to the greater average physical proportions of the male.

One might think from this, that the variation of a inside the male group was due to the differences in physical proportions. However, after correction of all male a-values with a factor f' = 86/ measured length of the extremity concerned, which means that all male extremities have been corrected to the average length, there is an unaltered dispersion in the male material (95 per cent between 8 and 32 mm). The highest values, which exceed these limits, are due to the above-mentioned person with an uncorrected a-value exceeding 30 mm. The length of the lower extremities of this person is smaller than the average.

In women, as well as in men, the distance a is biggest on the right side, averaging in men 19.8 mm on the right and 18.0 mm on the left side, and in women 16.3 mm on the right and 14.6 mm on the left side; but the differences are not significant on a 5 per cent level.

The angle, v, between the axis of the femoral shaft and the l. Bl. (Figure 1), varies in the material, as shown in Figure 2, inside a narrow interval around the mean value 32.6 degrees. The median is 32 degrees, the 2½ per cent percentile 26 degrees and the 97½ per cent percentile 40 degrees. This means that 95 per cent of the values are between 26 degrees and 40 degrees.

The individual differences between right and left angle v are very small, averaging 1.6 degrees; the range is from 0 to 5 degrees.

We have furthermore examined a few persons with the knee both in the 150 degree and in the 140 degree or 135 degree position and observed that the distance, a, during the last 10 to 15 degrees of flection is diminished drastically, see Figures 3 a and 3 b.

In our sample of normal subjects the index of Insall & Salvati, LT/LP, varies as shown in Table 3. The median is 1.0, the 2½ per cent percentile 0.9 and the 97½ per cent percentile 1.3. The upper limit for normal knees is thus 1.3, and knees with an index greater than this can be designated p.a., as a high location of the patella will give a large index. In a later publication Insall et al. (1972) used the reciprocal index, which does not seem logical to us.

Table 3. Distribution of the index of Insall & Salvati for the location of the patella. Total material.

Index: LT/LP	0.7	0.8	0.9	1.0	1.1	1.2	1.3
Knees	0	1	19	39	20	18	3

DISCUSSION

We have verified above that the normal patella is located considerably higher than suggested by Blumensaat. We therefore cannot accept his definition. If it is used, p.a. must be characterized as physiological. If certain symptoms from the knee joint are to be explained by a high location of the patella, one must use a more exact criterion on the basis of the limits of the normal location of the patella. In accordance with our investigations, we propose that the term p.a. only be used when the patella is located more than 30 mm over the extension of the l. Bl. measured perpendicularly from this to the apex patellae, when the knee flection is exactly 30 degrees (the knee being in the 150 degree position).

An exact measurement of the angle of knee flection is of decisive importance to the value of the distance a. As this value at 30 degrees of knee flection averages 17 mm and may be 30 mm, it is considerably smaller at about 45 degrees of knee flection.

This small difference in the angle of knee flection, 15 degrees, is easy overlooked on the radiograph if a measurement is not carried out.

As a schematic outline the tibia and the apex patellae can be regarded as fixed during the knee flection, while the femoral condyles with the l. Bl. are the moving parts. The l. Bl., then, turns like a watch hand in the direction of the apex patellae. The hand moves a greater distance from 30 degrees to 45 degrees than it does from 15 degrees to 30 degrees of knee flection, as the curve of the femoral condyles improves (the radius diminishes) during the knee flection. An exact analysis of this movement is, however, much more complicated, as the apex patellae actually moves posteriorly along an arc of a circle, the centre being the insertion of the patellar tendon on the tuberosity of the tibia. Moreover, besides the watch hand movement, the l. Bl. has a complicated movement in which the posterior point follows a curved line.

The results in our sample of normal subjects prove to be in accordance with the results of Insall & Salvati, and so we can now reject the doubt which we put forward above concerning their premises (that

the material of patients with meniscus lesion could represent a normal sample).

A difference in the distance, a, in men and women appears to be a result of the average larger physical proportions of the human male.

There is no statistically significant difference in the location of the patella between the right and the left knee.

Brattström suggests that the angle, v, between the axis of the femoral shaft and the l. Bl., is normally 45 degrees, and states in his material a great dispersion of the values. We cannot confirm these findings, as we in our material have demonstrated a considerably smaller angle v. The median in the material is 32 degrees, and there is only a small dispersion, as 95 per cent of the values lie between 26 degrees and 40 degrees. The difference between the angle v on the right and the left knee in the same person is negligible.

We therefore cannot agree with Brattström's proposal to designate a patella with a distance, a, of, for example, 20 mm and an angle, v, of 30 degrees a "false patella alta". We must assert that it is a case of normal location of the patella. We also cannot agree with the proposal of the same author to correct an angle, v, of about 30 degrees to the value 45 degrees.

These considerations appear to us to make the definition of p.a. more clear as a morphological-anatomical concept. Whether p.a. has any sense as a "unity of disease" cannot be stated from this investigation, but selection of a possible patient material must follow other criteria than those used up till now.

From a practical point of view it is difficult to obtain routine radiographs with a knee flection of exactly 30 degrees, and so we can agree with the proposal of Insall & Salvati for another measure for the location of the patella, than the relation to the l. Bl. Also, from a theoretical point of view, it seems logical to use a measure in which the length of the patellar tendon is related to the length of the patella, as it is exactly the mutual magnitude of these structures that determines the location of the patella. The value of this index, LT/LP, in our material is in good agreement with the results of Insall & Salvati. The average value in our material, as well as in the material of Insall & Salvati (1971) is 1.0. The upper limit of the normal area is 1.3 according to our material, and so persons with a larger index may be characterized by the term p.a. We propose that this index be used in the future.

SUMMARY

Much confusion has been brought into the discussion of the concept patella alta by Blumensaat's inexact definition. We have therefore investigated the vertical location of the patella in 100 normal knees. The subjects were selected by means of a thorough clinical examination. Their medical histories showed no injuries or medical or surgical joint diseases and their radiographs showed no lesions in the knee joint.

The mean distance from the apex patellae measured at right angles to the extension of the line of Blumensaat on the lateral radiograph, with the knee in a position of exactly 30 degrees of flection (the 150 degree position), is 17 mm. The 97½ per cent percentile is 29 mm. Thus, we are of the opinion that a distance of 30 mm is a reasonable upper limit for the normal vertical position of the patella. The term patella alta should be reserved for the cases with an even larger distance.

There is no statistically significant difference between right and left knees and, after correction for the average greater length of the male lower extremity, there is no significant difference between the distance in men and women. The angle, v, between the axis of the femoral shaft and the line of Blumensaat, is found to be 32.6 degrees in average, with a small dispersion. Thus, we cannot agree with another author who suggests the angle v to be 45 degrees, and who proposes a correction of a 30 degree angle to 45 degrees.

As radiographs of the knee joint with an angle of exactly 150 degrees between the femur and the tibia are difficult to obtain in practical daily work, and as it seems logical to use a measure in which the length of the patellar tendon, LT, is correlated to the length of the patella, LP, we propose to use the index of Insall & Salvati: LT/LP. In accordance with our material the upper limit for LT/LP should be 1.3 in normal knees.

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