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DETERMINATION OF HIP ADDUCTION, ESPECIALLY IN ARTHRODESIS

By

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It is usual to consider the frontal mobility of the hip-joint (abduction and adduction) in the sagittal position of the hip that is obtained when the patient is lying supine on a plane table; it is this mobility that was examined in this study. In most text-books and articles in which this mobility is dealt with, it is stated that the measurement shall be made from a zero position in which the leg forms a right-angle with a line between the anterior superior iliac spines. Values given for the movement from this zero position range from 25 to 45° abduction and from 10 to 35° adduction (2, 3, 5, 7, 14, 16). *Fick* (6) gives 46 and 28° respectively.

These wide variations in what is considered normal suggest that there is some inexactness in the methods of examination. *Perkins* (13) considers that adduction, in particular, cannot be measured accurately in degrees, and he does not give any magnitude for it. The shortcomings of the method of measurement are probably due in part to the difficulty in palpating and locating the exact site of the iliac spines, and to the fact that the axis of the leg is not well defined. It is extremely difficult for one person simultaneously to manipulate an angle-measuring device, adduct the leg and palpate the two spines. This method provides only a rough impression of the range of movement, for the extent to which the pelvis also moves is difficult to judge. When a hip arthrodesis has been performed the measurement is still more difficult because the spine is often involved in the scar tissue and is not infrequently used as graft material. Since, in hip arthrodesis, a small change in the frontal plane has a considerable effect on the length of leg and the position of the pelvis and spinal column (an adduction of 3° shortens the leg by about one centimetre), the inaccuracy of the method is a

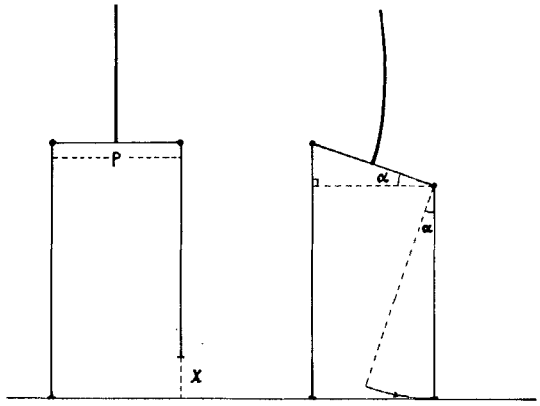

Fig. 1.
The relationship between the shortening of the leg and angle needed to compensate for the shortening.
The feet are the same distance apart as the centres of the femoral heads.

serious disadvantage. The problem has been noted by several authors (1, 8, 10, 11, 15) in respect of hip arthrodesis and subtrochanteric osteotomy, and tables have been compiled for the determination of the number of degrees of abduction required to correct for a given shortening of legs of different lengths and for different distances between the iliac spines or centres of the femoral heads. *Milch* (12) has designed a special appliance to natural size by means of which any required angle and change in length of leg can be set and measured (adduction osteotometer). Accurate tables for determining the angle are, however, of little value when the practical difficulties in measuring the angle on the patient remain.

This problem has assumed practical significance in a follow-up examination of patients with hip arthrodesis, and the author has developed a method for determining adduction, and in some cases abduction, to an accuracy of about 3°.

Briefly, the method consists in measuring the distance between the medial malleoli with the leg in maximum adduction; the measurement is made in the axial direction of the leg, and with the feet together. The adduction is then obtained in terms of a distance. When there is a real shortening the adduction is obtained by subtracting this from the intermalleolar distance.

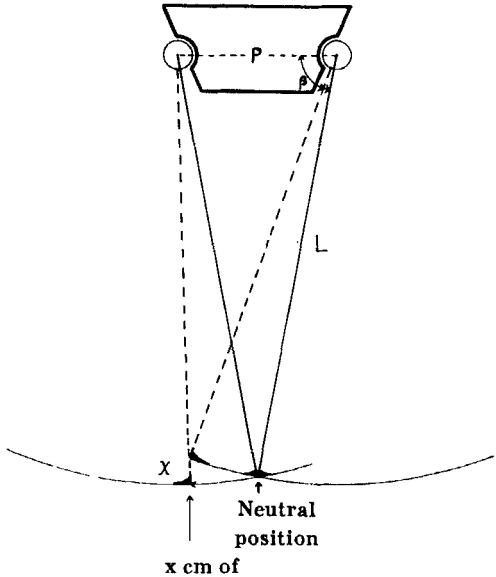

Fig. 2.

Th relationship between the shortening of the leg and the angle of the leg to the line joining the femoral heads. The feet are together.

MECHANICS OF THE FRONTAL MOBILITY

Most diagrams relating to the frontal mobility of the hip-joint are similar to that in Fig. 1. It is seen here that the extent to which the leg length is affected by a change in angle between the leg and the pelvis is dependent on the distance between the centres of the femoral heads (P). The angular deviation (α) corresponding to a shortening (X) is given by the expression $\sin \alpha = X/P$. This presupposes a normal position of the hip, with a right angle between the leg and the two spines, which implies that the leg length is determined in the usual zero position with the feet about 20 cm apart; but this is quite an unnatural position, whether standing or walking. With the feet together the difference in leg length is given by a different mathematical relationship. Fig. 2 shows a model of the relationship between leg length and the position of the hips in the frontal plane. For a certain angle of one hip the shortening of the leg with the feet together is given by the following formula:

$$X = L - (L^2 + P^2 - 2LP\cos\beta)^{\frac{1}{2}}$$

or

$$\cos\beta = \frac{P^2 + 2LX - X^2}{2LP}$$

where L = the leg length, P the distance between the centres of the femoral heads, X the shortening of the leg due to adduction, β the angle between a horizontal line through the pelvis and the line through the centre of the femoral head and the medial malleolus.

The longitudinal axis of the leg is not accurately enough defined for an exact measurement of the angle of adduction. In this study the longitudinal axis is taken as the line from the centre of motion of the femoral head to the tip of the medial malleolus. The centre of the head corresponds quite closely on the skin to the intersection of the inguinal ligament and the femoral artery. This axis does not coincide with the various clinical axes that can be obtained in the outer contour of the thigh, nor with the radiographic axis through the femur, which does not pass through the centre of motion (Fig. 3). Instead of the zero position with the feet about 20 cm apart and a right-angle between the legs and the horizontal, I have chosen a more natural basic position with the feet together. This is referred to below as the *neutral position.*

TABLE 1

The Neutral Angle for Different Lengths of the Legs and Distance between the Centres of the Femoral Heads.

Distance between femoral heads (cm)	Neutral angle for length of legs (cm)						
	80	85	90	95	100	105	110
19	83.2	83.6	83.9	84.3	84.5	84.8	85.0
20	82.8	83.2	83.6	84.0	84.3	84.5	84.8
21	82.5	82.9	83.3	83.7	84.0	84.3	84.5
22	82.1	82.4	83.0	83.4	83.7	84.0	84.3
23	81.7	82.2	82.7	83.0	83.4	83.7	84.0
24	81.4	81.9	82.3	82.7	83.1	83.4	83.7
25	81.0	81.5	82.0	82.4	82.8	83.2	83.5

The neutral angle δ is given by the expression $\cos\delta = B/2L$ where B is the distance between the centres of the femoral heads and L is the length of the leg.

In the neutral position the angle between the legs and pelvis will vary with the distance between the two centres of the femoral heads and with the leg length (Table 1). According to the former nomenclature there is in this neutral position an adduction of between 5 and

9°. For all values of adduction in one leg and abduction in the other there is for any particular person a relationship between the angle of adduction and the resulting shortening in length. For an average leg an adduction of about 3° gives a shortening of one centimetre (Table 2). It is extremely difficult to measure an angular change in the hip of 3°, but it is relatively easy to measure whether one malleolus is one centimetre higher than the other. Hence if, instead, the adduction is measured in terms of the longitudinal distance between the malleoli, not only will greater accuracy be achieved, but it will be possible to obtain directly the difference in leg length for the positions in question. Thus, there will be no need to calculate the shortening of the leg resulting from a certain adduction angle for a given leg length and width of the pelvis. If both legs are not the same length and there is thus a real shortening, its magnitude must be determined before it is possible to use the intermalleolar distance as a measure of the adduction position. This shortening can be obtained conveniently on radiographs (see below). A clinical measurement will not be particularly accurate, since it requires both hip-joints to be set identically in the frontal plane.

To determine the position of a hip in relation to the neutral position, it is necessary to subtract the real shortening from the intermalleolar distance.

TABLE 2

Changes in Angle for Shortening of the Leg by 1, 3 and 5 cm.

Shortening of leg (cm)	Change in angle for shortening of					
	1 cm		3 cm		5 cm	
Length of leg (cm)	*80*	*100*	*80*	*100*	*80*	*100*
Distance between femoral heads (cm)						
20	2.9	2.9	8.6	8.6	14.3	14.7
24	2.4	2.4	7.2	7.2	12.0	12.0

The change in angle $= \delta - \beta$. β is given by the expression $\cos \beta = \frac{P^2 + 2LX - X^2}{2LP}$

where δ = neutral angle, β = angle between a horizontal line through the pelvis and a line through the centre of the femoral head and the medial malleolus

P = distance between centres of femoral heads;
L = length of leg;
X = shortening of leg.

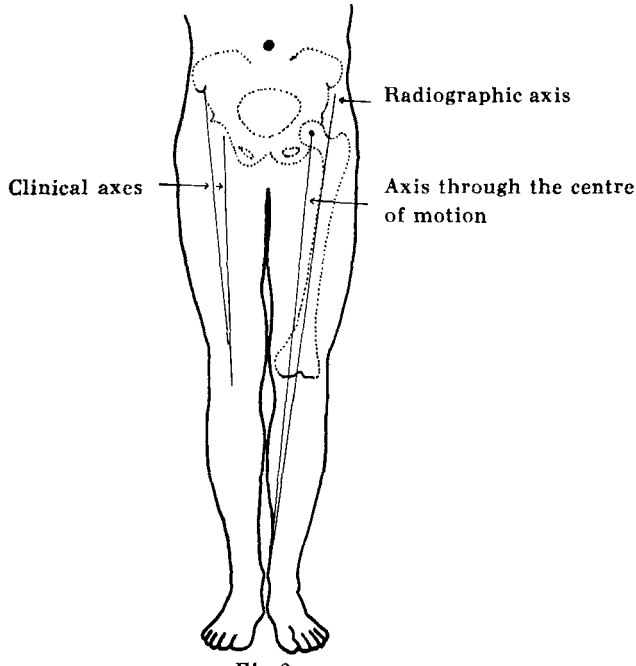

Fig. 3.
Various longitudinal axes of the leg.

There may be certain objections to this subtraction from the theoretical standpoint because a real shortening of one centimetre in the neutral position gives an intermalleolar distance of slightly more than one centimetre. This small difference is, however, of no practical significance. The same applies to errors that arise through migration of the acetabulum in the medial as well as the cranial direction.

RADIOGRAPHIC EXAMINATION OF FRONTAL MOBILITY AND POSITION

Though measurement of the range of movement of the hip-joint in the frontal plane by means of radiography in two extreme positions is simple from the theoretical standpoint, this method would seem to have been little used. An adduction *position* in the hip-joint can also be determined on radiographs, but the long axis of the leg through the head of the femur cannot be found unless a radiograph of the whole leg is obtained. The "clinical" axis in the centre of the thigh contour is not visualized and the axis obtained from the femur does not pass through the centre of motion (Fig. 3).

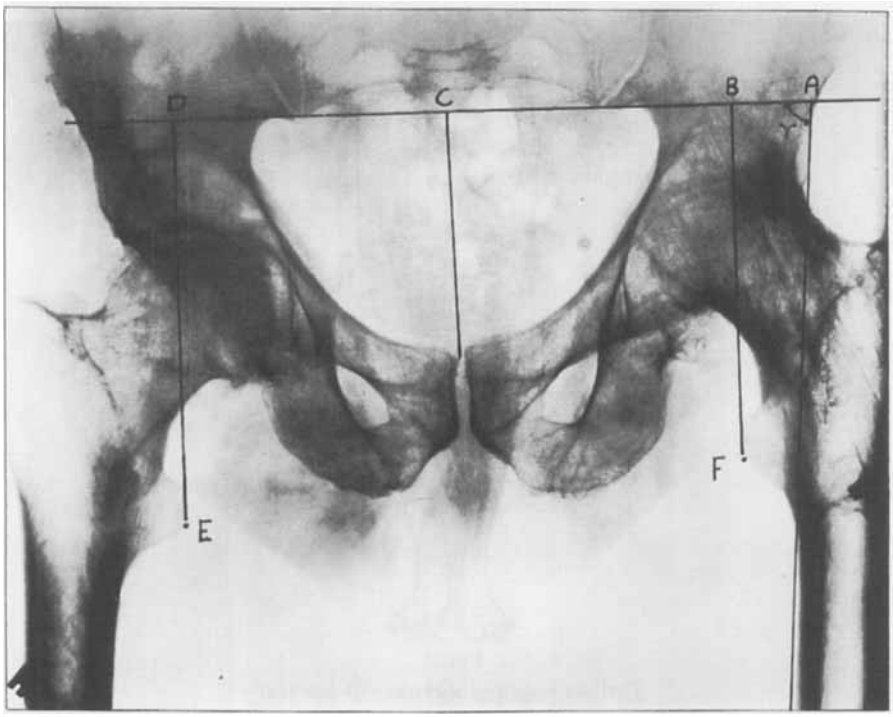

Fig. 4.
Radiograph of the pelvis and femurs from a patient with left-sided hip arthrodesis. DE–BF is the real shortening and γ the angle between the radiographic axis of femur and a horizontal line through the pelvis.

In 24 cases in which arthrodesis had been executed in the hip and in which the adduction position was examined by radiography, a frontal view was taken of the pelvis and the upper part of the thigh with a focal distance of 100 cm, and with the central ray midway between the hips. On these radiographs a 10 per cent enlargement was assumed, and this was usually in agreement with the true distance between the skeleton and the film in relation to the focal distance. On the radiographs a horizontal reference line was drawn, usually between the lower range of the two sacro-iliac joints (Fig. 4). The angle between this line and a line through the cortical contour of the femoral shaft was determined. This line usually passes in a direction towards the medial malleolus (Fig. 3). The distance between the intersection of the two lines (A) and a point midway between the hip joints (C) was measured (10 per cent reduction owing to the enlargement). On the

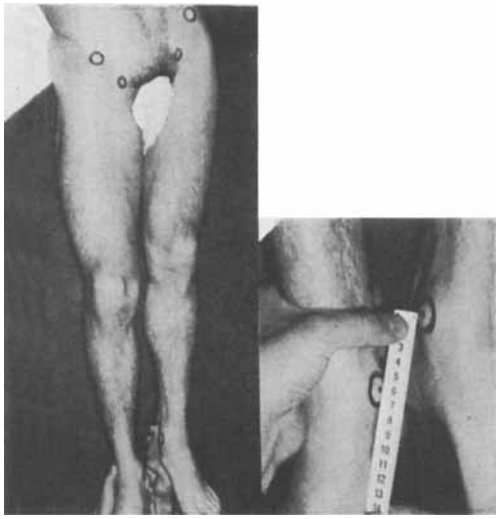

Fig. 5.
Technique for measuring the adduction in terms of the intermalleolar distance.

basis of the length of the normal leg and the distance A-C, the neutral angle of the normal side was calculated. The difference between this and the adduction angle on the rigid side was taken as a measure of the adduction in the rigid hip. In the determination of the extent of the adduction and the position of the leg on the radiographs several measurements and estimates must be performed, and it can therefore never be completely accurate. The determination of the angle between the femur and the horizontal line through the pelvis can, of course, be exact but this does not give any impression of the adduction of the hip in relation to the zero or neutral position.

The real shortening in the hip-joint on the side of the arthrodesis was measured by subtracting the distance on both sides between the horizontal reference line and the tip of the lesser trochanter (Fig. 4, DE-BF).

A NEW CLINICAL METHOD FOR DETERMINING THE ADDUCTION IN THE HIP-JOINT

The method can be used for one or two mobile hips but it is necessary for the *ad*duction of the hip under examination to be less than the *ab*duction of the other hip, as is normally the case, and usually is the case when it is desired to determine the adduction of a diseased hip. However, both legs must be the same length or any real shorten-

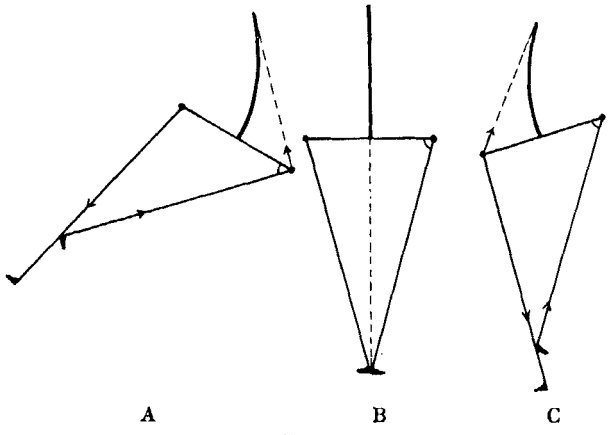

Fig. 6.

Diagram of the legs, hips and spinal column (B) in the neutral position, (A) in an oblique suitable for measurement of adduction, and (C) with the legs in the long axis of the body, a position unsuitable for the measurement of adduction.

ing must have been determined radiographically. The extent of the adduction, as the actual adduction position, is measured as the intermalleolar distance. The use of the medial malleolus as the reference point instead of the inferior surface of the heel involves a small approximation, which may be of clinical significance if there should be a considerable difference in size between the heels. To facilitate the measurement between the malleoli these should first be palpated and the tips marked on the skin. The hip under examination is then adducted by moving the leg in the direction of adduction; axial pressure is applied to it while traction is applied to the other leg. The legs are held close together throughout (Fig. 5). So as to be able to obtain full adduction it is important for the two legs to be taken to the side so that the back is also bent and the pelvis is held firm by stretching the muscles between the back and the pelvis (Fig. 6 A). If only pressure is applied to the leg to be adducted, and tension is applied to the other, adduction may be prevented through a too small mobility of the back, and in this position there is also a much greater elastic resistance to the adduction movement (Fig.6 C). The intermalleolar distance with the feet together is measured. If the legs are the same length this measurement is the adduction of the leg under examination (for instance, left hip: adduction —4 cm). If there is a true shortening of the leg of the examined side this (*e.g.* 2 cm) is subtracted from the intermalleolar distance (*e.g.* 7 cm) and the remainder (5 cm) is then

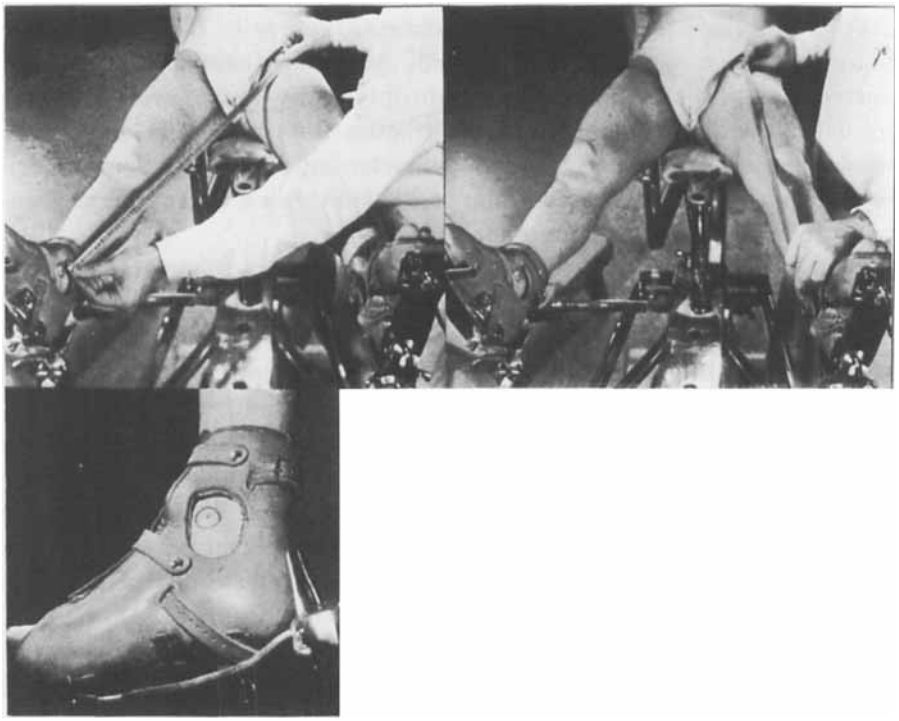

Fig. 7.
Measurement of the position of the left hip on the operation table in the frontal plane when a nail arthrodesis is about to be performed.

the measure of the adduction (—5 cm). In cases in which arthrodesis of the hip has been performed the intermalleolar distance is measured with the legs together and the real shortening is subtracted. The remainder constitutes the adduction position (*e.g.* left hip rigid with an adduction of —3 cm).

If there is an *ab*duction position that is so moderate that the mobile leg can still be taken to the rigid one, the value will be positive (*e.g.* left hip rigid with abduction position of +4 cm). Here, too, the distance between the malleoli (*e.g.* 2 cm) is measured, but in this case any true shortening (*e.g.* 2 cm) is added to give the abduction (+4 cm). In a determination of the magnitude of a contracture position the procedure is in principle the same. If there is an adduction contracture an attempt is made first to correct it so far as possible by pressing in the axial direction on the sound leg and applying traction to the contracted one. If there is still a distance between the malleoli (*e.g.*

2 cm) and the leg with an adduction contracture is still short, there is an adduction contracture of —2 cm. All these distances can be converted to angles either roughly by multiplying by 3, or more accurately by using the above formula, but in practice the distance value is more useful since this corresponds to the shortening that the patient experiences when walking and standing, or the shortening that must be compensated for by surgery or other means.

If in a case of hip arthrodesis it is necessary to set the leg in a certain position on the operation table the following reasoning may be used. Suppose that there is a true shortening of one centimetre through migration of the acetabulum, measured on radiographs. No further shortening is expected to result from operation and healing. It is desired to compensate for the shortening entirely by abduction, so that legs are the same length when walking and standing. According to the above reasoning the hip under examination must be set in such a position that the two malleoli are at the same level when they are held together. On the operation table it is, however, difficult or impossible to hold the legs together and it is therefore necessary to set the hip and then to measure with a tape (*i*) the distance from the centre of the mobile hip (the intersection between the inguinal ligament and the femoral artery) to the medial malleolus of the same leg, and (*ii*) the distance from the same centre to the malleolus of the leg to be operated on. These distances should then be equal (Fig. 7).

TABLE 3

Adduction Position for 24 Subjects for whom Hip Arthrodesis was Performed. Measurements Performed Clinically (C) and on Radiographs (R). Values in mm.

C	R	C	R	C	R	C	R	C	R	C	R
—14	—20	— 4	0	+12	+20	—47	—40	+10	0	+10	0
0	— 5	—32	—40	+12	+10	+ 8	0	—15	—15	—31	—40
—12	—25	—32	—45	+36	+45	—70	—70	—17	—30	—23	—30
+12	0	+ 3	+ 5	+22	+30	+21	+20	—18	—15	0	— 5

COMPARISON BETWEEN RADIOGRAPHIC AND CLINICAL MEASUREMENTS

In 24 patients for whom a hip arthrodesis had been performed the adduction from the neutral position was measured on radiographs and by the new clinical method. The agreement between the two methods was fairly close, for there was a deviation of more than one

centimetre (corresponding to 3°) in only 4 of the subjects (Table 3). In view of the unreliability of the numerous measurements on the radiographs, there is reason to believe that the clinical method is the more accurate.

TABLE 4

Adduction versus *Age, Measured by the Proposed Clinical Method.*

Age	20–29	30–39	40–49	50–59	60–69	70–79	Cases of osteoarthritis
No. of subjects	10	9	8	9	7	7	20
Mean adduction (cm)	—10.2	—9.4	—8.8	—6.1	—6.1	—3.4	—2.9
Range (cm)	8–14	6–12	5–13	2–10	1–8	0–7	0–5

VARIATION OF THE ADDUCTION WITH AGE

By means of the new clinical method a study of adduction was performed on a series of subjects with clinically sound hips (50 cases) and on 20 patients with osteoarthritis. The former were examined for other complaints not involving the hips and none had had symptoms from the hips; usually they had not undergone radiologic examination. It was found that the adduction capacity of the sound hips decreased with age and was low for subjects with osteoarthritis (Table 4). Quite large individual variations were found. Adduction contracture was, of course, common among the cases of osteoarthritis, and the magnitude of this contracture could be obtained accurately by this method.

DISCUSSION

It is of course difficult to change the time-honoured clinical methods of measurement, and this is especially true of adduction of the hip, which in most respects is not of major clinical interest. Since, however, this range of movement is entered in practically all record sheets at orthopaedic clinics, and expressed as an angle, and since the value is obviously quite arbitrary, this form of measurement should logically be abandoned when it is not required and should be made more accurately in the cases where it is of real interest. The method presented above would probably meet the usual requirements of accuracy and is, moreover, simple to use. Its greatest value is perhaps for setting the hip on the operating table when a nail arthrodesis is being planned.

In a series of 35 follow-up cases with hip arthrodeses[9] the adduction ranged from —3.3 to +6.4 cm (positive values indicate abduction) and the intermalleolar distance (without correction for the true shortening) from —7.0 to +4.5. These values reflect the difficulty in setting the joint in the right position for an arthrodesis, though, of course, there were other factors, too, that contributed to this large range.

SUMMARY

The usual clinical measurement of the frontal mobility of the hip is discussed and criticized. On the basis of the mathematical relationship between the shortening of the leg and adduction a new clinical method is presented for determining the adduction of the hip in which the distance between the medial malleoli is measured in the axial direction of the leg with the feet together. In this way a measure can be obtained of the true adduction position and of the total adduction; in the latter case the measurement is performed on the fully adducted hip. The method is more accurate than others and indicates directly the dependence of the length of the leg on the adduction, especially in connection with hip arthrodesis.

RESUME

La mensuration clinique usuelle de la mobilité frontale de la hanche est discutée et critiquée sur la base d'un rapport mathématique entre le raccourcissement de la jambe et l'adduction. Une nouvelle méthode clinique est présentée pour déterminer l'adduction de la hanche en mesurant la distance entre les malléoles médianes en direction axiale de la jambe, les deux pieds joints. De cette manière on peut obtenir une mesure en vraie position d'adduction et en adduction totale. Dans le dernier cas, la mensuration est effectuée sur la jambe entièrement en position d'adduction. La méthode est plus exacte que d'autres et indique directement la dépendance de la longueur de la jambe par rapport à l'adduction, en particulier en relation avec l'arthrodèse de la hanche.

ZUSAMMENFASSUNG

Die gewöhnliche, klinische Messung der frontalen Beweglichkeit der Hüfte wird besprochen und kritisiert. Auf Grund der mathematischen Beziehung zwischen Beinverkürzung und Adduktion wird eine neue klinische Methode zur Bestimmung der Hüftadduktion vorgestellt,

bei der die Distanz zwischen den medialen Malleolen in der axialen Richtung des Beines bei zusammengelegten Füssen gemessen wird. In dieser Weise kann man eine Messung der wirklichen Adduktionsstellung und der totalen Adduktion erhalten. Im letzteren Falle wird die Messung bei vollständig adduzierter Hüfte vorgenommen. Die Methode ist genauer als andere Methoden und zeigt die Abhängigkeit der Beinlänge von der Adduktion direkt auf, besonders im Zusammenhang mit einer Hüftarthrodese.

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