

ROENTGENOLOGICAL STUDIES OF THE ANATOMY OF THE PROXIMAL END OF THE FEMUR

BY

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We know that the characteristic form of the proximal end of the femur is conditioned chiefly by angulation and torsion, partly in the frontal, partly in the sagittal plane. Its configuration is liable to considerable variations, as well individually, in the different races and at different periods of life, as under pathological conditions of one kind or other; and these variations have been the object of thorough study on the part of both anthropologist and orthopedists. Thus in 1878, *Mikulicz* published the results of his measurements of a large number of specimens, and among the many others who in the course of years have dealt with the question from various points of view and have given valuable contributions to its solution may be mentioned *Martin*, *Friedländer*, *Drehmann*, *Gaston Backman*, *Haglund*, *Le Damany*, *Gruncwald*, *Lange* and *Pitzen*, *Valentin*, *Meyer*, *Schramm*, *Schultz* and *Schertlein*. The research methods used by these authors have been either anthropologic or roentgenologic.

Before speaking about the details of the anatomy of the proximal end of the femur it may be advisable to settle the matter of terminology, as in not a few instances mistakes have arisen through different terms being used by the different authors to designate one and the same thing.

The angle formed by the diaphysis and the axis of the collum is usually called the *collo-diaphyseal* angle. *Martin*, as well as *Backman* (who has indicated a method for the anthropological mensuration of the angles of the proximal end of the femur) determine this by measuring the angle formed by two straight

lines: one passing through the middle of the caput and collum, the other drawn from the upper to the lower end of the diaphysis. In my roentgenological measurements I have used the same lines, except that instead of the mid-point of the distal end of the femur I have chosen a point about 10 cm. below the lesser trochanter; because the film does not take in the whole length of the femur.

The deviation of the proximal end of the femur from the horizontal plane is more complicated, inasmuch as it is made up of several different components. It is conditioned by a gradually occurring rotation of the whole upper end of the femur in relation to the shaft; but this torsion includes not only the entire proximal end of the femur; also the collum and the caput may, independently, be placed at angles in relation to adjoining parts of the bones. *Martin*—from the anthropological point of view—designates as »angle of torsion« the angle which the bicondylic tangent forms with the axis of the caput and collum (measured between their mid-points as viewed from straight above). *Backman*, who measures the same angle, calls it »angle of rotation«. *Drehmann*, on the other hand, as well as *Lange* and *Pitzen*, who have given considerable study to the matter, designates the twisting of the whole upper end of the femur in relation to the condylic plane as torsion, while the angle which the axis of the collum forms with the proximal end of the femur is by them called »collum version«, and the angulation of the caput »caput version«. If there is any angular bend of the collum itself they call it »flexion«.

Schramm uses the term: *collo-condylic angle* to designate the twist of the whole upper end of the femur, and divides this into three components; namely, (1) the *angle of torsion*,—which indicates only the twist of the shaft, beginning a little below the lesser trochanter and ending in the intertrochanteric line; (2) the *versio colli*, and (3) the *flexio colli*; the two latter of which he defines in the same manner as the two authors just mentioned.

It is, of course, rather immaterial whether one designation or the other is used; the main thing is that *the definition* of the

chosen term is given so exactly as to preclude all possibility of mistake or confusion.

The only two angles of any *practical* importance are the one which the entire proximal end of the femur forms with the bicondylic tangent, and the one which the caput-collum axis forms with the horizontal plane. The first of these I have in my measurements termed *the angle of torsion of the proximal end of the femur*; the second I have called *the angle of torsion of the caput-collum axis*. Sometimes, but not always, these two principal angles of torsion coincide. If the last named is the

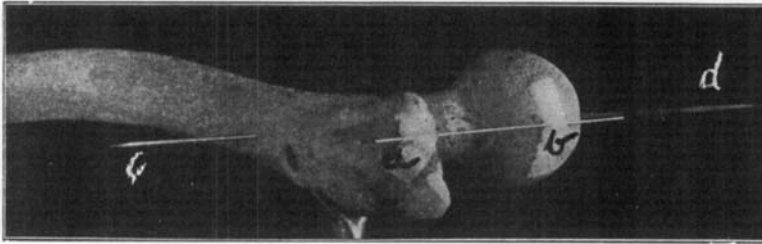


Fig. 1.

smaller of the two, it means that there is a retroversion of the collum + caput equal to the difference between the two angles; if it is larger than the other it means that there is anteversion. In order to avoid all possibility of mistake I have in *Fig. 1* tried to visualise both angles. The line *ab*, which connects the mid-point of the caput with the mid-point of the distal end of the collum, forms with the horizontal plane the angle which I have called the angle of torsion of the caput-collum axis; and in the same way the line *cd*, drawn between a point in the middle of the lateral part of the shaft, immediately distal to the plane of the lesser trochanter, and the mid-point of the caput, forms with the horizontal plane the angle of torsion of the proximal end of the femur.

From the studies of *Friedländer*, *Le Damany*, *Drehmann* and others, and especially from the researches of *Lange* and *Pitzen*, we know that under physiological conditions a regular change

of the torsion takes place, beginning at an early period of the fetal stage, and terminated, in the main, by the third or fourth year. As to the details of this process there is a certain diversity of opinion, but on the whole it may be said—following *Lange* and *Pitzen*—that during the second and third months of fetal life there is no antetorsion at all, but rather a certain degree of retortorsion. During the fourth month this primitive form undergoes considerable changes; a marked antetorsion takes place, which reaches its culmination already during the fifth and sixth fetal months, whereupon it remains fairly stationary until the second to fourth year of life. From then onward the torsion again diminishes somewhat until the subject reaches the age of full growth; but in reality this diminution is in the majority of cases conditioned by retroversion.

The collo-diaphyseal angle, which is hardly indicated during the fetal stage, gradually develops up to the third or fourth year. Whether it afterwards continues to diminish, up to the age of full growth, and whether there thus takes place a gradual change from collum valgum to collum varum, is a question that has given rise to much discussion, and on which opinion has been much divided. A detailed review of the problem, which is interesting both from the anthropologic and the orthopedic point of view, may be found in a paper by *Valentin* (see the appended list of literature). In the present connexion, where I am dealing chiefly with a question of methods, I do not feel that the matter need be gone into at greater length.

Both the collo-diaphyseal angle and the angle of torsion are liable to considerable physiological variations in different individuals and races. According to *Martin*, the individual variation in width of the former is very great, namely as much as 23° . The mean average for the different races has been found to range from 121° in the Indians to 133° in the Swiss. As for the torsion, *Martin* states that the mean figure varies, in the different races, between 8° and 35° , while the range of individual variation may even be as much as 67° ; namely from -25° to $+42^{\circ}$. Negative angle values are very unusual, however. In 71 femoral bones measured by *Lange* and *Pitzen* by the method

already described, they found the width of the angle to range from 3° to 42° ; in 43 per cent. of them the width was from 15° to 25° .

The anthropological studies here briefly referred to are based on skeletal measurements. Against the greater part of them it may be objected that no distinction has been made—nor could possibly have been made, of course,—between normal and pathological cases.

Attempts to determine the angles in question under normal conditions on living subjects have by no means been lacking, but the results have been more or less accurate, owing to the shortcomings attaching to the methods hitherto employed, which have been chiefly roentgenologic. Already in 1906, in a paper in the transactions of the Upsala Medical Society, where the functional consequences of asymmetrical collum angles were discussed, *Haglund* called attention to the sources of error in connexion with the roentgenological determination of the collo-diaphyseal angle; and his remarks apply to the angle of torsion, as well. An examination on extensive lines, by reliable roentgenological methods, of normal cases, including individuals of different races and of different age, should be of considerable interest.

Pathological changes of the proximal end of the femur are found chiefly in connexion with coxa valga and coxa vara deformities of the hip, and in cases of congenital luxation. They have been the object of thorough study on the part of the orthopedists, but even a brief review of those studies lies outside the scope of the present investigation, which is concerned principally with normal conditions. Besides, the shortcomings attaching to the methods employed have, of course, also in those cases made it impossible to obtain results that may be considered as absolutely reliable. If a clearer insight into those questions is to be obtained, it is therefore necessary, first of all, to find a method of investigation involving a minimum of sources of error.

For purely anthropologic, skeletal mensuration, serviceable methods have been indicated, for instance by *Backman* in a paper published in 1925. The illustrations *Fig. 2* and *Fig. 3* are

taken from that work, and show his method for determining the collo-diaphyseal angle and the angle of torsion of the caput-collum axis. The method used by *Lange* and *Pitzen* for determining the torsion of the proximal end of the femur is as follows: The femoral bone is laid on a flat table in such a manner that the posterior surfaces of the condyles rest firmly on the latter;

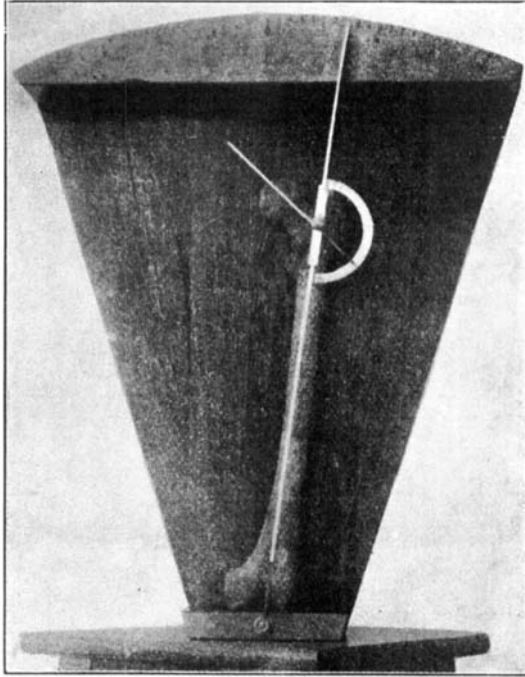


Fig. 2.

a sheet of glass is placed tangentially on the anterior surface of the neck of the femur; where-upon the angle which this sheet of glass forms with the surface of the table is measured.

In the case of living subjects entirely different methods are required, of course. The attempts made before the advent of roentgenology, with palpation and measuring, must be considered as very unreliable. The introduction of roentgen examination, and the gradually improved methods of the latter, have

undoubtedly brought the matter a step forward; but, as already said, the problem can hardly be considered as definitely solved yet.

Before proceeding to describe the method evolved by myself, and the results obtained by that method, I wish briefly to review the more recent roentgenological investigations into the subject.

As regards, in the first place, the collo-diaphyseal angle, it is impossible to determine it *directly* from the roentgenogram,

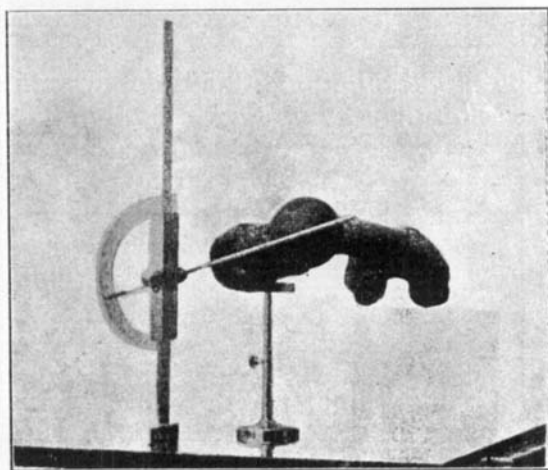


Fig. 3.

even with the femur in medial position, because the angle obtained is, of course, a projected—that is, an *apparent*—one, whose size depends upon the torsion. *Schramm*, determining it *anatomically* on 40 skeletal specimens, found for this angle a mean value of $118^{\circ}6'$; while, on determining it *roentgenologically*—that is, projected—in 20 subjects (= 40 femora) of ages ranging from $5\frac{1}{2}$ to 60 years, he got a mean value of $134^{\circ}5'$; in other words, a considerable difference. *Lange* has indicated a method for determining the collo-diaphyseal angle approximately. It is based on the distance of the lesser trochanter from the horizontal line of the dome of the caput, and is intended by him especially as a means of establishing the diagnosis of respective-

ly coxa vara and coxa valga. It may be useful for practical purposes, but it gives no exact measurement for the angle.

Among the attempts to determine the angle of torsion roentgenologically, those of *Schultz* and *Schertlein* deserve to be specially mentioned. The former uses Lauenstein's position—the leg flexed, abducted and rotated outwards—with a special arrangement for controlling the horizontal disposition of the axis of the condyle. The method is comparatively simple, and is in principle similar to the one employed by me, inasmuch as it enables one to determine the angle directly; but according to *Schultz* himself it gives the value only to within as much as 15 degrees of possible error. *Schertlein* takes two roentgenograms—with the patient in two positions, in planes at right angles to one another,—one in frontal projection, the other at an angle of 90° to the frontal plane, and thus obtains two values for the projected—i. e. the apparent—angles, not for the true ones. From these he then calculates the true angles—both the collo-diaphyseal and the angle of torsion—by means of a rather complicated mathematical deduction. Against this method it may be objected, among other things, that the combination of the two projections is liable, in certain cases, to increase the source of error that must already be reckoned with from either of them. Neither *Schultz* nor *Schertlein* records any considerable number of cases examined.

I now proceed to a description of my own method. As already said, roentgenography with the leg in medial position gives a wrong picture so far as the purpose of determining the *collo-diaphyseal* angle is concerned, owing to the physiological torsion of a portion of the proximal end of the femur, or, more exactly, of the caput-collum axis. If one knows the degree of this torsion, however,—which must therefore be determined beforehand,—it is possible, by means of a comparatively simple mathematical calculation, to find the true angle. It is this fact of which I have made use for determining the collo-diaphyseal angle.

The *angles of torsion*, on the other hand,—both that of the proximal end of the femur and that of the caput-collum axis,—can be determined directly, by proper adjustment of the tube

and cassette in relation to the patient. All that is needed is, *with the femur in medial position*, to direct the ray at right angles to the axis, and to place the cassette parallel to the latter. The manner of this adjustment will be seen from *Fig. 4*, which is borrowed from a paper by *Wittek-Saltzberg*, who has devised it as a method for taking lateral pictures of the hip-joint in general, but not for the special purpose here aimed at. The degree to which the leg under examination is abducted is im-

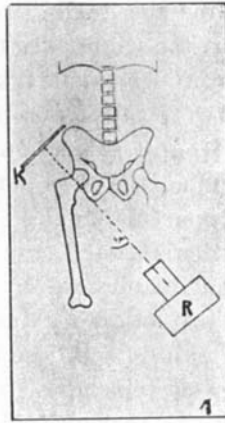


Fig. 4.

material. Nor is it necessary that the other leg should be flexed; it may just as well be abducted, just as, for instance, when it is a question of photographing a collum fracture during the process of reposition, when the sound leg has to be extended and abducted. In this way it is thus possible to determine the true angles—both those of torsion and the collo-diaphyseal one — by means of two exposures: an anterioposterior one in the usual manner, and a lateral one in the manner indicated above. The only condition is that in both cases the leg should be in a medial position.

The way in which the procedure is carried out is as follows. The patient lies on his back on the table, with his legs hanging down over the edge of the latter; in which position the bicondyl-

ic tangent automatically comes practically parallel to the horizontal plane. The first exposure is made with the tube focus centered as nearly as possible above the point of intersection between the axis of the collum and the axis of the diaphysis. With a focus-to-cassette distance of not less than 70 cm., a slight inaccuracy of the centering will have no practical influence on the result, as one may easily convince oneself by shadow ex-



Fig. 5.

periments with a point of light, a piece of wire bent at an angle and a sheet of white paper. A deviation of 3 cm. in one direction or another will cause an error in the projected angle of less than 3°. Before the exposure is made, three lead markers are fastened on the skin over the estimated place of the caput, and three others on the anterior side of the thigh, just below the trochanter. By means of these it will be easy to mark the axis of the collum for the purpose of the next exposure (see *Fig. 6*).

For the second exposure, the tube focus is directed at right angles to the axis of the collum (determined as described above) some centimeters above the plane of the trochanter (see *Fig. 5*). The cassette is placed in a special stand, parallel to the same axis, whereby it comes to project somewhat beyond the anterior

superior iliac spine. To the cassette is fastened a frame holding a water level, and this frame is pushed so far down on the

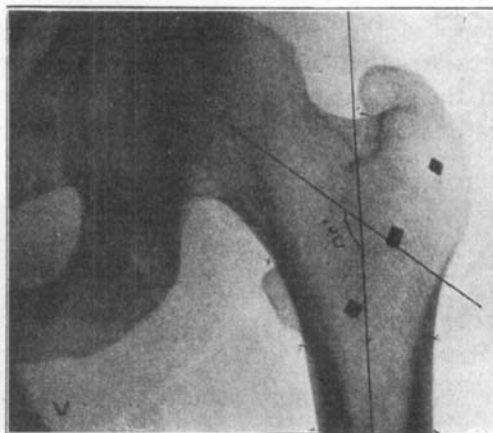


Fig. 6.

cassette that a projection of it is obtained when the exposure is made, whereby a fixed horizontal line is obtained for the

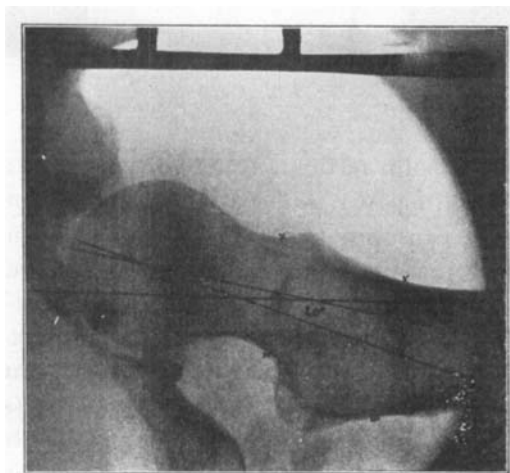


Fig. 7.

calculation of the angle. *Fig. 7* shows a normal hip-joint roentgenographed in this manner. Also with regard to this angle α

shadow experiment will prove that a slight deviation in one direction or another, in relation to the axis, has no practical influence on the result.

To calculate the *collo-diaphyseal angle* one marks on the roentgenogram (1) the mid-points of the caput and collum, and (2) the mid-point of the diaphysis in two places: one below the

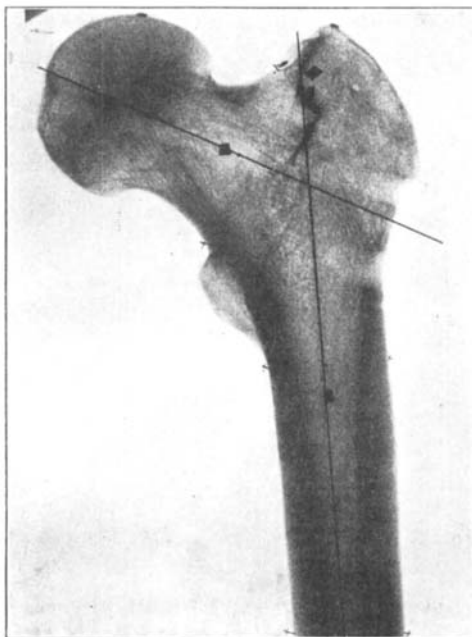


Fig. 8.

lesser trochanter, the other as far below this as the film permits, —say about 10 cm. It is advisable in one's work always to make this distance the same, in order to get comparable values for the different cases. The point of intersection of the two lines thus obtained indicates the *projected angle* (see Fig. 6). Fig. 8 shows the mid-points lead-marked in this manner before the taking of the projected roentgenologic picture. It will be noticed that the line systems agree almost exactly.

The true angle— x —is found by means of the formula $\cos x = \cos y \cos z$, in which y is the projected angle, z the angle of

torsion of the caput-collum axis measured in relation to the bicondylic tangent (= the horizontal plane).

The *mathematical deduction* is as follows. In the perspective diagram *Fig. 9*, the true position of the caput-collum axis is indicated by the dotted line, the unit length of which is assumed to be 1. Its projection *bc*, which lies in the plane of the paper, thus corresponds to the caput-collum axis projected on the film. If z is the angle of torsion, the length of *bc* is $\cos z$. The angle y

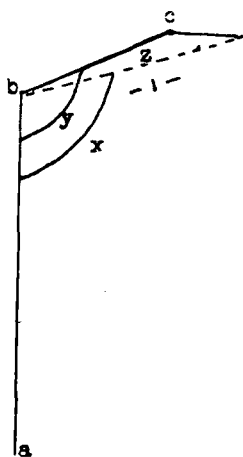


Fig. 9.

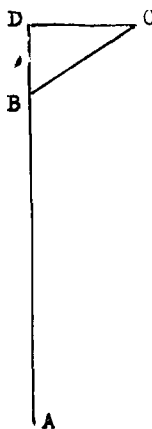


Fig. 10.

is thus the projected (apparent) collo-diaphyseal angle, and x the true collo-diaphyseal angle, which we set out to find.

In the supplementary construction *Fig. 10*, the angle ABC is equal to y , and BC equal to $bc = \cos z$. In the right-angled triangle BCD , BD is equal to $BC \cos (180 \div y) = \div \cos y \times \cos z$. If we now imagine the associate triangle moved over into the plane of the true angle x , where the line BC gets the length 1 (the unit length), BD will remain the same as before; in this case equal to $\cos (180 \div x) \times 1 = \div \cos x$. Hence we have $\div \cos x = \div \cos y \times \cos z$, or $\cos x = \cos y \times \cos z$.

Example: If the projected collo-diaphyseal angle is 135° , and the angle of torsion of the caput-collum axis 20° , the true collo-diaphyseal angle (x) is found by means of the equation:

$$\cos x = \cos 135^\circ \times \cos 20^\circ = \div \cos 45^\circ \times \cos 20^\circ;$$

$$\cos x = \div 0.707 \times 0.940 = \div 0.664;$$

$$\cos x = \div \cos 48^\circ;$$

$$x = 180^\circ \div 48^\circ = 132^\circ.$$

As already said, the most important angles of torsion, from a practical point of view, are *the angle of the caput-collum axis with the horizontal plane*, and *the angle of the whole proximal end of the femur with the same plane*.

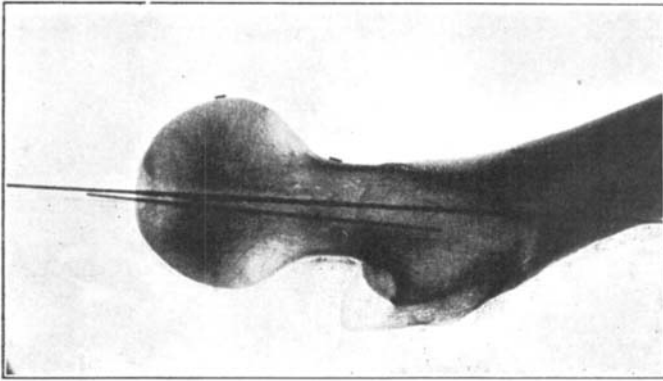


Fig. 11.

The former angle is determined as follows. On the film one marks the centre of the caput (found by means of a pair of compasses) and the middle of the collum close to the beginning of the trochanteric part. The angle which the line connecting those two points makes with the horizontal plane (in the film indicated by the shadow of the metal frame carrying the water level) gives the torsion of the caput-collum portion directly. It is this angle (z) that one, as already said, uses in the formula given above to determine the true collo-diaphyseal angle. *Fig. 11* shows the picture, taken in the manner already described, of a skeletalized femur, in which the caput-collum axis is marked with a metal nail (just as in *Fig. 1*). As it will be seen, the line marked on the films as connecting the midpoint of the caput with that of the distal limit of the collum coincides very nearly with the true axis, indicated by the nail.

The angle of torsion of the whole proximal end of the femur is somewhat more difficult to determine; but also this can be done, though perhaps not with quite the same accuracy. As already said, *Lange* and *Pitzen* used, to determine this angle anthropologically, a sheet of glass placed tangentially on the anterior side of the collum, and measured the angle which the

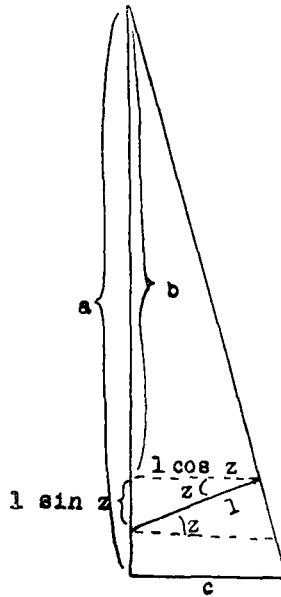


Fig. 12.

glass made with the horizontal plane. This line cannot be determined on the film, however. Still, it is possible to locate its various points fairly accurately in the latter, if one uses, instead, the straight line drawn from the middle of the caput to the mid-point of the vertical line of the shaft of the femur, just distal to the lesser trochanter (where the torsion begins). Also this may be seen from *Fig. 11*, where the long metal nail forms the connecting line between those two points (cf. *Fig. 1*). With small lead markers have also been marked the middle of the anterior and posterior sides of the shaft of the femur, just below the lesser trochanter. The boundary line between the latter and

the shaft is easily determined on the roentgenogram. If a line drawn from this point at right angles to the shaft, is halved, and the halving-point connected with the mid-point of the caput, this connecting line will coincide very nearly with the axis marked by the metal nail. In *Fig. 7*, both the angles of torsion here discussed have been measured. That of the caput-collum axis is 12°, that of the proximal end of the femur 20°. The retroversion of the caput-collum axis is thus 8°.

By the method here indicated it is also possible to determine another important variation of the anatomy of the proximal end of the femur, namely *the length of the caput-collum axis*, measured from the apex of the caput to the intertrochanteric line (or crest). It is found by means of a comparatively easy mathematical deduction based on its projected length in the frontal picture. In the diagram *Fig. 12* (next side), *a* is the distance from the tube focus to the cassette, *b* the distance from the tube focus to the plane of the trochanter, *c* the length of the projected—and enlarged—caput-collum axis, *l* the actual length of this axis, which we are trying to find. The angle *z* is the angle of the caput-collum axis.

The mathematical deduction is as follows. According to the rule of proportion we have $\frac{l \times \cos z}{c} = \frac{b - l \times \sin z}{a}$ whence we get

$$l = \frac{b}{\frac{a}{c} \times \cos z + \sin z}$$

Example.—If the distance from the tube focus to the cassette is 100 cm., to the plane of the trochanter 80 cm., the projected caput-collum axis 10 cm., and the angle of torsion 20°, the actual length of the caput-collum axis *l* will be equal to

$$\frac{80}{\frac{100}{10} \times 0.940 + 0.342} = \frac{80}{9.4 + 0.34} = 8.2 \text{ cm.}$$

I have examined by this method about a dozen normal hips; that is, hips without even the slightest clinical indications of deviation from the normal. The result is shown in *Table I*; the cases being set down in the order of the increasing value of the projected collo-diaphyseal angle.

TABLE I.

Sex	Age	a	b	c	d	e	f
♂	60 years	116°	113°	30°	27°	9	8.13
♂	56 »	125°	123°27	25°	17°	6	5.15
♂	19 »	125°	122°61	25°	20°	8.3	7.14
♂	44 »	127°	125°73	20°	14°	7	5.83
♂	44 »	130°	127°16	25°	20°	8.2	6.93
♀	66 »	132°	130°03	18°	16°	8.5	7.08
♂	42 »	134°	133°58	15°	8°		
♂	28 »	140°	136°04	22°	20°	7.6	6.45
♂	? »	141°	134°78	22°	25°	6	5.55
♂	? »	143°	134°33	29°	29°	6.9	6.2
♀	17 »	144°	141°59	20°	15°	7.5	6.25

a = projected collo-diaphyseal angle.

b = true, calculated collo-diaphyseal angle.

c = angle of torsion of proximal end of femur.

d = angle of torsion of caput-collum axis.

e = projected length of caput-collum axis.

f = true, calculated length of caput-collum axis.

These relatively few examples, representing full-grown individuals of various ages, and chosen at random, show how greatly the width, especially of the collo-diaphyseal angle (113° — 142°) can vary in functionally normal hips. Also the angle of torsion shows considerable variations.

In order to be able to determine, at least approximatively, the true collo-diaphyseal angle when the projected one and the angle of torsion are known, I have worked out the following table (*Table II*) according to the mathematical formula already given.

TABLE II.

z	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
90°	90	90	90	90	90	90	90	90	90	90
100°	100	99.84	99.40	98.65	97.64	96.41	94.98	93.41	91.73	90
110°	110	109.68	108.75	107.23	105.19	102.70	99.85	96.72	93.41	90
120°	120	119.50	118.02	115.65	112.52	108.75	104.48	99.85	94.98	90
y										
130°	130	129.27	127.16	123.83	119.50	114.41	108.75	102.70	96.41	90
140°	140	138.97	136.06	131.56	125.93	119.50	112.52	105.19	97.64	90
150°	150	148.53	144.47	138.59	131.56	123.83	115.65	107.23	98.65	90
160°	160	157.73	152.01	144.47	136.06	127.16	118.02	108.75	99.40	90
170°	170	165.90	157.73	148.53	138.97	129.27	119.50	109.68	99.84	90
180°	180	170	160	150	140	130	120	110	100	90

- x = the true collo-diaphyseal angle.
- y = projected collo-diaphyseal angle.
- z = angle of torsion of the caput-collum axis.

It will be seen that with a mean value for the projected collo-diaphyseal angle of about 130° the difference between the latter and the true angle barely amounts to 3°; that is, provided the mean value of the angle of torsion is still about 20°. If the angle of torsion is wider, the difference becomes greater; if its width is 40°, for instance, the difference is not less than about 11°.

As I have already repeatedly pointed out, it is a condition for the determination of the angles by the method here described

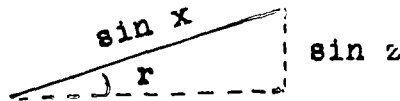


Fig. 13.

that the leg is in medial position, and, consequently, the bicondylic tangent parallel to the horizontal plane. But also in the case of a *rotated femur*—for instance a *clinical coxa-vara* position with outward rotation—it is possible to determine the angles of torsion quite exactly. The condition in that case is that one also knows the degree of the outward rotation, measured at the distal end of the femur. The relation between the rotation of the distal end of the femur and the angle of torsion is namely determined by the formula $\sin r = \frac{\sin z}{\sin x}$, where r is the degree of the (right-angled) rotation at the knee-joint, which, with a true collo-diaphyseal angle of x degrees, corresponds to an angle of torsion of z degrees.

The mathematical deduction of this formula is as follows (cf. *Figs. 9—10*). In the right-angled triangle (*Fig. 13*), where one imagines the femoral bone in horizontal position, seen from the knee, r is the angle of rotation which we are trying to determine. The opposite cathetus and the hypotenuse constitute the intersection of the planes of the angles x and z with a vertical plane through the proximal end of the femur, and therefore,

according to *Figs. 9 and 10*, are equal, respectively, to $\sin x$ and $\sin z$. Consequently, we have $\sin r = \frac{\sin z}{\sin x}$.

If now, in the given case, the outward rotation is 20° , the true collo-diaphyseal angle (measured in the usual way) x degrees, and we call the measured angle of torsion by outward

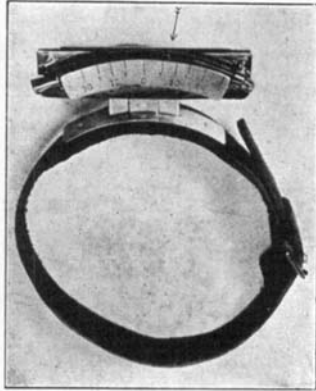


Fig. 14.

rotation z^1 , we shall have $\sin (r + 20) = \frac{\sin z^1}{\sin x}$, and the value of r will thus be equal to the value of the angle obtained by means of the formula $\frac{\sin z^1}{\sin x}$, less 20° . If we then substitute this value for r in the formula $\sin r = \frac{\sin z}{\sin x}$, we get the true angle of torsion (z), which was the one we set out to find.

For the determination of the degree of the outward rotation I have constructed a simple apparatus (*Fig. 14*), consisting of a strap with a graduated water level attached. It is fastened around the distal end of the femur, and is sufficiently exact for practical use.

Example.—If the projected collo-diaphyseal angle (y) is 130° , the angle of torsion of the caput-collum axis (z^1) 40° , and the angle of the knee-joint's outward rotation 20° , the true collo-diaphyseal angle (x) will, according to the formula \cos

$x = \cos 130 \times \cos 40$, be about 119° . According to the formula $\sin (r + 20^\circ) = \frac{\sin 40}{\sin 119}$, r will be about 27° , and the angle of torsion of the caput-collum axis about 23° .

Another Example.—In the course of an operation for collum fracture it is desired to bring the caput collum axis parallel to the horizontal plane. How many degrees (r) should the knee-joint be rotated inwards in order to obtain that position, if the true collo-diaphyseal angle is, for instance, 130° (x), and the

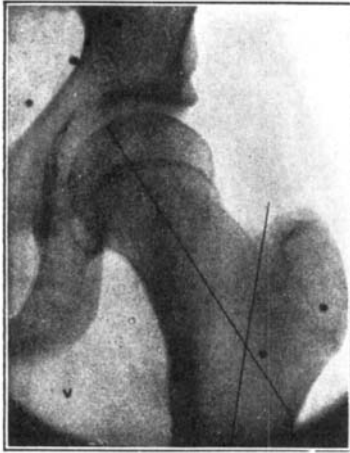


Fig. 15.

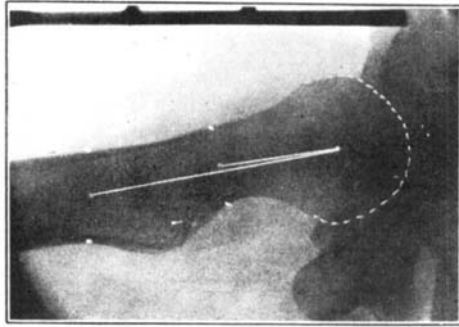


Fig. 16.

angle of torsion of the caput-collum axis (z) 20° ? According to the formula $\sin r = \frac{\sin 20^\circ}{\sin 130^\circ}$, $\sin r$ is equal to $\frac{0.342}{0.766} = 0.446$, and the answer is thus $26^\circ 5'$.

The following illustrations will help the comprehension of the result of measurements of the angles in a case of so-called coxa vara capitalis. On the sound, left side, the collo-diaphyseal angle (*Fig. 15*) is of the pronounced valgus type, with an actual width of the angle of 138° (in the roentgenographic projection 139°). The angles of torsion of the proximal end of the femur and of the caput-collum axis (*Fig. 16*) coincide very nearly; the former is 11° , the latter 9° . The true length of the caput-collum axis is 7 cm.

In the pathologically altered right hip, the actual width of the collo-diaphyseal angle (*Fig. 17*) is only 121° (proj.: 123°). The side view (*Fig. 18*) shows that the angle of torsion of the proximal end of the femur is only 5° . But a more thorough analysis discloses the fact that this small angle is due to a strong retroversion of the caput-collum axis, which has a negative angle of torsion of 18° . It is further found that *the torsion of the shaft*

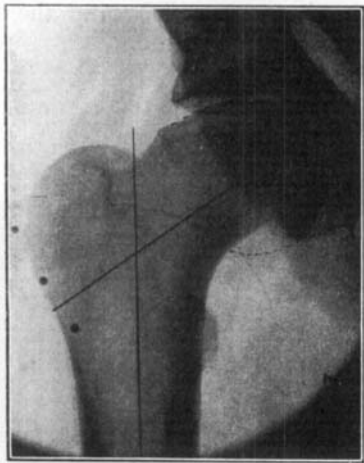


Fig. 17.

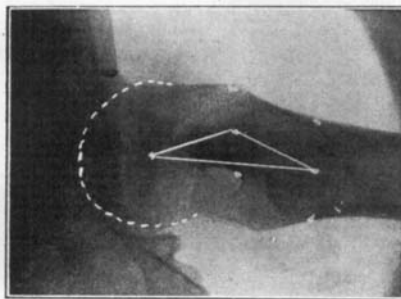


Fig. 18.

of the femur itself is fairly normal; that is, 25° , and the diminished angle of torsion of the whole proximal end of the femur in relation to the horizontal line is thus conditioned by an abnorm angle formation at the line of the collum's junction with the shaft. The actual length of the caput-collum axis is about 7.8 cm. The difference in length of the caput-collum axes of the two sides—0.8 cm.—is thus in reality less than it appears from the roentgenographs, where the difference is 1.7 cm.

SUMMARY

After a brief review of the anthropological and roentgenological methods hitherto employed for determining the different angles of the proximal end of the femur, the author describes a method evolved by himself for determining those angles. With

the leg in medial position, he first determines the roentgenographically projected collo-diaphyseal angle, then, by exposure in lateral projection, the true angles of torsion.

The true collo-diaphyseal angle is found by means of the formula $\cos x = \cos y \cos z$, in which y is the projected collo-diaphyseal angle, z the true angle of torsion of the caput-collum axis, x the true (anthropological) collo-diaphyseal angle. At the same time it is possible to determine the actual length of the caput-collum axis by means of a formula given by the author.

ZUSAMMENFASSUNG

Nach einem kurzen Überblick über die bisher angewandten anthropologischen und röntgenologischen Methoden zur Bestimmung der verschiedenen Winkel des proximalen Endes des femur beschreibt der Verfasser eine von ihm selbst entwickelte Methode zur Bestimmung dieser Winkel. Während das Bein sich in medialer Position befindet, bestimmt er zuerst den röntgenographisch projizierten collo-diaphysealen Winkel, dann durch Belichtung in lateraler Projektion den wirklichen Drehungswinkel.

Der wirkliche collo-diaphyseale Winkel lässt sich finden vermittels der Formel $\cos x = \cos y \cos z$, in welcher y den projizierten collo-diaphysealen Winkel, z den wirklichen Drehungswinkel der caput-collum-Achse und x den wirklichen (anthropologischen) collo-diaphysealen Winkel bedeutet. Gleichzeitig ist es möglich, die wirkliche Länge der caput-collum-Achse mit Hilfe einer vom Autor angegebenen Formel zu bestimmen.

RÉSUMÉ

Après avoir brièvement passé en revue les méthodes anthropologiques et roentgenologiques employées jusqu'ici pour déterminer les différents angles de l'extrémité proximale du fémur, l'auteur décrit une méthode, développée par lui, pour la détermination de ces angles. En posant la jambe en position médiale, il détermine tout d'abord l'angle collo-diaphyseal, projeté roentgenographiquement; puis, en plaçant la jambe en projection latérale, il détermine les angles réels de torsion.

L'angle collo-diaphyseal réel est trouvé au moyen de la formule $\cos x = \cos y \cos z$, dans laquelle y représente l'angle collo-diaphyseal projeté, z l'angle réel de torsion de l'axe de la tête du collum, x l'angle collo-diaphyseal (anthropologique) réel. Il est possible de déterminer en même temps la longueur qu'a l'axe de la tête du collum, au moyen d'une formule énoncée par l'auteur.

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