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THE "SCREW-HOME" MOVEMENT IN THE KNEE-JOINT

By

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The modern textbooks almost invariably make some reference to the "screw-home movement" in the knee-joint: "The medial condyle is $\frac{1}{2}$ in. longer than the lateral condyle, which permits the femur to screw home on full extension and this stabilizes the joint" (*Bailey* (1)). "The movement of medial rotation of the femur on the tibia associated with the later stages of extension of the knee constitutes a locking mechanism, which is an asset when the knee is subjected to strain" (*Gray's Anatomy* (6)). "The 'screw home' phenomenon made possible by the prolongation of the anterior portion of the articular surface of the medial condyle is the most important factor in stabilization of the knee in extension" (*De Palma* (7)). "The key to the function of the knee joint and to its derangements, is the rotation of the tibia on the femur which occurs on flexion and extension movements" (*Helset* (4)). "The screw-home movement is probably the key to the mechanism of the common meniscus lesion, and, as will be shown, probably the key to the common lesion of the anterior cruciate ligament also" (*Smillie* (10)).

All these authors point to the importance of the screw-home movement in various respects but no explanation of its mechanism is offered. In fact no exact account of the measurement or registration of the movement is to be found; it is usually pointed out simply that such a rotation must of necessity occur because the medial condyle of the femur is longer than the lateral one; *Helset* (5) states that in the last 10° of extension the tuberosity of the tibia can be seen to move laterally. If reference to the terminal rotation is traced back in the literature it is found that Virchow was among the first to point out its existence. In a major contribution on the mechanics of the knee-joint *Meyer* (9) made a careful analysis of the movement. He seems not to have made any direct study of the occurrence of a terminal rotation in the joint but bases his views on a long and in part quite involved reasoning on

the anatomy and mechanics of the joint. Broadly speaking, his explanation of the terminal rotation is that the medial condyle of the femur is longer than the lateral and, moreover, curved, with the convexity facing the intercondylar eminence.

Fick (8) observed the screw-home movement in patients and specimens but gives no details of his material or methods of measurement. He criticises *Meyer's* theory that the rotation is effected by the articular surfaces and considers that the structure of the ligaments in the knee, especially the structure of the cruciate ligaments, is bound to produce an outward rotation of the tibia when the knee is extended fully. According to *Fick* the form of the articular surfaces would be a consequence rather than a cause of the terminal rotation.

In the more recent discussions of the screw-home movement *Meyer's* and *Fick's* information on the existence and magnitude of the movement (an outward rotation of 5–10°) seems to be accepted without question.

The object of the present study is to examine the nature of the screw-home movement by experiments on a fairly large number of joints, without reliance on mechanical arguments and earlier observations, which form the basis for the prevailing views on the rotation. In this connection it was found that it was difficult to record accurately the small rotational movements of the lower leg when the knee was extended, and even when this could be managed by means of an angle measuring device there remained the difficulty of preventing simultaneous rotation of the femur in the hip joint. An attempt to overcome these difficulties was made by suitable choice of material and method.

NOMENCLATURE

For the purpose of this study *extension* is defined as the position in which the knee-joint is fully extended and presents resistance to further extension, whether this is in the 180 or 190° positions. *Outward* or *inward rotation* of the knee-joint is the movement described by the tibia about its axis in relation to the femur. When the knee is flexed the femur cannot rotate about its axis in relation to the tibia. The flexed knee can be rotated both actively and passively. Since a passive rotation is possible in extension (*Hallén & Lindahl* (3)) and, as will be evident from the results reported below, sometimes also an active one, it is necessary when measuring the rotation that occurs between a flexed and an extended position to define accurately the initial positions in

respect of rotation in both flexion and extension. A distinction will be drawn between active and passive rotation.

MATERIAL

1. Autopsy specimens: 16 knee-joints.

2. Hip arthrodesis cases:

(a) Eleven knee joints of patients with a nail arthrodesis performed on the hip of the same side 2-3 weeks earlier.

(b) Three knee-joints with an arthrodesis provided several years previously.

3. Surgical cases: Ten knee-joints of patients anaesthetized for operations on a lower extremity, not including the knee-joint.

The age and sex distributions are shown in the Tables 1-3. Except in the cases of old hip arthrodesis the knee-joints were normal, apart from the chondromalacia and osteoarthritis that is usual among older people. The joints of the patients with a fresh arthrodesis had been normal before the operation and had not been put in plaster; nonetheless, there was usually a moderate restriction of flexion.

METHODS

In all the above knee-joints a determination was made of the angle through which the tibia could be rotated in 160° flexion and extension, and the changes in rotation that could be produced actively and/or passively in the movement from the former to the latter positions.

On the *autopsy specimens* a special angle-measuring device was used that has been described elsewhere (3).

On the *hip arthrodesis cases* rotation of the femur was prevented. An instrument for measuring the angle—different in design from that used on the autopsy specimens—was attached to the lower leg (Figure 1). This gives correct values only when it is held vertically, and requires the lower leg to be kept horizontal while the position of the femur and the body is altered by tilting the table. The *passive* rotation accompanying extension of the joint was measured in the following ways (Figure 2):

- (i) Maximum inward rotation at 160° to maximum inward rotation in extension (In—In).
- (ii) Maximum " " " " " " " outward " " " (In—Out).
- (iii) Maximum outward " " " " " " " inward " " " (Out—In).
- (iv) Maximum " " " " " " " outward " " " (Out—Out).

In addition, the rotation occurring in *active* extension was measured. The patient was then required to assume an arbitrary rotation position at 160° and with the knee fully extended.

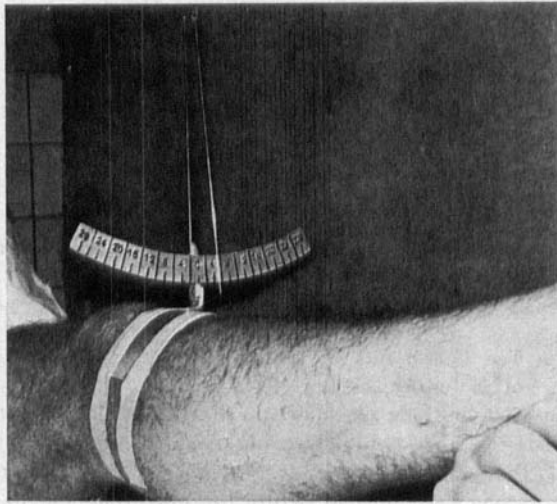


Figure 1. Apparatus for clinical measurement of the rotation of the tibia.

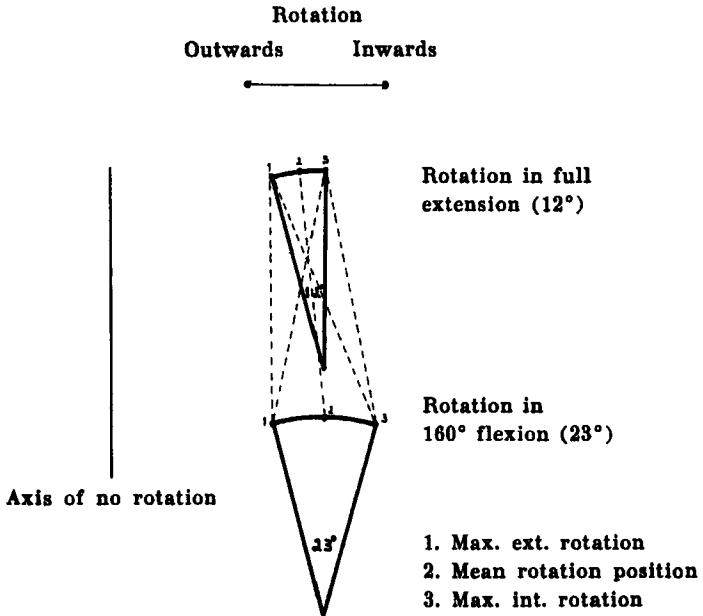


Figure 2. Diagram of the range of rotation of the knee-joint in extension (upper) and the 160° position (lower). The broken lines show how the knee-joint can be rotated in different ways during the terminal extension.

In the 10 *operation cases* Kirschner wires had been inserted in the femoral and tibial condyles from the lateral aspect near the knee-joint to serve as indicators. The change in angle between them measured in the longitudinal direction of the tibia was then determined as the lower leg was rotated passively in the 160° position and in extension. The rotation was also measured during extension for the same 4 changes in position as in the arthrodesis cases. Finally, the "spontaneous" terminal rotation was measured during extension: in the 160° position a relaxed more or less arbitrary neutral position was used, and the leg was allowed to hang freely in extension, supported only under the heel.

RESULTS

Autopsy specimens.—In extension, rotations of between 2 and 18°, mean 11°, were recorded. In the 160° position the range was 17–35°, mean 25°.

Both inward and outward rotations could be produced during the extension movement, depending on the initial and final rotation positions. The exact values for these rotations were not measured on the autopsy specimens. On extending the knee from an arbitrary rotation position in 160° by lifting under the heel, an outward rotation ranging from 1 to 14° was recorded. The magnitude of the rotation observed in these autopsy specimens has been reported in detail elsewhere (3).

Arthrodesis patients.—The recorded rotation values are given in Table 1.

Table 1. Knee-joint rotation for patients with newly performed hip arthrodesis. Positive values denote outward and negative values inward rotation.

Sex	Age	Rotation in				Active rotation		
		extension	160°	In-In*	In-Out*		Out-In*	Out-Out*
F	55	12	20	8	18	-13	0	6
M	56	7	18	11	18	-6	0	14
F	64	4	16	10	14	-5	-2	2
F	58	7	15	8	14	-5	0	12
F	44	13	20	7	25	-22	0	7
F	62	5	10	5	15	-4	0	10
F	62	10	15	6	17	-10	1	0
F	44	9	13	6	16	-6	2	8
M	61	12	21	8	27	-18	-1	8
M	61	13	38	8	21	-30	-20	5
M	60	14	22	10	23	-15	2	5
Mean		10	19	8	19	-12	-2	7

* See *Methods (i) - (iv)*.

The mean range of *passive* rotation in passive extension was 10°. The average screw-home movement was 12° inwards for the tests from the outward to the inward positions, and 19° outwards for the tests from the inward to the outward positions. A mean outward rotation of 7° was obtained for *active* extension from 160° with an arbitrary initial rotation position.

Table 2. Knee-joint rotation in patients with hip arthrodesis supplied several years previously. Positive values denote outward and negative values inward rotation.

Sex	Age	Rotation in extension	In-In*	In-Out*	Out-In*	Out-Out*	Spont. rotation	Active rotation in ext.
F	60	20	14	28	-24	-6	variable	5
F	55	26	15	42	-16	10	14	-
F	61	31	16	38	-18	15	5	6

Table 3. Rotation in the knee-joint in operation cases. Positive values denote outward and negative values inward rotation.

Sex	Age	Rotation in extension	Rotation in 160°	In-In*	Out-Out*	Spont. rotation
F	20	20	26	9	- 5	5
F	56	10	30	7	-19	7
M	65	14	27	9	-18	0
M	11	12	30	4	-10	6
F	56	13	9	20	- 8	20
F	17	18	21	17	- 1°	6
F	58	15	25	6	- 4	6
F	51	13	20	5	- 2	5
F	55	13	32	20	-10	8
M	44	17	20	0	- 1	7
Mean		15	24	10	- 8	7

The values for patients whose arthrodesis had been supplied several years previously are given in Table 2.

Although this is a fairly small group there is convincing evidence that the functional demands associated with the hip arthrodesis result in stretching of the capsule and ligamental apparatus of the knee, with

* See *Methods* (i) - (iv).

a consequent reduction in the joint's stability, and an increase in its range of rotation in different positions. In 2 of the cases also an active rotation was recorded in extension. For this reason the main study was performed on patients supplied with an arthrodesis within the previous 2-3 weeks, during which period it is unlikely that there could have been any appreciable alteration in the stability of the joint.

Operation cases.—The rotation values are shown in Table 3.

The mean rotation in extension was 15° , and in the 160° position, 24° . As in the arthrodesis cases, both inward and outward rotation could be obtained passively on extending the joint. In passive extension from an arbitrary "neutral" initial position in 160° flexion a mean outward rotation of 7° was recorded.

DISCUSSION

It seems to be generally accepted that the knee-joint cannot be rotated in extension but is necessarily locked by the "screw-home" movement.

Brantigan et al. (2) and *Akerblom* (11) have spoken of a rotation in extension: they alone report values of between 2 and 10° . In an earlier study (3) on autopsy specimens the present authors recorded a mean rotation of 11° in extension. This has been confirmed in the present study on a series of patients with hip arthrodeses and on operation cases where the range of the movement could be measured to an acceptable level of accuracy. This rotation, which was obtained passively, averaged 12° . Active rotation of the extended joint is extremely difficult to measure. When the quadriceps is under powerful tension it seems that an active rotation is difficult, if not impossible, to obtain. In some of the patients with an old hip arthrodesis, however, active rotation was in fact recorded in this position.

The *active* screw-home movement obtained in the arthrodesis cases would appear to confirm the view that extension ends with an outward rotation. The mean value was 7° . It must be borne in mind that the degree of rotation in the flexed joint can to some extent be influenced, and that this is possibly the case also in extension. Thus, this outward rotation can be more or less prevented by will power.

Of the obligatory *passive* screw-home movement mentioned in the literature there was no evidence in this material. Depending on the position of rotation both in 160° flexion and in extension, it was possible to obtain passively an outward or an inward rotation, or no rotation at all. As Figure 2 shows, however, the "mean rotation position" was

further outward in extension than it was at 160° , a difference that is possibly due to the shape of the condyles, the arrangement of the ligaments or to both.

In the light of these results it is difficult to accept the "obligatory screw-home movement" as a physiological fact, and likewise to see its significance as regards the stability of the knee-joint or the mechanics of various kinds of injuries to the joint.

SUMMARY

The "screw-home" movement is considered to be an important feature of the mechanics of the knee-joint. It would seem that the existence of such a movement has never been proven, and no measurements of it have been reported. On 37 normal knee-joints an examination was made of the rotation in maximum extension and the 160° position, and of changes in the rotation between these positions. In maximum extension a mean rotation of 12° was recorded, and in 160° , a mean of 23° . In active extension or when the knee is passively extended from 160° an outward rotation of about 7° was usually found; this would appear to confirm the prevailing view on a screw-home movement.

If, however a conscious effort was made to rotate the lower leg during the extension movement, either an outward or an inward rotation could be obtained. Thus, it was not possible to confirm the presence of an obligatory passive screw-home movement, which cannot therefore be ascribed particular significance in the mechanics of the knee-joint.

RESUME

Le mouvement "de vis" est considéré comme un important élément des mécanismes de l'articulation du genou. Il est vrai que l'existence d'un tel mouvement n'a jamais été prouvée et qu'aucune mensuration n'a été rapportée. Sur 37 articulations normales du genou, on a examiné la rotation en position d'extension maximum et dans la position de 160° , ainsi que les changements de rotation entre ces deux positions. En position d'extension maximum, une rotation moyenne de 12° a été enregistrée, et en position de 160° , une moyenne de 23° . Dans l'extension active ou lorsque le genou est en état d'extension passive de 160° , une rotation en dehors d'environ 7° a généralement été trouvée; cela semble confirmer le point de vue du mouvement "de vis".

Si néanmoins un effort conscient était fait pour tordre la partie infé-

rieure de la jambe durant le mouvement d'extension, il ne pourrait être obtenu ni une rotation en dehors, ni une rotation en dedans. Il n'est donc pas possible de confirmer la présence du mouvement "de vis" obligatoirement passif, auquel on ne peut par conséquent pas attribuer une signification particulière dans les mécanismes de l'articulation du genou.

ZUSAMMENFASSUNG

Die abschliessende Schraubenbewegung wird als ein wichtiges Geschehen in der Mechanik des Kniegelenkes angesehen. Es scheint, dass das Vorhandensein einer solchen Bewegung niemals bewiesen worden ist und über keinerlei Messungen derselben ist berichtet worden. An 37 normalen Kniegelenken wurde eine Untersuchung der Rotation bei maximaler Streckung unter der 160° Stellung, sowie von Veränderungen der Rotation zwischen diesen Stellungen vorgenommen. Bei maximaler Streckung wurde eine Durchschnittsrotation von 12° verzeichnet und in der 160° Stellung ein Durchschnitt von 23°. Bei aktiver Streckung oder wenn das Knie passiv von 160° gestreckt wird, wurde gewöhnlich eine Auswärtsrotation von 7° gefunden. Dies scheint die vorherrschende Meinung, dass eine Abschlusschraubenbewegung besteht zu betätigen. Wenn jedoch eine bewusste Anstrengung gemacht wurde den Unterschenkel während der Streckung zu rotieren, konnte entweder eine Auswärts- oder Einwärtsrotation erhalten werden. Es war daher nicht möglich das Vorhandensein einer obligatorischen, passiven, abschliessenden Schraubenbewegung zu bestätigen und man kann ihr daher keine besondere Bedeutung in der Mechanik des Kniegelenkes zuschreiben.

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