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ROTATION IN THE KNEE-JOINT IN EXPERIMENTAL INJURY TO THE LIGAMENTS

By

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It was shown in an earlier study of the stability of the knee after damage to the ligaments that the lateral stability of the knee-joint is not a very sensitive basis for detecting which of the ligaments has been divided (5). In a simultaneous examination of rotation in the knee it was found that the range of rotation was a more reliable criterion of the extent of the injury to the ligaments than was the lateral stability. An account is given in this article of a study of rotation in the knee-joint.

PREVIOUS STUDIES

As regards passive rotation in the normal knee in different flexion positions the findings reported in the literature diverge widely (Table 1).

TABLE 1
Total Rotation in the Knee-Joint in Different Positions.

	Extension	150°	135°	90°	45°
Brantigan et al.	2–10	–	–	6–24	4–21
DePalma	0	30–38	–	–	–
Fick	0	–	–	50	70
Hjortsjö	0	35	–	50	60
Meyer	0	40	–	50	60
Ross	–	–	41	37	39

The rotation of the knee-joint with damage to the ligaments seems not to have been studied to the same extent. *Abbott* and his collaborators (1) consider that the division of the tibial collateral ligament increases the rotation by 30° in the 90° position, and that the value is the same

for inward and outward rotation. *DePalma* (3) states that the division of the tibial collateral ligament does not result in any rotation in the extended position but that at 150° the outward rotation is increased from the normal 6–8° to 30°. The inward rotation is unaffected. *Brantigan et al.* (2) report that there was no increase in the rotation when the tibial collateral ligament was divided, whether in extension, or in the 90° or 30° positions. When both collateral and both cruciate ligaments were divided, the range of rotation was increased in all positions; in extension it was on an average 14°, and in the 90° position 31°. No distinction was made between inward and outward rotation.

NOMENCLATURE

In connection with rotation in the knee-joint, and especially the "screw-home" movement the term "inward rotation" is used sometimes to denote rotation of the femur inwards in relation to the tibia, and sometimes to denote rotation of the tibia inwards in relation to the femur. In the present study inward and outward rotation refer to the movement of the tibia in relation to the femur. Since, as will be evident from results reported below, a considerable rotation takes place in both extension and flexion positions, it is necessary in any discussion of outward and inward rotation in the knee-joint to define the initial position. This would seem, however, to present a major difficulty in extension and, especially, in flexion positions where an active rotation is possible. For this reason we preferred to record the *total rotation* in the knee-joint—that is, the range of rotation between the two extreme positions. As regards the various positions of the knee-joint, *extension* refers to the position of the joint where resistance to further extension is encountered, whether in the 180° or 190° position. The *flexion* positions are expressed in terms of the angle between the thigh and the lower leg.

MATERIAL

The study was performed on 16 fresh knee-joints from cadavera. The age and sex distributions were as follows:

	≤ 40	41–60	> 60 years
Men	–	4	3
Women	1	2	6

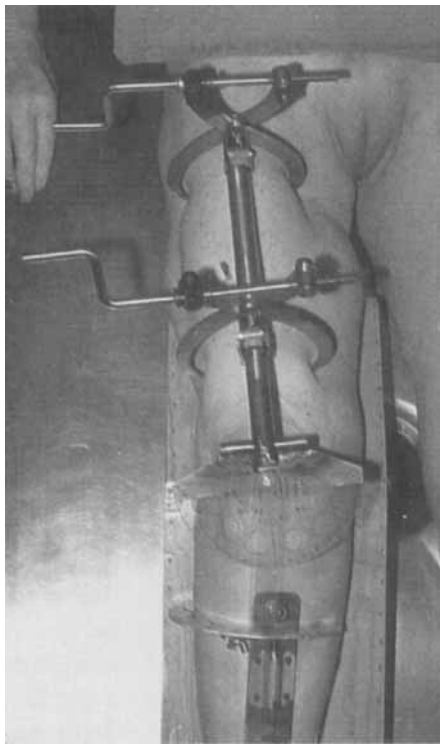

Fig. 1.
Apparatus for measuring the lateral mobility of, and rotation in, the knee-joint.

METHODS

To be able to measure the rotation between the femur and tibia in different flexion positions of the knee-joint an apparatus was designed, one part of which is fixed to the femur, and the other to the tibia (Fig. 1). The rotation in any desired position of flexion could be read off on a graduated scale. So as to reduce the number of values the rotation was determined in 4 positions of the knee-joint—namely, in extension and at flexion angles of 160, 120, and 90°.

The rotation was recorded in these positions for intact knees and then with the superficial portion of the tibial collateral ligament, its deeper portion, and the anterior and posterior cruciate ligaments divided in turn. The outward and inward rotations were recorded separately, but because of the difficulty of defining accurately an initial or neutral position the total rotation was generally used. The neutral position was taken as the position which the knee assumed spontaneously, without application of any external force in the outward or inward directions of rotation. However, this position is particularly unstable after division of the ligaments.

The magnitude of the rotational movement, especially when the ligaments had

been divided, was largely dependent on the force applied in rotating the lower leg. In the tests one investigator fixed the femoral part of the instrument, and hence the femur, while the other investigator, without looking at the scale, manipulated the lower leg with a moderate force, which as far as possible was made the same for the different tests.

This method was tried out on 5 knee-joints and the actual experiments were then performed on 11 consecutive joints. By the standardized procedure, with identical tests in all cases and division of the ligaments in the same order, it was possible to calculate whether the differences in rotation obtained were statistically significant. The usual methods of statistics were used and the values of P were calculated by means of Student's t test.

RESULTS

The tests on 11 knee-joints in 4 flexion positions and in 5 different types of lesion of the ligaments gave 440 observations of angles of inward and outward rotation, or 220 of total rotation. Since such a large number of values would be difficult to survey, and would be unpalatable in tabular form, the results are presented as means.

It is seen from Table 2 that there was also considerable rotation of the intact knee-joints in extension. Moreover, of the 4 positions the rotation of the intact knee was greatest for 120°. The difference in rotation between the 120° and the other positions was significant ($P < 0.01$; **). A significantly (**) greater rotation in the 120° position was also found after division of the various ligaments.

TABLE 2

Mean Total Rotation in the Knee-Joint in Different Positions.

	Extension	160°	120°	90°
Rotation in intact knee	11	25	29	26
Range	2–18	17–35	25–35	19–33
After division of:				
Tibial collat. lig.				
superficial portion	15	34	41	32
+ deep portion	17	47	55	45
+ Anterior cruciate lig.	21	57	70	64
+ Posterior cruciate lig.	19	55	73	67

Division of the ligaments in turn as described above resulted in a progressive increase in the range of rotation. Except for the posterior cruciate ligament this was significant (**) for each new step in the positions 160, 120 and 90°. In extension the rotation increased as each

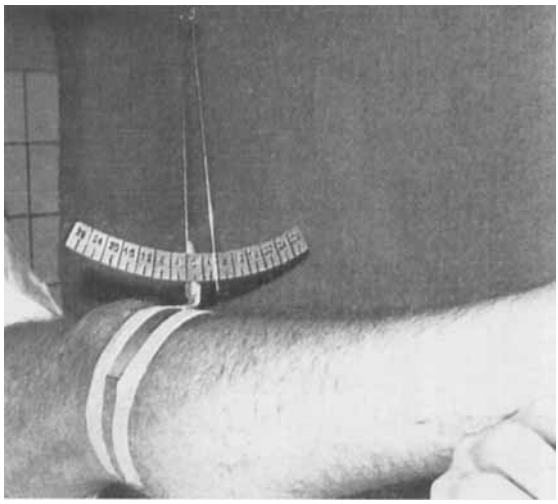

Fig. 2.
Apparatus for clinical measurement of the rotation of the tibia.

successive ligament was divided, but this difference was significant (**), only for the comparison between the intact knee and the division of both parts of the tibial collateral ligament.

Comparison of the values for the inward and outward rotations shows that it was chiefly the latter that was increased on dividing the two portions of the tibial collateral ligament. Owing to the difficulty of defining accurately and determining the initial position of rotation, this finding would seem to have limited practical value.

DISCUSSION

By means of the measuring apparatus and standardization of the order in which the ligaments were divided, values of some significance were obtained. It would seem justified to conclude from these that the increase in rotation in the knee-joint resulting from damage to the ligaments is greatest in the 120° position; this should therefore be used in examining the knee-joint in cases of injury to the ligaments. It might be possible to distinguish in this way between division of the superficial and both parts of the tibial collateral ligament.

To improve the accuracy of measurements of rotation in the clinic the authors have designed a special instrument (Fig. 2).

As regards the practical application of these observations in the clinic

it must be borne in mind that the injuries to the knee-joint that commonly occur in accidents are due to a wide variety of factors and seldom correspond exactly to the isolated division of ligaments obtained under experimental conditions. It is probable that any particular case involves a complex combination of total and partial division of ligaments, and ruptures both to the medial, lateral and posterior parts of the capsule. It must also be remembered that any instability in extension and flexion can be due to small compression fractures in the condyles which are not disclosed by radiographs.

An attempt to make an accurate morphological diagnosis by means of clinical examination of the individual ligaments would seem to involve a certain risk of over-schematization, even if the information provided by this study is applied.

Extensive damage to capsule and ligaments results in greater instability than limited damage and it is probably more logical to classify knee injuries according to the degree of abnormal mobility than to the structures that are believed to be involved.

Another problem is whether it is better to treat an actual injury by open surgery or by conservative measures. There are several authors that categorically recommend operation. However, one can see cases of total rupture of ligaments and capsule where an almost normal function has been recovered by conservative therapy. There seems to be no entirely valid study that has resolved this problem.

SUMMARY

A study was performed of the range of rotation in the knee-joint in maximal extension and in the 160, 120 and 90° positions. This range was also tested after the superficial and deep portions of the tibial collateral ligament had been divided, followed by the anterior and posterior cruciate ligaments. The study shows that in maximal extension the normal range of rotation in the knee-joint is on an average 11° (variation 2–18°) Of the different flexion positions tested, 120° gave the greatest rotation both for the intact knee and when the various ligaments had been divided in turn. With successive division of the ligaments the rotation in this position increased from 29 to 70°; the latter value was obtained when the tibial collateral and the anterior cruciate ligaments had been divided; division of the posterior cruciate ligament did not increase the range. It is conceivable that the range of rotation in the knee-joint in the 120° position is a more sensitive test

for differential diagnosis of isolated ligament injuries than is the usual test of lateral stability.

RESUME

Il a été procédé à une étude de l'étendue de la rotation de l'articulation du genou en extension maximum dans les positions de 160, 120 et 90°. Cette étendue a également été vérifiée après la division de portions superficielles et profondes du ligament tibial collatéral, suivie de celle des ligaments antérieur et postérieur croisés. Cette étude montre que dans une extension maximum, l'étendue normale de la rotation de l'articulation du genou est en moyenne de 11° (variation enter 2 et 18°) dans les différentes positions de flexion examinées; 120° a donné la plus grande rotation tant pour le genou intact qu'après la division des différents ligaments. Par une division successive des ligaments, la rotation dans cette position a pu être accrue de 29 à 70°; cette dernière donnée a été obtenue après la division des ligaments tibial collatéral et antérieur croisé; une division du ligament postérieur croisé n'a pas accru l'étendue de la rotation. Il semble que l'étendue de la rotation de l'articulation du genou en position de flexion de 120°, fournit un meilleur test pour le diagnostic différentiel des lésions d'un ligament isolé que le test habituel de stabilité latérale.

ZUSAMMENFASSUNG

Eine Untersuchung hinsichtlich des Ausmasses der Rotation im Kniegelenk bei maximaler Streckung und in 160, 120 und 90° Stellungen wurde vorgenommen. Dieses Rotationsausmass wurde auch geprüft nachdem der oberflächliche und tiefe Anteil des lig. collaterale mediale und nachher das vordere und rückwärtige Kreuzband durchschnitten waren. Die Untersuchung zeigt, dass bei maximaler Streckung das normale Rotationsausmass im Kniegelenk durchschnittlich 11° (Variation 2–18°) ist. Von den verschiedenen geprüften Beugestellungen gab 120° die grösste Rotation sowohl beim intakten Knie als auch wenn die veschiedenen Ligamente nacheinander durchtrennt worden waren. Mit der aufeinanderfolgenden Durchtrennung der Bänder erfolgte in dieser Stellung eine Zunahme der Rotation von 29 zu 70°. Der letztere Wert wurde erhalten wenn das lig. collaterale mediale und cruciatum anterius durchtrennt waren. Durchtrennung des lig. criciatum posterius vermehrte das Ausmass der Rotation nicht. Es ist denkbar, dass das Rotationsausmass im Kniegelenk in 120° Beugestellung eine feinere

Probe zur Differentialdiagnose von Bandschäden ist, als die gewöhnliche Probe auf laterale Stabilitet.

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