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# HIP ARTHRODESIS

## *The Connection between Function and Position*

*By*

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While the indications and the technique for the hip arthrodesis operation have been thoroughly treated in the literature, the problem of the best position for the hip is usually dismissed in a few lines; often a particular position is recommended as giving "the best results" but the grounds for the choice are rarely specified; nor does the relationship between position and function seem to have been analysed in a followed-up case material.

The following recommendations have been made in respect of the transverse, frontal and sagittal planes.

*Position in the transverse plane.*—The preferred angle of rotation ranges from the mean to an outward rotation of 15° (2, 3, 6, 7, 9, 10, 14, 17). Inward rotation is considered to be incorrect. *Watson-Jones* (16, 17) specifies the mean position, stating that any other recommendation "is of course nonsense". As a rule no information is given on how the angle was measured.

*Position in the frontal plane.*—Abduction between 0 and 25° have been mentioned (2, 3, 6, 7, 8, 14, 17) 25° being regarded as acceptable for children, while for adults 20° is the maximum. It is commonly held that any real shortening shall be compensated for by abducting the leg, and tables giving the appropriate abduction for different degrees of shortening have been compiled (1, 9, 10). Some authors caution against excessive abduction, recommending up to 10°; others prefer the zero position on the grounds that static scoliosis is liable to lead to back troubles. No objective examination of the possible connection between

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abduction and back pains seems to have been published. Here, too, the mensuration technique is usually not touched upon. Mention is occasionally made of the possibility of evaluating abduction on radiographs, by measuring the angle between the axis of the femur and a horizontal line through the pelvis. Usually the mensuration is done by "the regular clinical technique", *i.e.* by measuring the angle between the two spinae and the axis of the thigh.

*Gardiner* (8) alone prefers slight adduction, which has been found to "give a better gait than any other position".

*Position in the sagittal plane.*—Various flexion angles between 20 and 35° have been deemed the most suitable (1–10, 13–17), a larger angle generally being preferred for patients with sedentary in contrast to standing occupations; 5–10° between these two alternatives in usually considered to be suitable. No methods has been given for the examination of a mobile or an anchylotic hip, nor for obtaining the desired position on an operation or plaster table.

*Watson-Jones* (16, 17) states that the recommended flexion of 30° is obtained by placing the patient on a plane with the thoracic spine, seat and neck at the same level, when the natural lordosis of the lumbar spine will give the required angle. In an earlier study *Ahlbäck & Lindahl* (4) have shown, however, that the flexion of the hip in this position ranges from 7 to 22°—based on a zero position in maximum extension. In the commonly used nomenclature, flexion is defined as zero in the supine position.

The disparity between the recommendations of the various authors together with the absence of rigorous standard methods for measuring the position of an arthrodesed hip-joint prompted the following study of hip arthrodesis cases, with special reference to the relationship between the position of the hip-joint and function as reflected in the gait and comfort in the seated position. The function in daily life after hip arthrodesis has been dealt with in a separate study (12).

## MATERIAL

The follow-up clinical examination was performed on 35 patients who had been provided with a hip arthrodesis at least 2 years previously. The age and sex distributions were as follows:

| Age | < 40 | 40–49 | 50–59 | 60–69 | > 69 | Total |
|---|---|---|---|---|---|---|
| Men | 4 | 5 | 5 | 10 | 4 | 28 |
| Women | 1 | 1 | 1 | 2 | 2 | 7 |
| Total | 5 | 6 | 6 | 12 | 6 | 35 |

## METHODS

A careful case history was taken for each patient. In the subsequent examination special attention was devoted to the gait, comfort when seated, and the position in which the hip-joint had been fixed.

*Gait.* – The gait was judged mainly from the aesthetic standpoint. Note was made of limping (asymmetric gait), circumduction, wide gait, dropping on one leg, and placing only the stiff leg in front of the other. On the basis of this evaluation the gait was classed as good, fair or poor; good implies practically normal walking, the legs being placed alternately one in front of the other; poor gait was recorded when there was pronounced limping or asymmetry, circumduction or markedly wide gait.

*Sitting.*—On the basis of the patient's ability to sit comfortably and in a normal position on ordinary chairs, toilet stools and cinema seats, the sitting function was classified as good, fair or poor.

*Position in the transverse plane.*—The patient was placed supine with the knees extended and the ankles in dorsal extension. The angle between the vertical plane and the median contour of the foot (heel to head of the first metatarsal bone) was measured with an instrument designed for the purpose.

*Position in the frontal plane.*—A method devised by *Lindahl* (11) for determining the position of the hip in the frontal plane was applied. The adduction (or abduction) was taken as the difference between the real shortening of the leg, measured on radiographs, and the distance between the medial malleoli, measured in the axial direction of the leg with the feet together.

*Position in the sagittal plane.*—In an earlier study (4) of the range of sagittal movement in the hip-joint it was found that an accurate determination of the flexion of the joint demanded a more reliable reference position than is generally used. Accordingly, in the present study the position in the sagittal plane was measured from full extension. Provided that the other hip is normal, the flexion position of an arthrodesed hip will correspond to the difference in the angle between the thighs when the mobile hip is fully extended. For the measurement the patient is placed supine with both legs outside the examination couch and dropped to the full extent so that there is pronounced lordosis. The difference in the angle between the thighs is measured with a special instrument having long arms (4). If comparison cannot be made with a normal hip-joint, the angle of flexion cannot be assessed clinically, but it can be measured approximately on a lateral radiograph as the angle between the conjugata vera (a line between the promontory of the sacrum and the symphysis) and the axis of the femur. In the authors' series of 36 patients with clinically and radiographically normal hips, chiefly men, ranging in age from 42 to 67 years, the mean of this angle in full extension of the hip-joint was 50°.

For 8 cases of osteo-arthritis the mean was 33°. In cases in which the mobile hip was also diseased the flexion in the rigid hip was measured on radiographs as the difference between 50° and the actual angle between the axis of the femur and the conjugata vera.

*Radiographic examination.*—A frontal film was taken of both hip-joints, the pelvis and the upper part of both femurs, with the central ray passing midway between the hip-joints. Lateral films were taken of the same region with the mobile

hip fully extended and flexed the central ray passing through the hip-joints. The film – focus distance in both cases was 100 cm.

## RESULTS

*Position in the transverse plane.*—The rotational position of the hip-joints provided with arthrodeses were as follows (— denotes inward and + outward rotation):

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| —4 | 0 | +5 | 8 | 10 | 10 | 13 | 13 | 15 | 15 | 18 | 20 | 20 | 20 | 22 | 22 | 24 |
| 25 | 25 | 27 | 27 | 28 | 30 | 30 | 30 | 35 | 35 | 35 | 40 | 40 | 45 | 55 | 62 | 75 |

Angles from an inward rotation of 4° to an outward rotation of 75° are represented. All but 4 of the patients were content with the position of the foot so far as the angle of rotation was concerned. Two complained on cosmetic grounds (—4 and +40°), one (+62°) had difficulty in placing the foot on the accelerator and one (+75°) was unable to sleep on the side of the fixed hip because, owing to a stiff knee, the foot pointed down into the mattress. There was neither subjective nor objective evidence that the gait or seated position was affected adversely by the rotary position of the foot.

*Abduction and adduction.*—Only 4 out of 35 patients (11 per cent) complained of back pains that they ascribed to the arthrodesis. The distribution of these cases in the group was such that it was impossible to establish whether there was any link between the symptoms and pronounced malposition: the adduction was —33, —28, —2 and +4 mm (+ denoting abduction in relation to the "neutral position" [11]).

*Table 1. Connection between the gait and the functional length of the leg. Negative values denote a shortening, and positive ones a lengthening, on the arthrodesis side.*

| | Difference in length (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Good | —10 | — 5 | — 5 | — 5 | — 5 | 0 | 0 | 0 | 0 | + 5 |
| Fair | —30 | —25 | —20 | —20 | —15 | —15 | —5 | —5 | 0 | + 5 |
| Poor | —70 | —45 | —40 | —40 | —40 | —30 | —5 | 0 | 0 | +10 |
| | +10 | +20 | +20 | +30 | +45 | | | | | |

It is evident from Table 1 that on an average the gait was better for equal functional length of leg than for large differences in either direction. In the patients with approximately equal length of leg but poor gait the latter was generally ascribed to other factors such as bad flexion position, stiff back or painful osteoarthritis in the mobile hip. In the

above evaluation of gait the patients were required to walk without shoes. By raising the shoe—the height being changed from time to time—the gait could be improved. However, many did not care to compensate for the shortening in this way, preferring to walk with the mobile leg slightly flexed at the knee and hip.

A corresponding compilation of gait and position in the frontal plane (abduction and adduction) shows largely the same results, since the functional length of the leg and the position in the frontal are, of course, interdependent.

*Flexion angle.*—As would be expected, the seated position was more comfortable the greater the angle of flexion in which the hip was fixed (Table 2). The exceptions to this rule had particularly marked or restricted mobility of the lumbar spine, the seated position being respectively more or less comfortable.

*Table 2. Connection between comfort in seated position and flexion angle for the arthrodesed hip, measured from full extension. Negative values denote that the fixed hip was extended more than the sound one in full extension.*

| Comfort in seated position | Flexion angle | | | | | | | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | 30 | 35 | 35 | 40 | 40 | 45 | 50 | 50 | 55 | 60 | | | | | | 44 |
| Fair | 20 | 20 | 20 | 25 | 28 | 30 | 30 | 35 | 38 | 40 | | | | | | 29 |
| Poor | —5 | 0 | +15 | 18 | 18 | 19 | 20 | 20 | 22 | 23 | 30 | 30 | 34 | 35 | 40 | 22 |

*Table 3. Connection between gait and flexion angle for the fixed hip, measured from full extension. Negative values denote that the fixed hip was extended further than the sound one in full extension.*

| Gait | Flexion angle | | | | | | | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | 25 | 30 | 35 | 35 | 40 | 40 | 40 | 45 | 50 | 60 | | | | | | 40 |
| Fair | 18 | 20 | 20 | 28 | 30 | 30 | 35 | 37 | 50 | 55 | | | | | | 32 |
| Poor | —5 | 0 | +15 | 18 | 19 | 20 | 20 | 20 | 22 | 23 | 30 | 30 | 34 | 35 | 40 | 21 |

On an average the gait, too, was better the greater the flexion angle (Table 3). There was, in this respect, no appreciable difference between the gait and the comfort in the seated position.

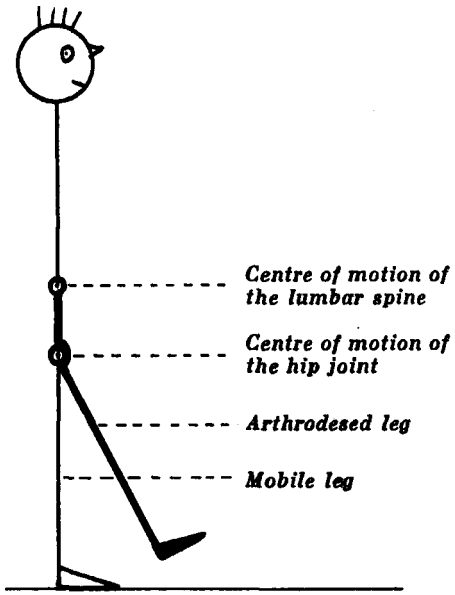


*Figure 1 A.*

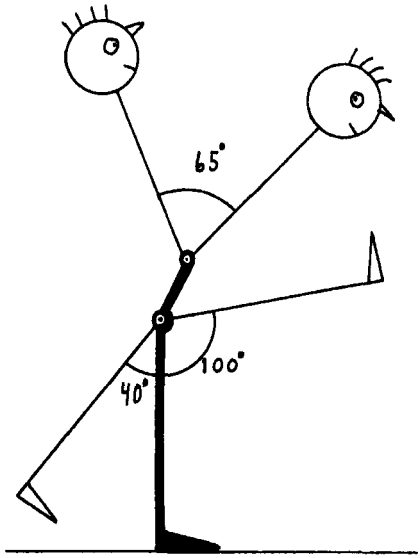


*Figure 1 B.*
*The normal ranges of movement in the lumbar spine and the mobile hip-joint when standing on the arthrodesed leg with the hip-joint fixed in the theoretically ideal angle of flexion.*

## MECHANICS OF WALKING AND SITTING WITH AN ARTHRODESED HIP

This discussion is based on movements of the lumbar spine and the mobile hip-joint measured and evaluated in relation to the axial direction of the thigh on the side of the arthrodesis (Figures 1 A and B).

For a fairly long pace forward the angle between the legs is normally about 50°. For the person with an arthrodesis an angle of 40° may be assumed to be large enough. When the mobile leg is put forward it would then be necessary for the mobile hip to be flexed 40° in relation to the fixed one (Figure 1 C). At the same time the lumbar spine is extended in relation to the pelvis (which is fixed to the femur on the arthrodesed side); this extension will be only one half as great, or 20°. When the next pace is taken from this position and the stiff leg is placed in front of the mobile position, and then extended a further 40° —provided that the flexion angle in which the hip-joint has been fixed is large enough and a full pace is taken (Figure 1 D). During the first

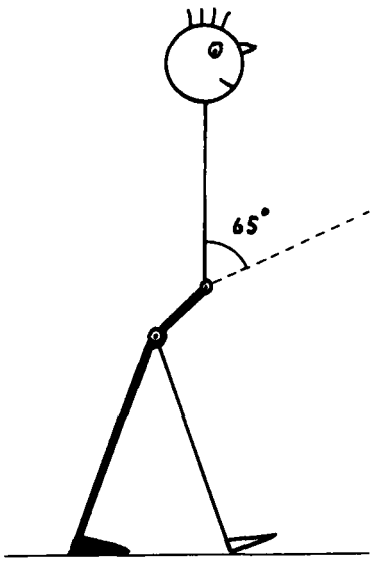


*Figure 1 C.*
*Positions of the back and legs when a 40° pace is taken with the mobile leg. For the thorax to remain upright, full extension of the lumbar spine (lordosis) is required. Such a pace can be taken even if the arthrodesed hip-joint is fixed in slight flexion or extension. It is often the only one the arthrodesis patient can take.*

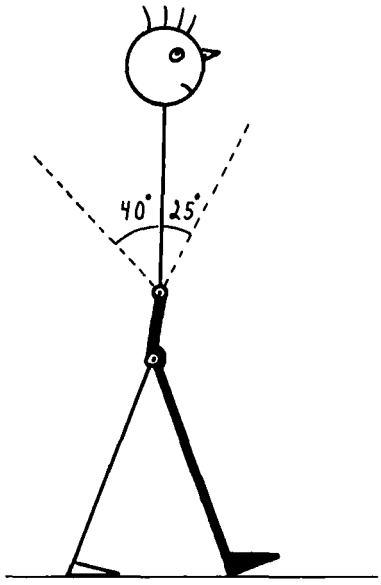


*Figure 1 D.*
*Positions of the back and legs when a 40° pace is taken with the arthrodesed leg. The lumbar spine is then slightly flexed. This step cannot be taken unless the angle of flexion in which the hip is flexed is at least 40°.*

half of the step the lumbar spine will be flexed 20°, and then, as the stiff leg is brought up, it will be bent a further 20°. A total movement of 80° will then have been made in the mobile hip-joint and 40° in the lumbar spine. For such paces the following conditions are thus necessary: the flexion angle for the fixed joint shall be 40° (measured from a zero posotion in full extension), the mobile hip shall have a flexibility of at least 80°, the range of movement of the lumbar spine shall be 40°, and the direction of movement shall be such that the angles on each side of the axis of the fixed thigh are the same. The gait of the few patients meeting these requirements was nearly perfect. If the flexion angle were less than 40° it would not be possible to place the rigid leg so far forward, and in the case of a very small flexion angle, the stiff leg could

not be placed in front of the mobile one; then only the mobile leg could be moved in advance, the rigid one being only brought up to it.

In the seated position, the flexion must be performed entirely in the lumbar spine if the patient is not to sit obliquely or with the stiff leg to the side of the chair. For sitting on an ordinary hard chair with the back against the rest the lumbar spine must be flexed 90° in relation to the stiff thigh. Few people sit so upright as this, as it is usual for one to slip forwards on the chair to such an extent that a flexion of the lumbar spine of only 40–50° is required. A person with a hip-joint fixed at a flexion of 45° will not be uncomfortable in any chair. To be able both to sit and to walk well a 20° extension and a 45° flexion in the lumbar spine are thus required. But the normal range of movement of the lumbar spine is about 65°, so that the above values should suffice to enable the person with a hip arthrodesis to both sit and walk without discomfort.

The soundness of this theoretical argument was borne out by the observations. Except for the cases in which the gait was affected by other factors, the patients who could walk best were those with the hip-joint fixed at a flexion angle of 40–50°, and with normal mobility of the lumbar spine.

## DISCUSSION

From the results of this study the gait and comfort in the seated position would appear not to be appreciably dependent on the *rotational position.* It would, however, seem to be an advantage, chiefly for cosmetic reasons, to avoid inward rotation and extreme outward rotation. In normal walking and standing the feet are usually rotated 10–20° outward, and fixation in this position is therefore to be recommended for an arthrodesis operation. A greater outward rotation may be a disadvantage from a theoretical standpoint, although no patient with such a position complained of it. In the case of outward rotation the knee will not articulate in the sagittal plane, a disadvantage in for example cycling. In the seated position an outward rotation will cause the lower leg to point inwards when the knee is flexed. In walking the movement of the foot will also be abnormal.

As regards the position in the *frontal plane,* the present method devised for measuring an adduction position provides considerably greater accuracy.

An important question is whether to compensate for a real shortening by abduction. Any such compensation (measured from the "neu-

tral position" [11]) results in a static scoliosis when the fixed hip is loaded. There was no evidence of a connection between back symptoms and static scoliosis in the present series, but the chance of such symptoms would probably increase with time and there is little reason to run this risk when a shortening of 1–2 cm can readily be compensated for by flexing the mobile hip and knee or by raising the heel on the rigid side.

As regards the position of the hip in the *sagittal plane,* not only the seated position but also the gait were better when the flexion angle was larger than is usually recommended. The values recorded are in conformity with the results of the above mechanical analysis of the gait in the case of a fixed hip. Provided that the range of movement of the back is normal, a flexion angle of about 45° is to be recommended on the basis of this study. One reason that this value is greater than is usually recommended is that the measurement was made from full extension, while the ordinary reference position, though not defined, usually implies a flexion of between 7 and 22° from full extension. If this angle is subtracted it is found that the recommended 45° is not much greater than that usually proposed.

At ages when a hip arthrodesis is most commonly performed there is usually a restriction of the flexibility of the lumbar spine. In these cases a 45° angle of flexion in the hip-joint cannot be used.

A patient with an arthrodesed hip is usually very satisfied with the operation (freedom from severe aching and troublesome pains when walking), quite apart from the comfort in the seated position and his ability to walk normally. One reason for this is no doubt that the patient has no other, possibly better, position with which to compare. Since the hip arthrodesis is a permanent thing and the patient must live with it to the end of his days, it is encumbent on the surgeon to make every effect to ensure the most suitable position and to fix the hip accurately in this position, even though this may entail considerable practical difficulties.

## SUMMARY

The position for a hip arthrodesis recommended in the literature varies widely from one author to another. Methods for measuring the position of a stiff hip are rarely reported and those that are, are wanting in accuracy.

In 35 patients provided with a hip arthrodesis the relationship between the position of the hip and the gait and comfort in the seated

position has been examined. The mensuration techniques for determining the position for the rigid hip are described. The results show that the rotational position is apparently of minor importance so far as function is concerned, and that the best gait is obtained with a setting in the frontal plane near the "neutral position" (11) with little shortening. In the sagittal plane the gait and comfort in sitting were best when the flexion angle of the hip was 45° (measured from a zero position in full extension).

The results were in close conformity with the theoretical values obtained from an analysis of the mechanics of the mobility of the lumbar spine and the sound hip after arthrodesis.

## RESUME

La position recommandée dans la littérature pour l'arthrodèse de la hanche varie beaucoup d'un auteur à l'autre. Les méthodes pour mesurer la position de la hanche rigide sont rarement rapportées et celles qui le sont manquent de précision.

Chez 35 malades ayant une arthrodèse de la hanche, on a examiné le rapport entre la position de la hanche et la marche, ainsi que le confort dans la position endommagée. Les techniques de mensuration pour déterminer la position de la hanche rigide sont décrites. Les résultats montrent que la position de rotation est apparemment d'importance mineure en ce qui concerne la fonction et que la meilleure marche est obtenue par une pose dans le plan frontal près de la "position neutre" (11) avec un petit raccourcissement. Dans le plan sagittal, la marche et le confort de la position assise étaient les meilleurs lorsque l'angle de flexion de la hanche était de 45° (mesuré de la position zéro jusqu'à pleine extension).

Les résultats furent entirèrement conformes aux valeurs théoriques ressortant d'une analyse des mécanismes de la mobilité de la colonne lombaire et de la hanche saine après arthrodèse.

## ZUSAMMENFASSUNG

Die Stellung, die für die Hüftarthrodese in der Literatur emphohlen wird, ist von den einzelnen Verfassern weit verschieden angegeben worden. Metoden zur Messung der Stellung einer stifen Hüfte werden selten mitgeteilt und diejenigen welche veröffentlicht wurden, sind ungenau.

Bei 35 Patienten, die eine Hüftarthrodese hatten, wurde die Beziehung

zwischen der Hüftstellung, dem Gang und der Bequemlichkeit im Sitzen untersucht. Die Messungstechnik zur Bestimmung der Stellung der steifen Hüfte wird beschrieben. Die Ergebnisse zeigen, dass die Rotationsstellung scheinbar hinsichtlich der Funktion von geringerer Bedeutung ist und dass der beste Gang mittels Einstellung in der Frontalebene nahe der "neutralen Position" (11) mit geringer Verkürzung erzielt wird. In der Sagittalebene war der Gang und die Bequemlichkeit im Sitzen am besten, wenn der Beugungswinkel der Hüfte 45° war (gemessen von der Nullstellung bei voller Extension).

Die Ergebnisse waren in genauer Übereinstimmung mit den theoretischen Werten, die von einer Analyse der Bewegunsmechanik der Lendenwirbelsäule und der gesunden Hüfte nach Arthrodese erhalten wurden.

## REFERENCES


1. Abbott, L. & Fischer, F. (1931) *Surg. Gynec. Obstet.* **52**, 863–871.
2. Abbott, L. & Lucas, B. (1954) *J. Bone Jt Surg.* **36**-A, 1129–1140.
3. Adams, A. (1931) *Surg. Gynec. Obstet.* **52**, 261–265.
4. Ahlbäck, S. & Lindahl, O. (1964) *Acta orthop. scandinav.* **34**, 310–322.
5. Cholmeley, J. & Nangle, E. (1951) *J. Bone Jt Surg.* **33**-B, 365–375.
6. Dickson, J. & Willien, L. (1947) *J. Bone Jt Surg.* **29**, 687–696.
7. Ehalt, W. (1954) *Wien. klin. Wschr.* **66**, 658–659.
8. Gardiner, T. (1962) *J. Bone Jt Surg.* **44**-B, 588–594.
9. Grenshaw, A. (1956) Campell's operative orthopaedics. Ed. J. Speed & R. Knight, third ed., Mosby Comp., St. Louis, Vol. II, p. 1250.
10. Karlén, A. (1944) *Acta chir. scandinav.* **91**, Suppl. 96,
11. Lindahl, O. (1966) *Acta orthop. scandinav.* **36**, 280–293.
12. Lindahl, O. (1966) *Acta orthop. scandinav.* **36**, 453–458.
13. Lindström, N. (1957) *Acta orthop. scandinav.* **26**, 255–269.
14. Stinchfield, F. & Cavallero, W. (1950) *J. Bone Jt Surg.* **32**-A, 48–58.
15. The committee on medical rating of physical impairment. (1958) *J. Amer. med. Ass.* Special Edition, Feb. 15, p. 76–84.
16. Watson-Jones, R. (1938) *J. Amer. med. Ass.* **110**, 278–280.
17. Watson-Jones, R. & Robinson, W. (1956) *J. Bone Jt Surg.* **38**-B, 353–377.