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# HIP-JOINT ARTHRODESIS: TO FIND THE BEST POSITION

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Since a hip-joint arthrodesis implies that the hip is to be immobilized in a certain position for the rest of the patient's life, it would seem incumbent on the surgeon to ensure that the position decided upon is the best possible. But at this point a theoretical and a practical problem are encountered, namely, what is the best position and how can it be obtained at the operation. In this paper these problems are discussed and bases for their solution are proposed.

## THE THEORETICALLY BEST POSITION

In an earlier paper *Ahlbäck & Lindahl* (2) have examined closely the positions in the transverse, frontal and sagittal planes that have been preferred by various authors. On the basis of a follow-up examination of hip arthrodesis cases, *Ahlbäck & Lindahl* themselves recommended the following positions: in the transverse plane, slight outward rotation; in the frontal plane, in or near the neutral positions (5); and in the sagittal plane, about 45° flexion, counted from an initial position in maximum extension (*Ahlbäck & Lindahl* (1)). For the joint to be fixed in such marked flexion it is essential for the spinal mobility to be great enough and the direction of motion to be correct.

The significance of these two factors is considered in this paper.

## PREOPERATIVE EXAMINATION

In the pre-operative analysis of the most suitable position the following examinations are necessary:

1. Examination to establish whether an outward rotation contracture prevents the leg from being immobilized with an outward rotation of 10–30°. It is acceptable if the leg can be positioned between these limits; if not, the advisability of resorting to surgical measures to achieve this must be considered. Usually, however, the patient is satisfied with any outward rotation position that is not too extreme.

2. A radiological examination to find whether there is any real shortening of the leg. A determination of the actual length of the leg is essential if the "neutral position" is to be found and the leg is to be arthrodesed in this position in the frontal plane (5).

3. Examination to ascertain whether the leg is so mobile in the frontal plane that it can be set in the neutral position. If there is an adduction contracture which precludes this position the advisability of adductor tenotomy to achieve it must be considered. As a rule the mobility increases slightly under anaesthesia, and the required position may then be attainable.

4. Examination of the total sagittal range of mobility of both hip-joints. The method has been described elsewhere (1).

5. Examination of the total sagittal range of mobility of the lumbar spine (L). An account of the method has been published (6).

6. Measurement of the angle between the thoracic spine and the rigid thigh ($Th_eT_r$), with maximum extension in both the lumbar spine and the hip.

## MECHANICS OF SAGITTAL MOBILITY OF LUMBAR SPINE AND HIP-JOINTS

In a theoretical analysis to find the most suitable position, account must be taken of the dependence of various functions (sitting comfort and length of pace) on certain initial conditions (range of mobility, angles) in the choice of arthrodesis angles in the sagittal plane.

To facilitate description of the involved trigonometrical relationships the following terminology and abbreviations will be used:

*Fore pace (F):* The pace taken with the rigid leg forward.

*Rear pace (R):* The pace taken with the mobile leg forward.

*ThT:* Angle between the thoracic spine and one thigh.

$Th_eT_a$: The angle *ThT* with the lumbar spine fully extended and the thigh in the position for arthrodesis.

$Th_eT_m$: The angle *ThT* in full extension of the lumbar spine and the mobile thigh with the hip-joint extended.

$Th_eT_r$: The angle $ThT$ with full extension of the lumbar spine and the rigid thigh in maximum extension.

$S$: Sitting angle, the angle between the thoracic spine and the rigid thigh in full flexion of the lumbar spine.

$L$: Range of mobility of the lumbar spine, from full extension to full flexion.

$H_f$: Flexion angle for the hip-joint, measured from normal full extension (1).

To simplify the analysis, the following assumptions may be made (with other assumptions the analysis will take a different form):

1. A pace with an angle of 40° between the two legs is acceptable for a person with an arthrodesis (the normal pace is slightly longer, 50°).
2. If for some reason one of the steps must be shorter than normal it is of minor importance whether it is the fore or the rear pace that is shortened. After arthrodesis the fore pace will usually be the shorter one.
3. In the ordinary seated position the angle $S$ ranges from 90 to 135° (in the latter extreme there is a backward inclination of the lumbar spine). For an arthrodesis patient an angle of 135° is acceptable, but sitting will be more comfortable if it is about 115°.

Table 1 shows the fore and the rear paces obtained with different values of $Th_eT_m$ and the arthrodesis angle $Th_eT_a$. The sitting angles are given for different lumbar spinal mobility ranges from 65° down to 45°.

An angle $Th_eT_m$ of 120° is found at lower ages and corresponds usually to a good spinal mobility; in these cases the direction of motion is usually suitable for the hip arthrodesis. It is seen in the table that for the arthrodesis positions with large flexion angles the ranges of mobility are good for both paces. A flexion position of about 50° would seem to be optimal—possibly larger for a person with a sedentary occupation (Figure 1). With a small flexion angle, such as 30°, sitting is less comfortable, and there is no improvement in the length of pace, if both paces are considered.

A number of persons quite normally adopt a slight stoop when walking, and many with arthrodesis have the same posture, apparently without discomfort. It would therefore seem natural to accept a slight forward inclination of the thoracic spine—say about 20°—as the rear pace is being taken, since this considerably lengthens the step. The acceptance of such a gait will bear on the choice of arthrodesis position.

*Table 1. Relationship between fore pace (F), rear pace (R), sitting angle (S) and arthrodesis angle ($Th_eT_a$) for various thoracic spine—thigh angles for the mobile thigh ($Th_eT_m$) and various ranges (65°, 55° and 45°) of lumbar spine mobility (L). B/20° denotes the length of the rear pace for a forward inclination of 20° of the thoracic spine. $H_f$ is the flexion in the hip-joint in the planned arthrodesis position The figures in italics are the recommended combinations.*

| $Th_eT_m$ | $Th_eT_a$ | $H_f$ | *F* | *R* | B/20° | *S* L 65° | *S* L 55° | *S* L 45° |
|---|---|---|---|---|---|---|---|---|
| 120 | 180 | 60 | *60* | 0 | *40* | *115* | *125* | *135* |
| 120 | 170 | 50 | *50* | 20 | *60* | *125* | *135* | 145 |
| 120 | 160 | 40 | *40* | 40 | *80* | *135* | 145 | 155 |
| 120 | 150 | 30 | 30 | 60 | 100 | 145 | 155 | 165 |
| 120 | 140 | 20 | 20 | 80 | 120 | 155 | 165 | 175 |
| 130 | 180 | 50 | *50* | 0 | *40* | *115* | *125* | *135* |
| 130 | 170 | 40 | 40 | 20 | *60* | *125* | *135* | 145 |
| 130 | 160 | 30 | 30 | 40 | 80 | 135 | 145 | 155 |
| 130 | 150 | 20 | 20 | 60 | 100 | 145 | 155 | 165 |
| 130 | 140 | 10 | 10 | 80 | 120 | 155 | 165 | 175 |
| 140 | 180 | 40 | *40* | 0 | *40* | *115* | *125* | *135* |
| 140 | 170 | 30 | *30* | 20 | *60* | *125* | *135* | 145 |
| 140 | 160 | 20 | 20 | 40 | 80 | 135 | 145 | 155 |
| 140 | 150 | 10 | 10 | 60 | 100 | 145 | 155 | 165 |
| 140 | 140 | 0 | 0 | 80 | 120 | 155 | 165 | 175 |
| 150 | 200 | 50 | 50 | *a* | 0 | 95 | 105 | 115 |
| 150 | 190 | 40 | 40 | *b* | 20 | 105 | 115 | 125 |
| 150 | 180 | 30 | *30* | 0 | *40* | *115* | *125* | *135* |
| 150 | 170 | 20 | *20* | 20 | *60* | *125* | *135* | 145 |
| 150 | 160 | 10 | 10 | 40 | 80 | 135 | 145 | 155 |
| 160 | 200 | 40 | 40 | *a* | 0 | 95 | 105 | 115 |
| 160 | 190 | 30 | *30* | *b* | *20* | *105* | *115* | *125* |
| 160 | 180 | 20 | *20* | 0 | *40* | *115* | *125* | *135* |
| 160 | 170 | 10 | 10 | 20 | 60 | 125 | 135 | 145 |
| 160 | 160 | 0 | 0 | 40 | 80 | 135 | 145 | 155 |
| 170 | 200 | 30 | 30 | *a* | 0 | 95 | 105 | 115 |
| 170 | 190 | 20 | *20* | *b* | *20* | *105* | *115* | *125* |
| 170 | 180 | 10 | *10* | 0 | *40* | *115* | *125* | *135* |
| 170 | 170 | 0 | 0 | 20 | 60 | 125 | 135 | 145 |
| 180 | 200 | 20 | *c* | *a* | 0 | 95 | 105 | 115 |
| 180 | 190 | 10 | *d* | *b* | *20* | *105* | *115* | *125* |
| 180 | 180 | 0 | 0 | 0 | 40 | 115 | 125 | 135 |

*a* Cannot be performed without forward inclination of more than 20°.
*b* „ „ „ „ „ „ „ „ „ 10°.
*c* Maximum 20° possible, when forward inclination will be 10°.
*c* „ „ „ „ „ „ „ „ 5°.

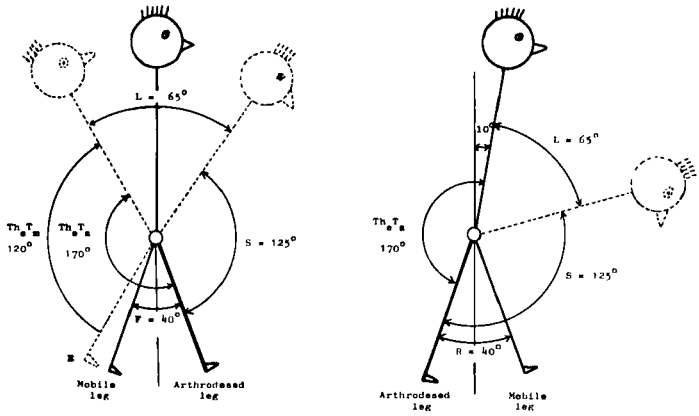


*Figure 1. Diagram illustrating sagittal movements of the lumbar spine and mobile hip in an arthrodesis case. The conditions are: $Th_eT_m$ 120°, L 65° and $Th_eT_a$ 170°. Both F and R have been made 40°. F can be 50° if the mobile hip is extended to position E. R requires a forward inclination of the upper trunk of 10°. If this is increased to 20° the pace can be 60°. The sitting angle, S will be quite comfortable (125°).*

The length of the rear pace when the upper trunk is inclined 20° forwards is given under *B*/20°.

An angle $Th_eT_m$ of 140° is probably quite common at ages at which arthrodesis are usually performed, and at 40–60 years it is normally about 145° (6). It is seen here that an arthrodesis set with a small angle of flexion results in not only a less comfortable seated position but also a shorter fore pace, while the rear pace will be unnecessarily long, and will not be fully exploited. For this group an arthrodesis position with 30–40° flexion would seem optimal for the arthrodesis.

As $Th_eT_m$ is increased further (160°), so is the difficulty of obtaining a good length of pace, but a comfortable sitting position is more easily achieved. Here, a flexion of only 20–30° is perhaps to be preferred.

When $Th_eT_m$ is as large as 180° a pathological condition also of the mobile hip-joint may be suspected and the chance of obtaining a good length of pace is yet more slender, though a comfortable seated position is still reasonably certain. For such cases extension or slight flexion (10°) may be best for the arthrodesis (Figure 2).

Since the flexion contracture will probably be larger for the affected than the mobile hip ($Th_eT_r$ is almost invariably greater than $Th_eT_m$), there may be difficulty in achieving the desired position.

The discussion has been limited so far to the size of $Th_eT_m$ and its effect on the length of pace for various arthordesis positions. A reduc-

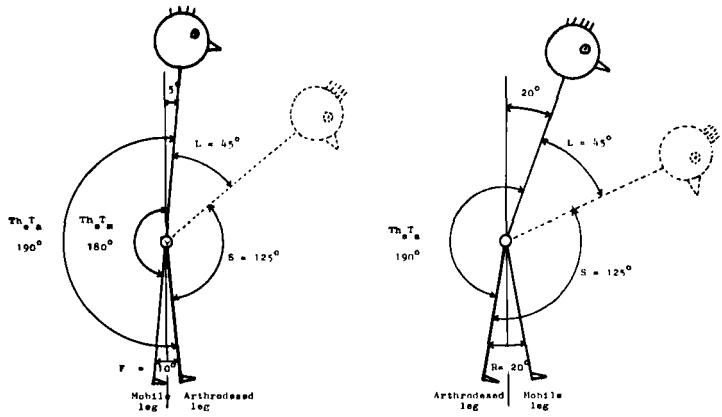


*Figure 2. Diagram illustrating the sagittal movements of the lumbar spine and mobile hip in an arthrodesis case. The conditions are: $Th_eT_m$ 180°, L 45° and $Th_eT_a$ 170°. F will then be only 10°, with a forward inclination of the upper trunk of 5°. If the forward inclination is 20° R will be 20°. The paces will be short but the sitting angle S will be quite comfortable (125°).*

tion in the range of mobility of the lumbar spine, as often occurs in these cases, must also be taken into account in deciding the arthrodesis position.

If the range of lumbar spine mobility is not below 45°—when a hip arthrodesis would probably not be very suitable—there is no risk that the reduction in mobility will restrict either pace. On the other hand, the comfort in sitting is reduced when the mobility of the lumbar spine decreases. If a maximum of 135° for $S$ is taken as providing an acceptable level of sitting comfort, the choice of suitable arthrodesis positions is considerably restricted when the spinal mobility is reduced, and then the more flexed positions are preferable.

For an analysis of the relationship between the various functions on the basis of other conditions and other angles, the following relationships may be used:

$S = 360 - Th_eT_a - L$

$F = Th_eT_a - Th_eT_m$ provided that $Th_eT_a \leq 180$ and $Th_eT_m < 180$

$R = 2\,(180 - Th_eT_a)$

$H_f = Th_eT_a - Th_eT_m$ provided that the extension in the better hip is considered to be normal.

## PREOPERATIVE EVALUATION

Without entering on a trigonometrical analysis in the individual case it is possible to form an opinion on the most sutitable arthrodesis angle

from an examination of the patient and the data in Table 1. The data required are the total sagittal range of mobility ($L$–65°, $L$–55° and $L$°–45 in the table) and the angle between the thoracic spine and the mobile thigh in full extension of both the lumbar spine and the hip ($Th_eT_m$ in the table). From these values the size of the fore and the rear paces and the sitting angle ($F$, $R$ and $S$) can be found. If one accepts a rear pace with a forward inclination of 20° when the pace is made, its size will be found under $B/20°$. A certain arthrodesis angle can then be decided upon ($Th_eT_a$ or $H_f$) that gives values that will apparently be optimal for the patient, with due regard to such factors as his occupation and sitting habits. It must also be checked whether this position lies within the limits for the range of mobility of the rigid hip. If this is not the case it is necessary to consider, as in the case of outward rotation contractture or adduction contracture, whether surgical measures must be resorted to in order to free the rigid hip so that the required position can be achieved.

## OPERATING TABLE AND TECHNIQUE

To realise a planned arthrodesis angle there are certain practical requirements. Although from a theoretical aspect a number of surgical methods may be used, it would seem to be most easily performed by a nail arthrodesis on an extension operating table so as get the hip into the exact position. To obtain healing of the bone, a graft combined with drilling through the joint is recommended. Methods requiring initial dislocation of the hip, removal of cartilage and shaping of the femoral head and acetabulum, after which the hip joint is repositioned, call for such extensive manoeuvres of the leg that it is difficult, if not impossible, to make the necessary measurements on the patient under aseptic conditions and to obtain the desired position.

The operating table should permit rotation of the leg about its axis, and abduction and adduction in both legs. A combined abduction and adduction of both hip-joints is often best obtained by extending one leg and applying pressure to the other, and such a movement must therefore be feasible. For positioning in the frontal plane it must be possible to indicate both malleoli and to determine the centre of the mobile hip. This is best done by fluorescopy with, for instance, X-ray television, when the centre of the femoral head can easily be marked on the skin in the region of the groin.

To be able to position the hip-joints and spine in the sagittal plane

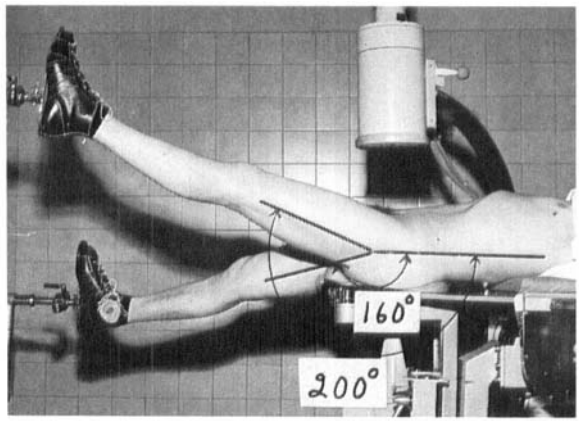


*Figure 3. Operating table with the patient in position for an arthrodesis. $Th_eT_m$ is 160°, $Th_eT_a$ 200° and $H_f$ 40°.*

it must be possible for both legs to be raised and lowered through an angle of at least 40°.

## PRE-OPERATIVE SETTING OF THE HIP-JOINT

First the leg is set in a suitable rotation position (for instance 15° outward rotation). Since there is a certain rotation in the knee also in the extended position (*Hallén & Lindahl* (3)) and there is a large rotation in the foot, the required rotation position should be checked on the patella.

The position in the frontal plane is then achieved by traction and pressure in the axial direction of the legs so as to bring both ankles to the same distance from the centre of the mobile hip. If the real shortening is more than 1 cm it may be necessary to compensate for it and to secure the neutral position (5) to avoid tipping of the pelvis in the standing position.

The saggittal position is then obtained. First full extension of the mobile hip and lumbar spine is achieved by lowering the mobile leg (the angle $Th_eT_m$ is then obtained between the thorax and this thigh; Figure 6 A, page 247 in article with reference No. 6). The rigid thigh is then placed in the determined flexion position ($Th_eT_a$) and the angle between the thoracic spine (plane of the operating table) and the rigid hip is measured. When this position has been achieved a new check should be made in the frontal plane, in which there may have been a change during these manipulations (Figure 3). The position so obtained is retained throughout the operation.

## DISCUSSION

The performance of a theoretical analysis followed by attainment of the desired position might appear an involved procedure for an arthrodesis and one may wonder whether so great an apparatus is necessary.

In many cases the hip has been set naturally in a more or less ideal flexion position through a flexion contracture of 30–40° (note the difference between the angle obtained by Thomas's test and the true flexion contracture (1)), and in these cases the required flexion position is obtained only by allowing the patient to lie on a plane operating table with the lumbar spine slightly lordosed through the weight of the thigh. Whether this actually happens can be found by the procedure described, and it is then unnecessary to make any major arrangement at the operation. In these cases *Watson-Jones'* (7) words are perhaps relevant: "As the patient lies on the table there is enough lordosis to be sure that the final position of consolidation will amount to only 30 degrees of fixxed flexion, which is quite enough for comfortable sitting and is correct for comfortable standing". In a fair number of cases, however, these conditions are not present and it would seem that an analysis and more exact positioning are essential if the patient's potential mobility is to be realized by the operation.

Since the patient himself is almost invariably satisfied because his pain has been banished (4), and since he will not know which position would be better, one need not in such a case take a satisfied patient as a mortgage to realize the best possible result.

## SUMMARY

In the performance of a hip-joint arthrodesis there are two problems, in addition to that of the surgical technique, namely, which position of the hip will give the best function, and how this is to be realised at the operation. On the basis of a trigonometrical analysis of the sagittal mobility of the hip-joints and lumbar spine, an account is given in tabular form of the relationship between certain ranges of mobility measured before the operation, and the postoperative function with different arthrodesis angles. The positioning in the frontal and transverse planes has been discussed in earlier papers. After a pre-operative analysis of the "best arthrodesis angle" a method is presented for achieving this position at the operation.

The need for such a careful procedure is discussed.

RESUME

Lorsqu'en procède à une arthrodèse de la hanche, il faut tenir compte en plus de la technique chirurgicale de deux problèmes, à savoir quelle position de la hanche donnera la meilleure fonction et comment cell-ci peut être réalisée par l'opération. Sur la base d'une analyse trigonométrique de la mobilité sagittale des articulations de la hanche et de la colonne lombaire, un compte redu est donné sous forme de tableau de la relation entre certaines étendues de mobilité mesurées avant l'opération et la fonction post-opératoire avec différents angles d'arthrodèses. La mise en position dans le plan frontal et transversal a été discutée dans des publications autérieures. Après une analyse pré-opératoire du "meilleur angle d'arthrodèse", une méthode a été présentée pour l'établissement de la position par l'opération.

Le besoin d'une procédure minutieuse de ce genre est discuté.

ZUSAMMENFASSUNG

Bei der Ausführung einer Hüftgelenksarthrodese sind, abgesehen von der chirurgischen Technik, zwei zusätzliche Probleme vorhanden, nämlich – welche Stellung wird die beste Funktion ergeben und wie kann man dies unter der Operation klarlegen. Auf Grundlage einer trigonometrischen Analyse der sagittalen Beweglichkeit der Hüftgelenke und der Lendenwirbelsäule wird in tabellarischer Form ober die Beziehung zwischen gewissen vor der Operation gemessenen Bewegungsbereichen und der postoperativen Funktion bei verschiedenen Arthrodesewinkeln, berichtet. Die Einstellung in der frontalen und transversen Ebene ist in einer früheren Arbeit besprochen worden. Nach einer präoperativen Analyse des "besten Arthrodesewinkels" wird eine Methode zur Erhaltung dieser Position während der Operation mitgeteilt.

Dit Notwendigkeit eines derartigen sorgfältigen Vorgehens wird besprochen.

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