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Legg-Calvé-Perthes' Disease

Radiological Results of Treatment and Their Late Clinical Consequences

A Study of the Efficacy of
Three Methods of Treatment:

- Wheelchair
- Bed rest without traction
- Traction in bed

BY

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PREFACE

In 1955 Professor *E. Thomasen* conceived the idea to try treating Legg-Calvé-Perthes disease (LCPD) in a wheelchair.

This idea was realized in the Orthopaedic Hospital, Århus, and in the late 1960's *Jørgen Lauritzen* initiated a study on the results. In 1967 Professor Thomasen asked me to assist Dr. Lauritzen in a way so that it would be possible to compare the radiological results of wheelchair treatment with those obtained by traction in the Seaside Hospital, Refsnæs.

This collaboration was the starting point of the present publication, and I am therefore greatly indebted to Professor Thomasen for the invitation to collaborate in the study of the wheelchair series.

My collaboration with Dr. Lauritzen was very successful. That to me it was an inspiration is witnessed by the volume I am submitting now. For the many years of good collaboration and pleasant hours spent together I am sincerely grateful.

For assistance in the follow-up examinations I am indebted to *Knud Mose,* M. D., Physical Therapy Department, Central Hospital, Nykøbing Falster, and to Drs. *Louise Hjorth* and *Mette Ulfeldt.* For help and guidance in assessing X-ray films I acknowledge my indebtedness to *Marcus Schalimtzek,* M. D., *Erik Rostgaard Christensen,* M. D., and *Ellen Jensen,* M. D., Radiology Department, Orthopaedic Hospital, Copenhagen, as well as to *Henrik Schiøler,* M. D., Radiology Department, Rigshospitalet, University of Copenhagen.

I am indebted to *Hans Bohr,* M. D., Head of the Seaside Hospital, Refsnæs, for the permission to use case records for patients treated in that hospital and for the kind helpfulness with which I am invariably met by Dr. Bohr and his entire staff.

For the statistical calculations my thanks are due to *Jørgen Nyboe,* Head of the Statistical Department, Rigshospitalet, University of Copenhagen.

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Refsnæs, September 1976.

Johannes Meyer.

CONTENTS

INTRODUCTION

In a previous study (Meyer 1966) it was endeavoured to assess the efficacy of 4 different methods of treating Legg-Calvé-Perthes' disease (LCPD): Bed rest *with* traction, bed rest *without* traction, ambulatory relief from weight-bearing with *Thomas' splint, no or merely symptomatic* treatment.

During recent years I have also had occasion to study the efficacy of another therapeutic method – in collaboration with Jørgen Lauritzen and through the kindness of Professor E. Thomasen – viz. ambulatory relief from weight-bearing in *wheelchair*. The results of this method were compared with those of two of the previously studied methods: *Bed rest with and without traction* – the methods used by me.

In the course of these investigations it was realized that the methods of assessment used in the previous study were insufficient when the treatment in wheelchair was included in the evaluation.

The following principal views must be maintained in assessing therapeutic results:

The value of any treatment must be assessed according to the *clinical* result obtained. In the evaluation the share of treatment must be elucidated as far as possible, taking into consideration also the strain it has been on the patient. The significance of the *radiological* result is restricted to its relation to the clinical condition.

First, as regards the clinical result:

A year or two after the discontinuation of treatment the radiological appearances show that after the stage of fragmentation the contours of the affected femoral head are again uninterrupted and well-defined, so that the deformity of the head, and thus also of the hip joint, after treatment may be assessed. This time may be called the time of *primary healing* and is thus determined on the basis of the X-ray film – one might say: the radiological condition.

At the time of primary healing the clinical condition is practically always good: The children are, broadly speaking, symptom free regardless of the treatment used.

On the other hand, the *late* clinical condition, at the end of many years, is often poor, characterized by increasing osteoarthritis – so-called secondary osteoarthritis – and this is the condition on which the assessment of the efficacy of treatment must be based.

However, the late clinical condition cannot – at present – be directly observed. In the most recent follow-up studies of the earliest treated materials (Helbo 1953, Gower and Johnston 1971, Danielsson & Hernborg 1965) the patients have reached a mean age of only about 40. The entire subsequent development of osteoarthritis – perhaps the most important part – has not been established by direct observation.

But although the subsequent development of osteoarthritis has not yet been directly observed, we are not debarred from assessing the efficacy of the therapeutic methods. The fact is that even at an early juncture it is possible to predict, indirectly and in broad features, the development of osteoarthritis. In their follow-up studies of fairly large series int. al. Sundt, Helbo, and Danielsson & Hernborg arrived at the main thesis that the time of onset of secondary osteoarthritis and its severity were directly proportional to the radiological deformity of the hip joint at "primary healing": The greater the divergences from normal, the greater the risk of osteoarthritis. Of course, this rule is based merely upon experience concerning the development of osteoarthritis up to the age of about 40 – but there is nothing to indicate that it could not apply also to subsequent development of osteoarthritis.

Thus, if we have a method for objectively determining – measuring – the radiological deformity of the hip joint at "primary healing", it is possible to establish with reasonable certainty, already at this early juncture, whether one treatment is more effective than the other in preventing the occurrence of secondary osteoarthritis. This means the *relative* efficacy of the methods.

This method also affords some idea of the absolute, factual development of osteoarthritis in the series. Those cases that have healed with practically normal femoral heads may be regarded, without major errors, as having no risk of osteoarthritis. The percentage of the remaining cases then indicates the maximum possible extent of osteoarthritis in the series. But this indirect method affords no concrete information about the actual time of onset of osteoarthritis, if any, its actual extent, or severity. Such information is obtainable only, if it is possible to establish a definite relationship between early radiological deformities and the clinical nature of the late osteoarthritis. This may be tried, but it is inevitably uncertain – and the accuracy of the result can be ascertained only by direct, late observation.

The indispensable basis for any assessment of the efficacy of the various therapeutic methods, therefore, must be giving a dependable picture of the radiological deformities at primary healing in the available materials. Not until then can any attempt be made to elucidate the clinical consequences of these radiological results.

However, the primary deformity of a hip joint is dependent not only upon the treatment. Several factors seem to be operative (Mose and others):

1. Treatment.
2. Age at onset of the disease.
3. Stage of disease at institution of treatment.
4. Sex.

Moreover, genetic and constitutional factors must be expected to influence the result, but so far these factors are outside the scope of objective assessment. In materials from a racially homogeneous population and from a geographically uniform area, however, the influence of such constitutional factors may presumably be expected to be of approximately the same extent in the various series.

Then, in assessing the relative efficacy of different treatments, it is not sufficient merely to determine the radiological deformity of the hip joints after completion of the treatments. We must also isolate the share of treatment in the radiological result from the influence of the other factors.

This problem is eliminated if the series to be assessed vary only with regard to treatment, being largely uniform as to the other factors. In the 1966 study the present author determined the named factors in the different series. In the series treated *with* traction and with bed rest *without* traction (called "traction series" and "bed rest series") they were in fact of approximately the same order of magnitude; at least this was how they were interpreted. In the other series, which to me were "second-hand", it was difficult at least to establish with certainty the stage at institution of treatment. All considered, the conclusion of the 1966 study was that the named "other factors" did not vary so widely in the series concerned that they had to be considered. Therefore, when determining the primary deformity of the hip joints in the various series, by the special measuring methods, it was concluded that the differences reflected the efficacy of the treatments applied. No doubt this was in the main correct with regard to the traction series and bed rest series – the two series of most interest – less correct in the others.

However, when the result of ambulatory *wheelchair* treatment was to be compared with those of the other therapeutic methods, it was found that the wheelchair series differed appreciably from the other series in respect to those factors which, apart from treatment, exert an essential influence upon the primary radiological deformity of the joint. The relatively simple procedure used in the study from 1966 was no longer sufficient: In the assessment regard had to be paid, to a much greater extent, to the influence of "other factors". This was attained by extending and supplementing the 1966 method. This, I hope, improved method was applied to the old bed rest series, an increased traction series, and the wheelchair series. As might be expected, the results found for the two previously investigated therapeutic methods were practically the same as found in 1966, only elaborated in more detail so as to permit comparison with the results of treatment in wheelchair. This elaborated method for the radiological evaluation of the therapeutic results will be described in the next sections.

The *plan* of the study to be described below was thus:

1. To give a well-defined, quantitative description and assessment of the nature and extent of the *radiological deformities of the joints* in the three series at primary healing. In other words, it was endeavoured to arrive at a measure of whether, and if so how much the affected hip joint differs from normal after completion of treatment.
2. To determine the *influence of the various above-mentioned factors* upon the radiological appearances, especially with a view to isolating the role of treatment.
3. To predict the *later clinical course* – i.e. assess the risk of osteoarthritis on the basis of the radiological appearances in the series at primary healing.

   In other words, it was endeavoured partly to determine the *relative* risk of osteoarthritis in the various series, partly the *absolute* risk of osteoarthritis in the individual series. The former does not pose much difficulty, but the latter certainly does. This may be stated more accurately: Deciding which degree of radiological deformity of the joint can be accepted at primary healing, if the late clinical result is to be designated good.

In particular, it was the achievement of the second item of the plan which required elaborating and supplementing the old methods. The third item – especially its last part – was the most difficult one and the result least reliable. True, this did not necessitate new methods, but a deeper probing into the problem was required to substantiate the reliability of the conclusion.

In carrying through the plan, all measurements were performed by *two persons.* This was done to test whether the measuring methods were applicable by two investigators, independently of each other, with consistent results. This is of the utmost importance with a view to comparing therapeutic results obtained in different clinics and by different clinicians.

It was Professor E. Thomasen who suggested this testing. The measurements were performed by Jørgen Lauritzen and Johannes Meyer (LAU. and J.M.). The results will be described in a special section, supplemented by a discussion of the two investigators' somewhat divergent conclusions on the basis of the measurements (p. 78).

Lauritzen reported his results in 1975 (Diss.).

Total *Survey of abbreviations and symbols* fixed and defined in *the radiological section:*

Abbreviations: Wh = wheelchair, BR = bed rest without traction, Tr = traction in bed (often used in combinations, such as Wh series, Tr treatment, etc.).

Symbols for patient groups (with features of significance in the evaluation):

A. Patients arriving early for treatment, i.e. during the stage of condensation without flattening (initial quot. >85).

B. Patients arriving late for treatment, i.e. in the stage of condensation with flattening (initial quotient ⩽ 85) or in the stage of fragmentation.

I. Patients aged ⩽ 4 years at institution of treatment

II. Patients aged 5–8 years at institution of treatment

III. Patients aged ⩾ 9 years at institution of treatment

"SPH.": Cases healed with "spherical" heads – i.e. heads whose surface, measured with Mose's plate, has a circular countour in 2 planes.

"NORM.sph.": Cases healed with "spherical" heads of normal shape and size (Ep. qu. >60, jt. surf. qu. >85, radius qu. <115 – i.e. all quotients within the "normal range", cf. Appendix, Comment 1).

"PATH.sph.": Cases healed with "spherical" heads of pathological shape and/or size (at least one of the quotients outside the "normal range").

"NON-sph.": Cases healed with non-spherical heads (without circular contour).

A. RADIOLOGICAL ASSESSMENT OF THERAPEUTIC RESULTS

1. Methods of Assessment

A radiological description of articular deformities at primary healing should preferably bear the closest possible relationship to the *risk of osteoarthritis* in the series. Therefore, in selecting methods of radiological description, care must always be taken that the phenomena measured really do bear relationship to the risk of osteoarthritis. This risk must be included in the considerations. Therefore, it is inevitable that even the radiological section should include a discussion of clinical problems. A more detailed discussion of the clinical significance of the radiological results will follow in Section B.

The development of deformity in the hip joint in the course of the disease is a somewhat complicated process. Primarily, the *epiphysis* gets deformed because of the disease process localized therein. To the epiphyseal deformity the bony tissue in the metaphysis reacts by compensating growth processes trying to maintain the normal spherical shape of the femoral head (2/3–3/4 of a sphere as the joint surface normally makes up about 2/3–3/4 of a spherical surface). This may be accomplished in the mild epiphyseal deformities, but as a rule the head as a whole will get deformed. In some cases it "flattens", i.e. the joint surfaces remain parts of a spherical surface – but only a smaller part than normal, with a longer radius. In other cases the joint surface cannot be maintained as a spherical surface, and it assumes a more irregular shape.

These deformities of the head again induce reactions from the bony tissue in the *acetabular roof,* viz. compensating growth processes trying to adapt the acetabular joint surface to the deformed joint surface of the head. This will widely succeed – but the deformity of the head may become too marked. In other words, the acetabular changes are secondary to, and vary largely in proportion to, the deformity of the head.

A side effect to the severe cases of epiphyseal disease will be a reduction in the function of the epiphyseal line and thereby a reduction in the longitudinal growth of the femoral neck. As the epiphyseal line of the trochanter, which looks after the longitudinal growth of the lateral part of the proximal end of the femur, is undamaged, the longitudinal growth of the entire proximal femoral end will become lopsided. It remains normal laterally, but is inhibited medially. This gradually leads to varus deformity of the neck. Thus, a shortening and varus deformity of the neck also bear relation to the deformity of the head: Shortening and varus deformity of any extent occur only in the presence of severe deformities of the head – e.g. the typical, flat "mushroom" on a short stalk.

Mild subluxation of the hip joint has often been reported as being among the sequelae to LCPD. In my experience, this is very uncommon. At any rate it occurs, like the changes of the neck, only in the presence of very pronounced deformity of the head – and acetabulum.

All considered, *the deformity of the hip joint is determined by the deformity of the femoral head.* Accordingly, there is no need to perform special measurements of acetabular deformity, the position of the head in the acetabulum, or of the length and position of the neck. It is fully adequate to measure only the deformity of the head when looking for information about the deformity of the hip joint as a whole.

As mentioned above, the radiological deformity of the head extends over a wide range – from slight "flattening" with preserved spherical shape of the joint surface to actually angular heads. A striking phenomenon, broadly speaking common to all, is *a marked increase in the growth of the head.* This comprises also, though to a lesser extent, the acetabulum. Unlike the shortening of the neck and the coxa vara, an increase in growth may occur also in the mildest deformities; indeed, it may be seen in some cases without deformity: The affected head is merely larger than the unaffected one. The role of this enlargement in the risk of osteoarthritis is difficult to estimate. There is little doubt that the risk of osteoarthritis, at a given deformity of the head, will be increased when the affected head is also larger than the contralateral one, the curvature of the joint surface getting smaller. The effect is accentuated when the increase in acetabular growth is unable to keep pace with that of the head, so that the head grows too large for the acetabulum.

On the whole, it may be said that a description of head deformity is incomplete without recording the attendant enlargement. (Therefore, the word deformity as used below will signify deformity + enlargement, unless otherwise apparent from the context).

However, a description of the deformity of an affected head presupposes a normal head as reference, and this is available only in unilateral cases – viz. the head on the unaffected side. As a result, the assessment was done *only in unilateral cases* – presupposing that in bilateral cases, under the same circumstances, the hip joints are affected exactly as in unilateral cases.

The determination of the radiological deformity of the femoral head was carried out as follows: (For a more detailed description cf. Meyer 1966):

First all bilateral cases were excluded. In all the series they made up 15–17 %.

Thereafter, the unilateral cases were divided into two groups: (1) cases with *spherical heads,* (2) cases with *non-spherical,* "irregular" heads. The distinction was done by the aid of Mose's plastic plate with scored circles. A femoral head was classified as *spherical* when one of the circles covered the contours of the joint surface, in the anteroposterior as well as in Lauenstein's view (a 2 mm variation in radial length was permitted in one plane and between two planes). If this demand could not be fulfilled, the head was calssified as *non-spherical,* "irregular": This applies to large, flat heads whose contours are more curved along the edges than centrally as well as to the angular ones. Within this group the deviation from normal is so great that the clinical prognosis must be definitely poor, with a great risk of osteoarthritis.

If only the series has been fairly well treated, the group of spherical heads is a large one in which the capital shape ranges from entirely normal – like that of unaffected femoral heads – by way of somewhat "flattened" heads in which the joint surface makes up a smaller part of a sphere with a longer radius than on the unaffected side, to the greatly deformed, mushroom-

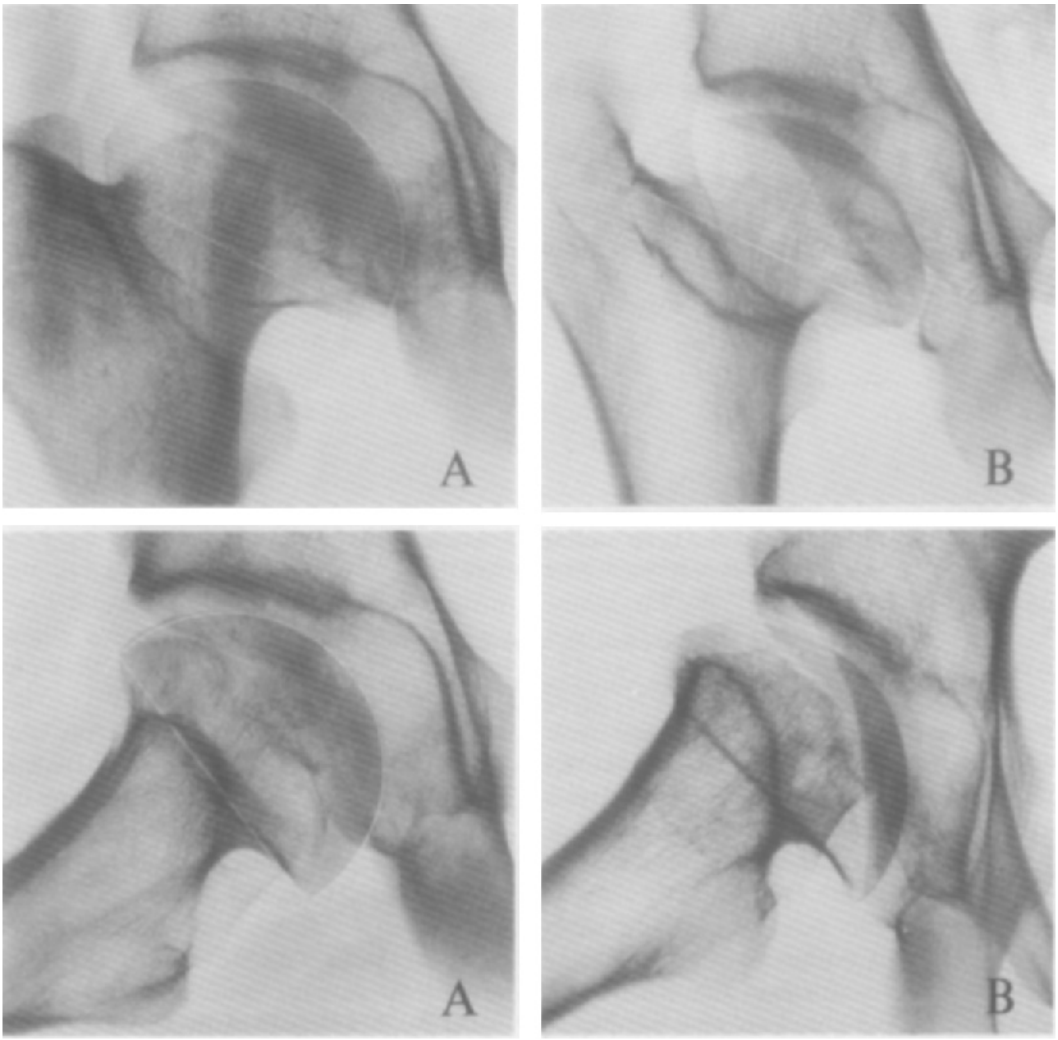


Figure 1. Two cases of right-sided LCPD healed with femoral heads which, though "spherical" *in Mose's terminology, are greatly deformed.*
Thus, these cases belong to the group "PATH.sph.".
Anteroposterior and Lauenstein views.

A, ♂ aged 18 years.
Ep. quot. 65, jt. surf. quot. 80, ra. quot. 127.

B, ♂ aged 22 years.
Ep. quot. 59, jt. surf. quot. 66, ra. quot. 138.

shaped heads in which the contours are circular, but make up only a small part of a circle, with a long radius. (Fig. 1).

In other words, there is a wide scope of deformities within this group which, therefore, ought to be divided into a couple of smaller, but well-defined groups. It was attempted to attain this by picking out those cases in which the difference in shape and size between the affected and unaffected head *does not exceed that which may be observed between the right and left head in X-rays of a normal pelvis.* The remainder – the other group – will then comprise cases in which the head is spherical, but the difference in shape and (or) size between the affected and unaffected head is beyond what may be observed in normal persons.

The former group is of importance, seeing that it may reasonably be predicted that these cases, having essentially normal

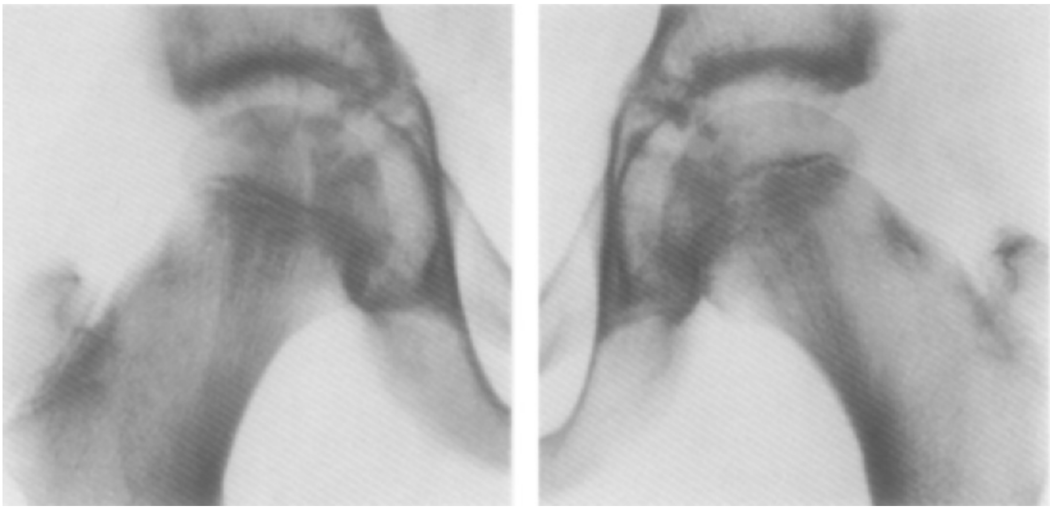


Figure 2. Left-sided LCPD healed with a "normally spherical" *femoral head.*
This case, then, belongs to the group "NORM.sph.".
Anteroposterior view.
♂ aged 14 years.
Ep. quot. 78, jt. surf. quot. 86, ra. quot. 111.

The joint surface quotient is just above the bottom limit of the "normal range".

femoral heads, must have a favourable clinical prognosis, at least as compared with the other groups. However, these hip joints are not *entirely* normal: The affected and unaffected head are rarely exactly alike. In the majority of cases there is a slight difference (but within the normal range). In *a normal* material, on the other hand, the right and left head are exactly alike in the majority of cases – deviations occurring in only a very few. Perhaps, this difference between the mild capital deformities in this group and the slight physiological deviations in a normal material are not devoid of prognostic significance, but let us start by supposing that the risk of osteoarthritis in this group is *not appreciably greater than the risk of primary osteoarthritis in normal persons.* (Fig. 2).

In the group comprising the remaining patients with spherical heads we are dealing with real capital deformities and increases in growth considerably exceeding the modest normal variations. In this group the clinical prognosis must be at least inferior to that in the 1st group.

It may be said, briefly, that the 1st group comprises all cases with normally spherical – i.e. in fact normal – heads and the second group all cases with pathologically spherical heads. Below, the former group will be abbreviated *"NORM. sph."* and the latter *"PATH. sph."*. The third group of patients with abnormal, non-spherical heads will be designated *"NON-sph."* – and the large group with spherical heads: *"SPH."*.

Thus, the presupposition for dividing the "spherical" cases into two groups must be accurate methods of determining the shape and size of the spherical head.

Three such methods were used: Measurement of the *epiphyseal quotient, joint surface quotient,* and *radius quotient.*

Let it be emphasized at once that these methods are *applicable only to spherical heads* with well-defined circular contours. They cannot be applied to irregular or fragmented heads, as the quantities "radius of head" and "height of epiphysis", which are included in the measurements, make no sense in such cases and are therefore not measurable.

A detailed description of these methods was given previously – Meyer: 1966, pp. 39, 42, 92, and 93, so that here it will only be briefly stated what they mean:

The joint surface quotient is a direct expression of the shape of the affected joint surface, and thereby the affected head, in relation to the unaffected head. An increase in capital size does not affect the joint surface quotient. In a group of normal persons the joint surface quotient is usually 100, but in a few cases it may be as low as 85.

The epiphyseal quotient is a direct expression of the shape of the affected epiphysis, i.e. its flattening as compared with the unaffected one (but not as stringently stereometrically as the joint surface quotient expresses the shape of the joint surface). Increased growth of the epiphysis also does not affect the epiphyseal quotient. In a normal material the epiphyseal quotient is usually 100, but may in a few cases be as low as 85.

The applicability of the epiphyseal quotient as a measure of *capital shape* is due to a rule set up by Mose: Even though the epiphysis gets deformed (flattens) beyond the range in a normal material, so that the epiphyseal quotient drops below 85, the above-mentioned compensatory growth processes in the metaphysis (possibly as far down as the neck) will *maintain the normal shape of the head,* so that it is not deformed beyond the normal range. By careful, but not quantitative observations, the correctness of which I can confirm, Mose ascertained that such maintenance of normal capital shape occurred if only the epiphyseal quotient *exceeded 60.* Thus, the epiphyseal quotient could be used as a measure of capital shape: When the epiphyseal quotient exceeded 60, the shape of the head was within the normal range. If an epiphyseal quotient of 60 is not used, in the radiological assessment, as the bottom limit of normally shaped heads in *LCPD* series, but an epiphyseal quotient of 85 – which is the bottom limit of epiphyseal quotients in normal children – it is not possible to single out *all* cases with normally shaped *heads* in the LCPD series, only those with normally shaped *epiphyses.* Accordingly, this quantity is of no prognostic importance, but is a good measure of whether the treatment is able to prevent epiphyseal flattening.

In other words, the epiphyseal quotient may be used to single out cases with normally shaped heads in a LCPD series.

Below, "normal range of the epiphyseal quotient" refers simply to the range in *normally shaped heads* – comprising in a series of LCPD all epiphyseal quotients >60, *not* the range in *normal children* in whom the epiphyseal quotients never go below 85. (cf. Appendix, Comment 1)

Now, we have two measures of capital shape after LCPD: The *joint surface quotient* which directly measures the shape of the femoral head, and the *epiphyseal quotient* which directly measures epiphyseal shape, but indirectly may be applied – by using Mose's rule – as a measure of capital shape.

Both measurements have their advantages and disadvantages. One might think that the direct measurement of capital shape, the joint surface quotient, would be preferable, but matters are not so simple. Measurement of the joint surface quotient is rather more complicated than measurement of the epiphyseal quotient – and therefore also carries somewhat greater uncertainty. On the other hand, Mose's rule – epiphyseal quotient exceeding 60 = normally shaped head – is not based upon objective measurement, but upon an estimate; although it seems reliable, it is nevertheless a subjective estimate. However, measurement of the epiphyseal quotient has the advantage of being the method most often used by previous authors – but rarely applying Mose's rule, and this renders the assessment of their results somewhat more difficult.

In fact, it is difficult to decide which measuring method is more reliable. As a rule their results agree, as may be expected. Only, there seems to be a tendency for the difference between the results in two series to be greater measured by the epiphyseal quotient than by the joint surface quotient. (The cause is not quite evident, but the phenomenon is possibly related to the application of an epiphyseal quotient >60 as a normal value, not compensating entirely for the epiphyseal shape varying more than capital shape).

However, the difference between the results of the two methods is slight – but there *are* differences, due to various inaccuracies attaching to the two methods.

Considering the great importance of measuring the shape of the affected head, with a view to the risk of osteoarthritis, I preferred, whenever possible, to use *both* measurements, hoping that they could act as mutual control and thereby perhaps disclose measuring errors and accidental divergences. At least, good agreement between the two measuring methods in dividing the group with spherical heads will increase confidence in the correctness of the results.

The third measurement, that of the *radius quotient*, is the simplest one: The radius of the affected head divided by that of the unaffected head. In a normal material the radius quotient is usually 100, but may sometimes rise to 115.

The main advantage of the radius quotient is that it is influenced by the size of the femoral head – which does not apply to the other two quotients. In return, it is not *directly* influenced by the shape of the head: The head *may* easily change in shape, i.e. alter from a large part of a sphere – as in normal children – to a smaller one, without its radius, and thereby its radius quotient, undergoing the slightest alteration.

It is a different matter altogether that a major change in the shape of the head is usually accompanied by a greater reactive

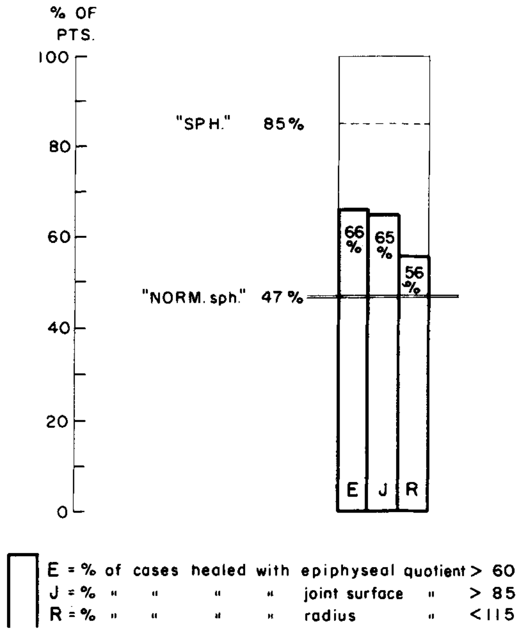


Diagram 1. Example of dividing the "SPH." group into two sub-groups by means of one figure: % "NORM.sph." instead of into 3 x 2 groups by means of 3 figures: one % for each of the 3 quotients.

The patients of the material are imagined to be listed by increasing joint deformity from below and upwards.

"SPH." = Cases healed with "spherical" heads.

"NORM.sph." = Cases healed with "spherical" heads in which all 3 quotients are within the normal range (Ep. quot. >60, Jt. surf. quot. >85, Ra. quot. <115).

(Abbreviations and symbols cf. survey p. 12).

skeletal growth in and around the joint – a greater "increase in growth" – than a minor change in shape.

Therefore, a major change in shape is generally associated with a longer radius: *Indirectly,* then, the radius quotient is influenced by a change in shape.

In practice, assessment by radius quotient is a little stricter than assessment by the other measuring methods – presumably because the radius quotient is affected by any increase in growth, also an increase in growth without any change in shape.

However, measurement of the radius quotient has a drawback which has to be taken into account. It has been a presupposition of the considerations above that the final shape and size of the head could be determined at the time of primary healing, a year or two after completion of treatment. Indeed, this is right in all essentials – but not quite. During the period between primary healing and completion of growth, there occurs some reduction in the difference between the affected and unaffected head, with regard to shape as well as size, mostly the latter: The unaffected head grows relatively more than the affected one during continued growth until puberty. Consequently, the measurements will "improve", especially the radius quotient. This improvement is most marked up to the age of 9 years – and thereafter slight.

Ideally, then, all measurements should not be carried out until after the completion of growth, at the age of 16, possibly after the age of 9, as thereafter the changes are negligible. However, this is difficult to practice in the case of all patients. Therefore, the demand must be confined to aiming at a fairly equal age distribution in the series to be compared, i.e. approximately equally long follow-up periods, somewhat longer in series with the earliest onset of the disease – and the largest possible number of patients over 9 years of age at the time of the measurements.

From what has been stated above it is apparent that in an attempt at grouping the patients with "spherical" heads into the two groups "NORM.sph." and "PATH. sph." by *each* of the three radiological measuring methods, the size of the groups will not be the same:

Measurement of the epiphyseal quotient and of the joint surface quotient affords approximately, but not quite the same result, whereas measurement of the radius quotient gives a somewhat smaller group of "NORM.sph." than the other two.

But the object was to perform *one well-defined grouping* that could be expressed by 1 figure – not 3 groupings expressed by 3 figures, one for each measuring method.

This is practicable only, if it is demanded that the group "NORM.sph." should comprise only patients in whom *all three measuring methods afford results "within the normal range"* (epiphyseal quotient >60, joint surface quotient >85, and radius quotient <115), while the remainder – i.e. all cases in which merely one method gives a result beyond the normal range – are assigned to the group "PATH.sph.".

This affords not only a division into two groups whose size may be expressed in 1 figure, but it also makes the group "NORM.sph." correspond better to the definition: Cases healed with heads of normal shape and size (Fig. 2). The criterion of belonging to the group "NORM. sph." is thereby stricter than when based merely upon the result of one measuring method – and the size of the group consequently smaller (Diagram 1).

The distinction of such a group based upon the result of *three* measuring methods was suggested by Jørgen Lauritzen (thesis 1975) and will be used below in dividing the group "SPH.".

(As to the possibility of grouping by the aid of merely one of the measuring methods, cf. Appendix, Comment 3).

Let us now briefly recapitulate the *terminology* concerning the various groups of patients to be used below, in the text, tables, and diagrams (Diagram 2):

The large group of patients with spherical heads will be called "SPH.". It will be divided into two sub-groups called "NORM.sph." and "PATH.sph.". The third group, with abnormal, irregular heads, will be called "NON-sph.".

This division of the series into 3 groups forms the basis of the following descriptions, but a simple division into two groups may also be desirable. The series might be divided, for instance, into cases with normal heads and cases with abnormal heads. In that case, the groups will be designated simply "NORM." and "PATH." – the former referring to the same group as

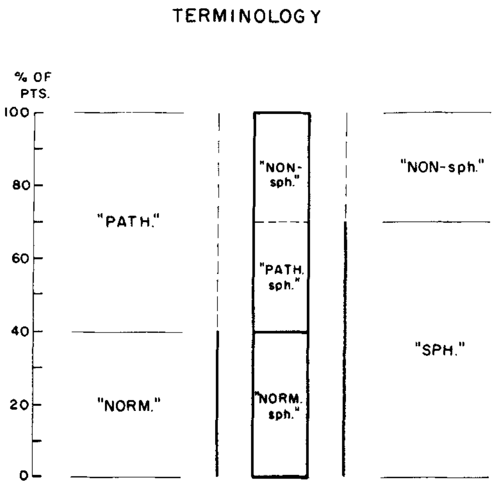


Diagram 2. Terminology in dividing an LCPD series at primary healing on the basis of the radiological shape and size of the affected femoral head.

"NORM." = Cases healed with heads of normal shape and size (= "NORM.sph.", vide infra).

"PATH." = Cases healed with heads of pathological shape and/or size.

"SPH." = Cases healed with "spherical" heads.

"NON.sph." = Cases healed with "non-spherical" heads.

"NORM.sph." = Cases healed with "spherical" heads in which the 3 quotients: Epiphyseal quotient, joint surface quotient, and radius quotient are within the "normal range". (Ep. quot. >60, Jt. surf. quot. >85, Ra. quot. <115).

"PATH.sph." = Cases healed with "spherical" heads in which one or more of the 3 quotients are outside the "normal range".

On the diagram the patients of the material are imagined to be listed by increasing joint deformity from bottom to top.

The grouping of the material was arbitrarily selected. (Abbreviations and symbols cf. the survey p. 12).

"NORM.sph." and the latter combining the groups "PATH.sph." and "NON-sph.". A division into two groups according to whether or not the heads are spherical may also be considered. In that case the former group will be identical with "SPH.", the latter with "NON-sph.". These divisions into two groups are simpler, but whether they are too simple cannot be decided until later.

In assessing his series, Mose used a division into 3 groups according to exactly the same principles. Only, in dividing the group with spherical heads he employed just *one* measuring method: *Epiphyseal quotient.* The three groups of patients which resulted from this division of his series were called "good", "fair", and "poor". Although the following assessment is based upon *three* measuring methods, the terms good, fair, and poor might easily have been transferred to the three groups into which the series were divided also at the present assessment. However, these terms seemed less apt, because *a priori* they included a subjective evaluation. The more objective, descriptive terms "NORM.sph.", "PATH. sph.", and "NON-sph." were, therefore, preferred.

Should it be necessary to refer to the previous "good" and "fair" groups, the new terms will be used below, merely adding a letter to designate the measuring method used, e.g. "NORM.sph." (J) or "PATH.sph." (E).

If it seems expedient to base the grouping upon two measuring methods – omitting e.g. the result of the radius quotient measurement – this is of course also practicable, if only the resulting groups are appended by two letters (J-E).

Diagram 2 gives a survey of the terminology used in the present paper.

A list of abbreviations is given on p. 12.

2. Results in the Series as Referred

As already mentioned, the results obtained in the series as they were referred depend not only upon the treatment, but also upon sex and upon the patients' age and the stage of the disease at institution of treatment.

The results to be reported in this section are due to an interaction of all these factors. As the series very probably differ not only in the treatment received, but also in the other factors, the results tell us nothing about the effect of these treatments under uniform conditions.

In the next section it will be endeavoured to elucidate this – our main problem.

In assessing all therapeutic results below, most emphasis will be laid upon the number of patients with normally spherical femoral heads – the percentage size of the normal group designated "NORM.sph.".

This percentage is considered as a measure of the number of good results obtained by the treatment:

It is only in this group that the shape and size of the head is within the normal range, and therefore the risk of osteoarthritis cannot essentially exceed that of primary osteoarthritis in normal persons. This must be called a satisfactory result, and if this is set up as a reasonable – and well-defined – criterion of the desired result, only the cases of the group "NORM.sph." can be classified as good radiological results.

In patients of the group "PATH.sph.", on the other hand, the shape and size of the head are definitely abnormal and the risk of osteoarthritis accordingly greater than in people with previously healthy hips. Thus, if it is maintained that the risk of osteoarthritis in normals is the criterion of a good result, such a result is not obtained by the patients of the group "PATH.sph.". These patients are bound to develop osteoarthritis of a somewhat greater frequency and severity than would a corresponding group of normal persons.

However, it is possible – and it has been claimed – that in actual fact these cases of osteoarthritis are so few and so mild that in practice it would be justified to call them good clinical results. If so, all cases of the large radiological group "SPH." could be called radiologically satisfactory.

If this were right, it would mean that articular deformities far beyond the normal range would have to be accepted as good radiological results.

A priori, this does not seem likely – Fig. 1 – and is, at least pending further analysis, quite uncertain.

As a preliminary point of view, therefore, only cases of the group "NORM.sph." can be considered satisfactory radiological results.

An essential part of the later clinical sections, then, will be devoted to proving – or disproving – the correctness of this viewpoint, i.e. to investigating whether, and if so to what extent, osteoarthritis develops in the pathologically deformed part of the group "SPH." – i.e. in "PATH.sph.".

Therefore, in the following radiological sections the main emphasis will be on establishing (and depicting) the size of the group "NORM.sph.". Owing to the uncertainty concerning the development of osteoarthritis in "PATH.sph.", however, the size of the entire "SPH." group – and thus also of "PATH.sph." – will be recorded.

The radiological assessment concerned three series treated by three different methods:

1. *113 patients,* viz. all patients treated for unilateral LCPD in the Seaside Hospital, Refsnæs, during the period 1958–1963. The majority, (about 3/4) were treated by bed rest plus traction for one year, followed by bed rest without traction for 6 months + ambulatory non-weight-bearing for another 6 months (for further details of the treatment, cf. Meyer 1966, p. 54). One-quarter of the patients, who were not, or only briefly, treated by traction, had bed rest without traction. This is the "traction series" described by Meyer (1966) supplemented by 42 patients. Below it will be designated the *"traction series".*

2. *114 patients,* viz. *all* patients started on treatment for unilateral LCPD in the Orthopaedic Hospital, Århus, during the period 1957–1964. All had ambulatory treatment in a wheelchair. For details of

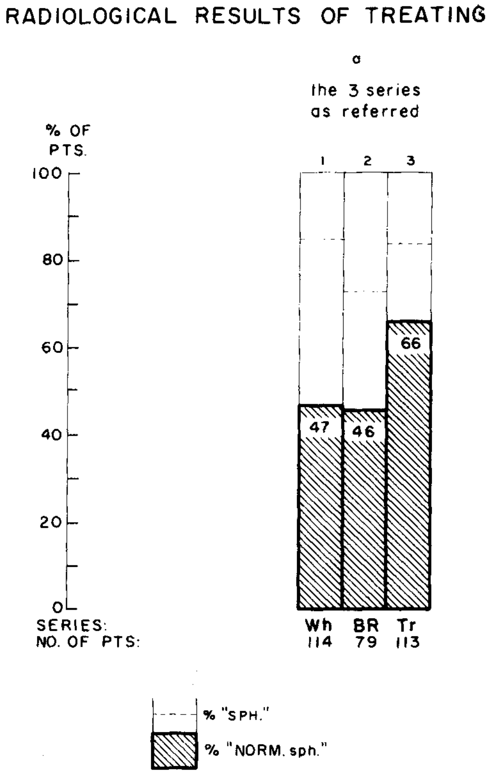


Diagram 3. Radiological results of treating:

a	*1: the Wh series as referred by Wh*	*("SPH.": 85 %)*
	2: the BR series as referred by BR	*(" : 73 %).*
	3: the Tr series as referred by Tr	*(" : 84 %)*

(1, 2, and 3 signify Wh, BR, and Tr treatment).

A total tabulation of the radiological results is given in the Appendix, Table 27.

Statistical calculation

There is a significant difference in the frequency of patients with "normal spherical" heads ("NORM.sph.") between

the Tr series and Wh series as referred (p <0.01) and
the Tr series and BR series as referred (p <0.01)
(cf. also Appendix, Table 28).

(Abbreviations and symbols on p. 12).

this treatment, cf. Lauritzen (1975). This series will be referred to below as the *"wheelchair series"*.

3. *79 patients,* viz. *all* those treated for unilateral LCPD in the Seaside Hospital, Refsnæs, during the period 1953–1957. Treatment: Bed rest without traction in hospital for 18 months, followed by ambulatory non-weight-bearing for 6 months. This series has previously been published by Mose (1964) and Meyer (1966). Below it will be designated the *"bed rest series"*.

The following abbreviations will be used, to save space, on diagrams and tables.

Wh = wheelchair
BR = bed rest without traction
Tr = bed rest with traction.

These abbreviations will be used either alone or in combinations, e.g. Wh series, Tr treatment, etc.

According to the lines described above, each of these series will be divided into three groups of patients: "NORM.sph.", "PATH.sph.", and NON-sph.".

The results are apparent from Diagram 3 and Table 1 (details in the patient lists) and from the Appendix, Tables 22, 23, 24.

Table 1. Radiological results of wheelchair (Wh), bed rest (BR), and traction (Tr) treatment in the three series (as referred). (No. of pts., cf. Appendix, Table 26).

Radiological groups	Wh series 114 pts.	BR series 79 pts.	Tr series 113 pts.
	%	%	%
"NON-sph."	15	27	16
"PATH.sph."	38	27	18
"NORM.sph."	47	46	66

The follow-up periods and patient age at the time of measurement are shown in Table 2.

There might have been better agreement – but it seems acceptable. In practice, it is difficult to attain complete agreement. It proved necessary to carry out new measurements on the traction series three years after the first ones, as at that time the follow-up period had been far too short and patient age too young. The results of this new measurement were in striking conformity with those of the former except for the expected, moderate improvements due to the longer follow-up period.

Table 2. Follow-up period and patient age at the time of measurement in the Wh, BR, and Tr series.

	Follow-up period after institution of treatment (mean)	% of pts. ⩾9 years at time of measurement
Wh series (114 pts.)	5½ years	81 %
BR series (79 pts.)	4½ years	87 %
Tr series (113 pts.)	6 years	92 %

These improvements were of modest, but not inconsiderable extent. Thus, the percentage of "NORM.sph." had increased from 61 % to 66 %.

From Diagram 3 it is evident that the percentage size of the "NORM.sph." group, i.e. the percentage of "good results" in the wheelchair and bed rest series was practically the same, viz. 47 % and 46 %, but appreciably higher in the traction series, 66 %.

Considering the fairly uniform follow-up periods and ages at measurements, these three values ought to be comparable as an expression of the efficacy of the three methods of treatment, i.e. only in the series as referred, without paying regard to possible differences in sex and in age as well as stage of disease at institution of treatment.

From Diagram 3 (and Table 1) it is apparent, incidentally, that the *group "SPH."* ("NORM.sph." + "PATH.sph.") made up 85 %, 73 %, and 84 % of the wheelchair, bed rest, and traction series respectively.

Thus, the percentage of "SPH." was the same in the wheelchair and traction series despite the fact that the percentage of "NORM.sph." was considerably lower in the wheelchair than in the traction series.

This was unexpected in so far as in 1966 Meyer, measuring the epiphyseal quotient in four series, found the percentage of "SPH." to vary in all series by the percentage of "NORM.sph." (E) (Meyer 1966, Diagram 20) – only with smaller differences. This applied also to the joint surface quotient and radius quotient – and there is no reason why it should not apply also to "NORM.sph." calculated on the basis of all three measuring methods. Indeed, Diagram 3 shows that it applies to the bed rest series and the traction series. Only the values for the Wh series were not according to the rule.

It is difficult to elucidate the cause. The values were found in the series as referred – and as they were not of the same prognostic severity, the values are not directly comparable. The apparent disagreement is probably due chiefly to the different nature of the series. However, the mechanism of action of the treatments may be operative. All considered, it does not seem reasonable to ponder too much, at this site, upon the cause of the peculiarity in the wheelchair results. This is better deferred until the next sections which deal with the therapeutic results in comparable groups of patients.

The main results of the analysis in the present section, then, may be briefly summed up as follows:

By the three methods of treatment in the series as referred, about half the patients of the *wheelchair series* and of the *bed rest series* obtained what is called, at least preliminarily, a good radiological result, as they belong to the group "NORM. sph.". In the *traction series* this result was found in about two-thirds of the patients.

Contrary to expectation, the more comprehensive group "SPH." proved to be of the same size in the wheelchair and traction series despite the pronounced difference in "NORM.sph.". However, the groups are of the same size only quantitatively, while qualitatively the group "SPH." in the wheelchair series is appreciably inferior to that in the traction series: It includes a far smaller number of cases that can be classified as "NORM.sph.".

In the bed rest series, the size of the "SPH." group is, as might be expected, smaller than in the traction series – corresponding to the smaller group "NORM. sph." in the bed rest series.

3. Results in Series Differing Only – As Far As Possible – in Therapeutic Methods

The results described in the preceding section express only the efficacy of the treatment in the series as referred – with the differences that may exist with regard to sex, age, and stage of the disease at institution of treatment.

Thus, the results are determined not only by the various methods of treatment, but also by the three factors mentioned above.

However, the main problem of the present study was the relative efficacy of the treatments under *uniform* conditions, i.e. in series varying only with regard to the treatment, not the other factors.

Further elucidation of this problem will be attempted below.

First, the variation of the three factors in the series must be mapped – if they vary at all.

Patients' age at institution of treatment was as shown in Table 3.

Table 3. Age distribution in the Wh, BR, and Tr series. Percentage of patients in the series (for No. of pts. cf. Appendix, Table 26).

Series treated by	Age groups I ⩽4 years	II 5–8 years	III ⩾9 years
	%	%	%
Wheelchair (114 pts.)	32.5	60.5	7
Bed rest without traction (79 pts.)	21	61	18
Traction in bed (113 pts.)	27	55	18

It is apparent that in the wheelchair series the percentage of patients in the youngest group is higher and that of patients in the oldest group lower than in the other two series. The bed rest series is from the prognostic point of view the "heaviest" one, having a lower percentage of patients in the youngest group than the traction series, while in the oldest groups these series showed the same percentage ($2\frac{1}{2}$ times that of the wheelchair series (18 %/7 %).

Somewhat more uncertainty attaches to classification of the series by *stage* of disease at institution of treatment.

A classification into three groups was made, by condition of the epiphysis at institution of treatment:

A: Epiphysis condensed – but without flattening or fragmentation.
B: Epiphysis condensed and flattened, but without fragmentation.
C: Epiphysis distinctly fragmented.

Whether a condensed epiphysis – the first two groups – was flattened even before institution of treatment was determined by measurement.

This measurement was carried out exactly like that of the epiphyseal quotient after completion of the treatment: By measuring epiphyseal height and width. These two measurements afford a numerical expression of epiphyseal flattening.

To avoid confusion with the epiphyseal quotient, measured *after* completion of the treatment, this new quotient, measured at institution of treatment was called, at the suggestion of J. Lauritzen, the *INITIAL QUOTIENT*. Measurements of the epiphyseal quotient in normal persons have shown that without any signs of disease in the epiphysis this quotient may range from 100 down to 85. Therefore, the epiphysis was deemed not flattened at institution of treatment, when the similarly measured initial quotient exceeded 85, whereas an initial quotient below 85 indicated flattening of the affected epiphysis.

As group C, I classified cases in which the epiphysis was so fragmented as not to permit measurement of the initial quotient.

In practice, however, it was soon apparent that group C cases were so few and so difficult to distinguish definitely from group B cases that it seemed reasonable to combine these groups into a larger group B. Below, then, we shall operate with two groups: An *"early" group A* and a *"late" group B*. These groups are distinguished by measurement of the flattening of the condensed epiphysis – a measurement which is adequately well-defined and therefore affords reasonably definite distinction. Group A is of a far more uniform composition than group B, which contains cases in which the epiphysis was merely condensed but flattened as well as cases with severely fragmented epiphyses.

Table 4. Distribution by "early" and "late" treatment in the three series. Percentage of patients in the series. (For No. of pts., cf. Appendix, Table 26).

A: Cases in the stage of condensation without *flattening (initial quot. >85) at institution of treatment.*

B: The remainder – i.e. cases in the stage of condensation with *flattening (initial quot. ≤85) and cases in the stage of fragmentation at institution of treatment.*

Cases of "Dysplasia epiphysialis capitis femoris" without flattening (J.M. 1964) are assigned to group A.

Series treated by	Stage at institution of treatment Early treatment A	 Late treatment B
	%	%
Wheelchair (114 pts.)	65	35
Bed rest without traction (79 pts.)	49	51
Traction in bed (113 pts.)	55	45

Table 4 gives the distribution into groups A and B of the three series.

It will be seen that in the wheelchair series a larger number of patients had early treatment than in the other two series. The largest number of cases having late treatment was found in the bed rest series.

The sex ratio may be seen from Table 5.

The largest number of girls were in the bed rest series, the smallest in the traction series, while the wheelchair series was in

Table 5. Sex ratio in the Wh, BR, and Tr series. Percentage of patients in the series (No. of pts., cf. Appendix, Table 26).

Series treated by	Sex ♂	 ♀
	%	%
Wheelchair (114 pts.)	82	18
Bed rest without traction (79 pts.)	76	24
Traction in bed (113 pts.)	86	14

between. The differences are not inconsiderable, but are no doubt due to chance. However, they seem too marked to be left out of account.

If, after having mapped the variation of the three factors in the series, we can pick out three groups of patients, one from each series, in which all three factors are identical and only the methods of treatment have varied, the results in these groups are determined solely by the efficacy of the treatment. Thereby, it would be possible to gain a clear impression of the relative efficacy of the three methods of treatment in these groups – ridded of the influence of other factors.

Let us first try to obtain three groups of patients in which two factors – *age* and *stage* of disease at institution of treatment – were as uniform as possible.

This may be achieved by combining Tables 3 and 4 in the way that each of the series is divided into six groups:

$$A_I - A_{II} - A_{III} - B_I - B_{II} - B_{III}$$

The first group, A_I – patients under 5 years of age who had early treatment – is then the "lightest" one, i.e. the one in which the best results may be expected. The last group B_{III} comprises the oldest children who had late treatment, and therefore the results must be expected to be poorest. The prognostic severity of the intermediate groups will – broadly speaking – increase from left to right.

Since, however, *age* has most influence upon the results, the results in group A_{III}

Table 6. Composition of the series with regard to patients' age and stage of disease at institution of treatment. (No. of pts., cf. Appendix, Table 26).
Meaning of I, II, III, and A, B, cf. Tables 3 and 4.
% = % of all pts. in the series.

Series treated by	Age/stage groups A I	A II	A III	B I	B II	B III
	%	%	%	%	%	%
Wheelchair (114 pts.)	21	40	4	11	20	4
Bed rest without traction (79 pts.)	6	30	12	16	30	6
Traction in bed (113 pts.)	12	29	14	15	26	4

are often inferior to those in groups B_I and B_{II}. If the sequence is to correspond to the increasing severity, group A_{III} ought to be moved between groups B_{II} and B_{III}. This will be done when such a sequence is desired.

The result of the classification is presented in Table 6.

It shows that the "lighter" nature of the *wheelchair series* is even more apparent in this combination of Tables 3 and 4.

A look at the number of patients in each group shows that it is regrettably small. Group A_{II} is the largest one, and the only single group which is perhaps sufficiently large to permit an attempt at determining the relative efficacy of the treatments in the three series. In another way too A_{II} must be presumed to be suited. In the very mild cases the nature of treatment is presumably of less importance to the results: Practically all will be good, no matter what the treatment. About the same applies to the most severe cases: All results are more or less poor, regardless of the treatment. Group A_{II} belongs to the intermediate groups in which the efficacy of the treatments will probably manifest itself more clearly.

However, the *sex ratio* in the groups is not the same:

The percentage of girls in the A_{II} groups of the Wh, BR, and Tr series is 13 %, 21 %, and 18 % respectively. The difference between these percentages is not inconsiderable (but no doubt due entirely to chance). Since, however, the difference in therapeutic results in girls and boys is slight, the difference in the sex ratio within the three series is not likely, in spite of all, to have any major influence upon the results. But it is necessary first to make sure that this assumption is correct.

The only way in which we can avoid an effect of a difference in sex ratio is by performing all analyses *only on the boys,* who make up about 4/5 of all the series. Therefore, such analyses will be carried out to check whether the result of analysing the groups with both sexes have afforded sufficiently reliable information about the

Table 7. Results of treatment in age/stage groups in the Tr, Wh, and BR series as referred. (No. of pts., cf. Table 24, Appendix, Table 26).
% = % "NORM.sph." in the groups.

Series treated by	Age/stage groups A I	A II	A III	B I	B II	B III
	%	%	%	%	%	%
Wheelchair (114 pts.)	79	48	0	46	30	0
Bed rest without traction (79 pts.)	80	54	30	58	29	(50)
Traction in bed (113 pts.)	100	85	27	76	52	20

relative efficacy of the three therapeutic methods – or whether a correction for the slight sex difference is needed.

In other words, the main study will be on the undivided groups and series, comprising both sexes. Analysis of the boys alone was only done as a supplement.

The results obtained in the 6 groups into which the three "mixed" series were divided may be seen from Table 7 – or perhaps more clearly from Diagram 4 (only for the Wh og Tr series).

From the table as well as the diagram it is apparent that largely the results get poorer the older the patients are and the later they arrive for treatment. This applies also when analysing separately the rela-

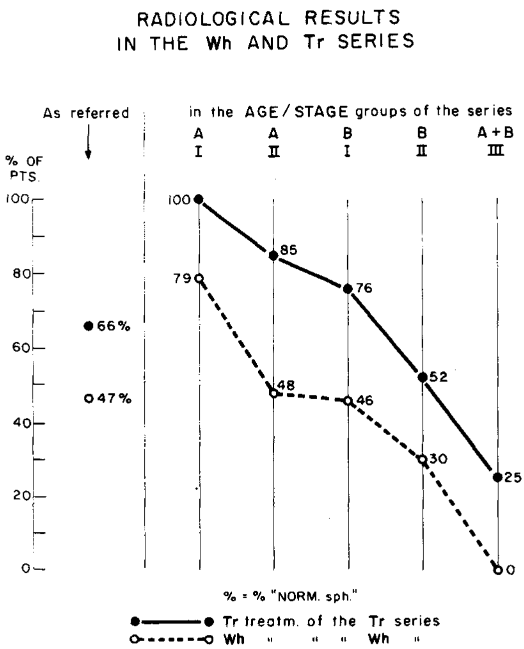


Diagram 4. Radiological results in the Wh and Tr series as referred and in the age/stage groups of these series.

As the results in the oldest age group (III) are poor regardless of stage, the groups A III and B III (which are very small) were combined into one (A III + B III). This affords a larger number of patients as well as a sequence of the groups, from left to right, according to decreasing results.

(Abbreviations and symbols as listed p. 12.
% given in number of pts. in the Appendix, Table 26).

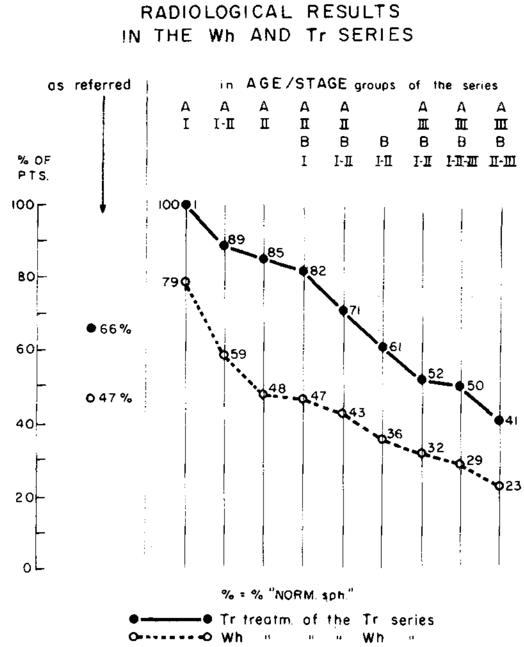


Diagram 5. Radiological results in the Wh and Tr series as referred as well as in age/stage groups of these series, of increasing severity from left to right.

The age/stage groups in this diagram are combined groups having a larger number of patients and a more even transition from the mildest to the most severe group than the 6 simple groups on Diagram 4. However, the combined groups in both series are less comparable than the 6 simple ones.

(Abbreviations and symbols as listed p. 12.
% given in number of pts. in the Appendix, Table 26).

tionship of the course to age and stage. There are few exceptions to this rule. It is evident also that the difference between the results of the three treatments – especially between Tr and the other two – is most marked in the intermediate groups (A_{II} and B_{I}), less in the "milder" and very "severe" cases. This is even more distinct in Diagram 5 in which the 6 groups are combined, in various ways, into 9, so that the transition from the mildest to the most severe group is more even and the number of patients in each group larger. However, these combined groups are appreciably less uniform and comparable than the 6 main groups.

Out of these six groups A_{II} is best suited to our purpose: To determine the results of

RADIOLOGICAL RESULTS OF TREATING

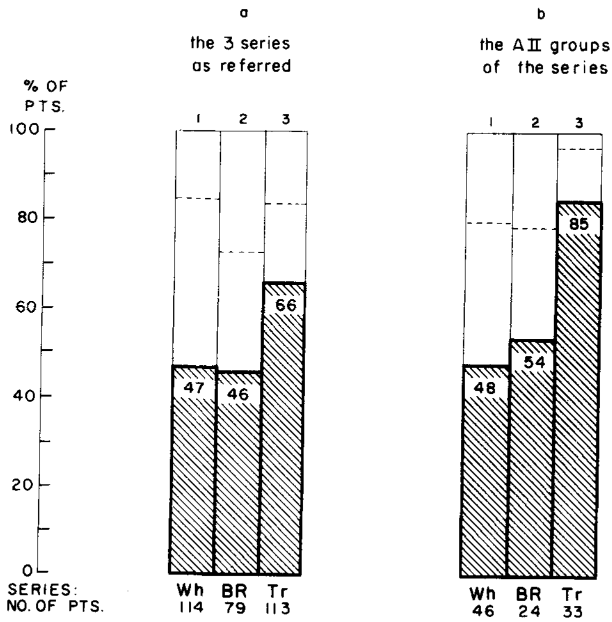
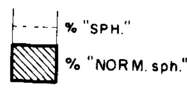


Diagram 6. Radiological results of treating:

a	*1: the Wh series as referred by Wh*	*("SPH.": 85 %)*	
	2: the BR series as referred by BR	*(" : 73 %)*	
	3: the Tr series as referred by Tr	*(" : 84 %)*	
b	*1: the A II group of the Wh series by Wh*	*("SPH.": 80 %)*	
	2: the A II group of the BR series by BR	*(" : 79 %)*	
	3: the A II group of the Tr series by Tr	*(" : 97 %)*	



A total tabulation of the radiological results is given in the Appendix, Table 27. (Abbreviations and symbols p. 12).

Statistical calculation *(cf. also Appendix, Table 28).*
Re results in the series as referred cf. Diagram 3.
Re results in the A II groups of the series:
There is a significant difference in the frequency of pts. with "normally spherical" heads ("NORM.sph.") between
the A II groups of the Tr series and Wh series ($p < 0.01$) and
the A II groups of the Tr series and BR series ($p < 0.05$).

the three methods of treatment in uniform groups of patients.

The result of such an analysis is presented in Diagrams 6–7.

From Diagram 6 it may be seen that the differences between the results of the three treatments are more pronounced in the A_{II} groups (uniform with regard to age and stage) than in the total series of a more heterogeneous composition.

By *wheelchair* and *traction* treatment 47 % and 66 % "good" results, i.e. "NORM.sph.", were obtained in the total series – in the more uniform A_{II} groups 48 % and 85 % respectively. By *wheelchair* and *bed rest* 47 % and 46 % "NORM.sph." were obtained in the total series – in the A_{II} groups 48 % and 54 % respectively.

These appreciably increased differences in the A_{II} groups are explicable as follows (perhaps best illustrated in Diagram 7):

The results in the *traction* and *bed rest* series improve on transition from total series to groups A_{II}, because removal of the heavy part of these severe series (groups A_{III} and $B_{I-II-III}$) has more effect than removal of the small, mild A_{I} groups. In the *wheelchair series,* on the other hand, the removal of the heavy end of the series counterbalances the removal of the numerically larger mild group A_{I} in the way that the result in group A_{II} of the wheelchair series is largely identical with that in the total series.

Thus, the more marked differences in therapeutic results between the more uniform A_{II} groups ought to afford a more reliable picture of the relative efficacy of the therapeutic methods than do the less marked differences in the total series as referred, which are not uniform with regard to severity. (Statistical calculation cf. legend to Diagrams 3 and 6).

RADIOLOGICAL RESULTS OF TREATING

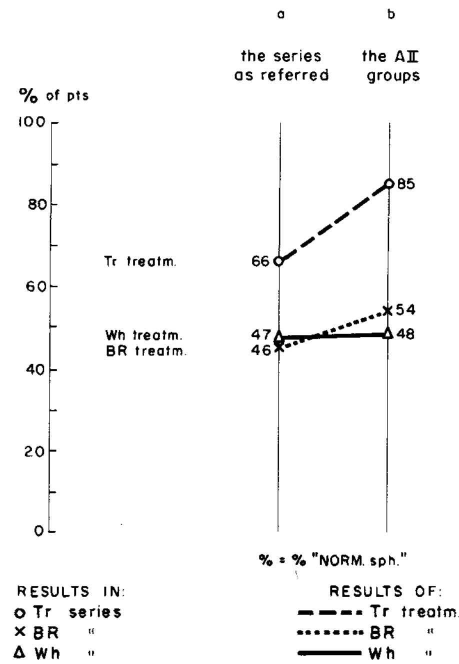


Diagram 7. Radiological results of treating the Wh, BR, and Tr series as referred (a) and their A II groups (b).

Diagram 6 in a more perspicuous form (only "NORM. sph.").

The 3 small symbols on the vertical lines signify the results in the 3 series as referred and in their A II groups.

The oblique lines between the vertical lines connect the results of the same form of treatment.

(No. of pts. and % of "SPH.", cf. Diagram 6 and the Appendix, Table 27. Abbreviations and symbols on p. 12).

However, the A_{II} grups have two essential defects: In the first place they are too *small,* comprising only 46, 24, and 33 patients respectively. Therefore, chance may influence the results. However, it must be mentioned that the shape of the curves in Diagram 4, without any inexplicable kinks, does not indicate that they are characterized by chance. In the second place, the *sex ratio* is not the same, as already mentioned, there being rather more girls in the A_{II} group of the traction and bed rest series than in the wheelchair series.

But both defects can be remedied.

The uncertainty attaching to the small number of patients in the A_{II} groups may be reduced, if we do not restrict the analyses to utilizing only the results in the A_{II} groups, but include the results in *all* groups. Basing the analysis on a larger number of patients and patient groups ought to increase the statistical reliability.

This may be practised as follows:

Among the 114 patients of the wheelchair series 47 % good results (% "NORM. sph.") were obtained – by wheelchair treatment. The material was then divided into six groups, so that the patients within each group were uniform with respect to age/stage at institution of treatment. The 113 patients of the traction series were divided into corresponding groups, each comprising cases of as far as possible exactly the same severity at admission as the corresponding groups of the wheelchair series. Thus, *one* treatment ought to afford the same result in two corresponding groups. In other words: *If* e.g. group A_{II} of the wheelchair series *had been treated by traction,* it would have shown the same result as the A_{II} group of the traction series.

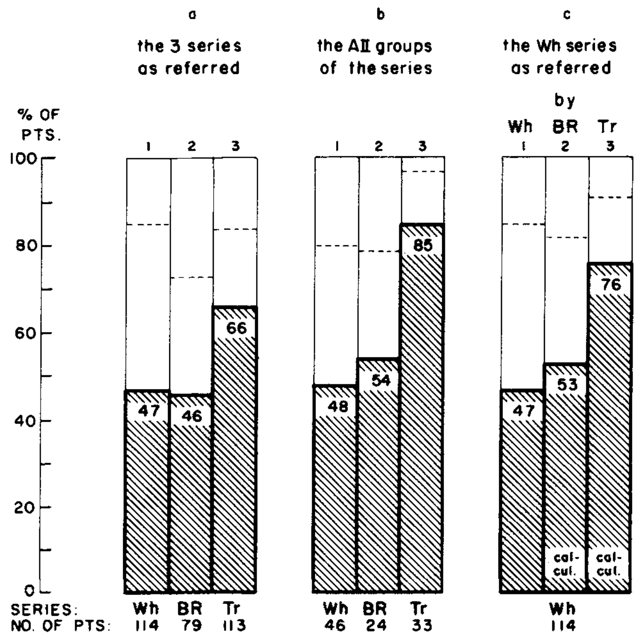


Diagram 8. Radiological results of treating:

a	*1: the Wh series as referred by Wh*	*("SPH.": 85 %)*
	2: the BR series as referred by BR	*(" : 73 %)*
	3: the Tr series as referred by Tr	*(" : 84 %)*
b	*1: the A II group of the Wh series by Wh*	*("SPH.": 80 %)*
	2: the A II group of the BR series by BR	*(" : 79 %)*
	3: the A II group of the Tr series by Tr	*(" : 97 %)*
c	*1: the Wh series as referred by Wh*	*("SPH.": 85 %)*
	2: the Wh series as referred by BR (calculated)	*(" : 82 %)*
	3: the Wh series as referred by Tr (calculated)	*(" : 91 %)*

(A total tabulation of the radiological results in the Appendix, Table 27. Abbreviations and symbols p. 12).

In c the "Wh series as referred" could be replaced with "3 identical series composed like the Wh series" (with regard to patients' age and stage of disease at institution of treatment).

Thus, the results in a have been obtained by Wh, BR, and Tr treatment of 3 series which were, in respect to pts.' age and stage of disease at institution of treatment, very different – heterogeneous. The results in b have been obtained by treating groups of patients (A II groups) almost uniform in these respects, those in c by treating 3 entirely identical series, composed like the Wh series.

If now, we transfer the percentage results from *all* six groups of the *traction* series to the corresponding patient groups in the *wheelchair* series, it is possible to find the number of patients in each of the six groups of *the wheelchair series* who would have obtained a "good" result, i.e. a "normal spherical" head, by traction. By addition, this number may be found for the total wheelchair series – and thereby the percentage of "NORM.sph." that would have been obtained, *if the total wheelchair series had been treated by traction.* In the same way it is possible, of course, to calculate the result that would have been obtained by bed rest treatment of the wheelchair series.

Hereby, we have ascertained how one series of a given composition and of considerable size, like the wheelchair series,

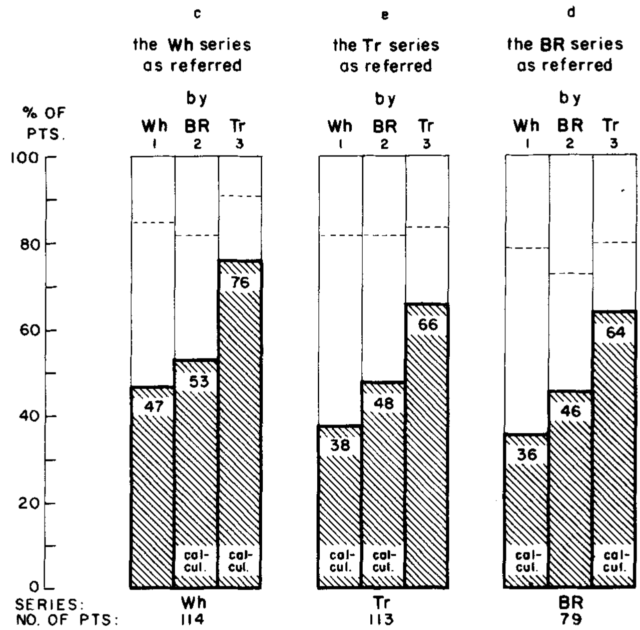
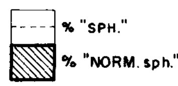


Diagram 9. Radiological results of treating:

c	*1: the Wh series as referred by Wh*	*("SPH.": 85 %)*
	2: the Wh series as referred by BR (calculated)	*(„ : 82 %)*
	3: the Wh series as referred by Tr (calculated)	*(„ : 91 %)*
e	*1: the Tr series as referred by Wh (calculated)*	*("SPH.": 82 %)*
	2: the Tr series as referred by BR (calculated)	*(„ : 82 %)*
	3: the Tr series as referred by Tr	*(„ : 84 %)*
d	*1: the BR series as referred by Wh (calculated)*	*("SPH.": 79 %)*
	2: the BR series as referred by BR	*(„ : 73 %)*
	3: the BR series as referred by Tr (calculated)	*(„ : 80 %)*



(A total tabulation of the radiological results is given in the Appendix, Table 27. Re group c, cf. legend of Diagram 8. Abbreviations and symbols on p. 12).

will respond to *three different treatments.* In other words, the three results are comparable, expressing the different efficacy of the three therapeutic methods in *one* series – or, if you will, in *three* identical series – of a composition like the wheelchair series.

Of course, it may be calculated, in the same way, what the three treatments could have effected *in the traction series* and *in the bed rest series.*

Diagrams 8–9–10 set out the results of these calculations (showing for comparison the results in the series as referred and their A_{II} groups).

It is evident that the results of the three methods of treatment in the wheelchair series do not differ essentially from those in the A_{II} groups (Diagram 8). Only, the difference between the results of traction and wheelchair treatment are somewhat less marked than in the A_{II} groups, simply because the differences in the "light" and "heavy" groups, now included, are less than in the A_{II} groups (Diagram 4) and therefore reduce the difference in the total wheelchair series. On the other hand, the difference between the results of *bed rest* and *wheelchair* treatment are not inferior

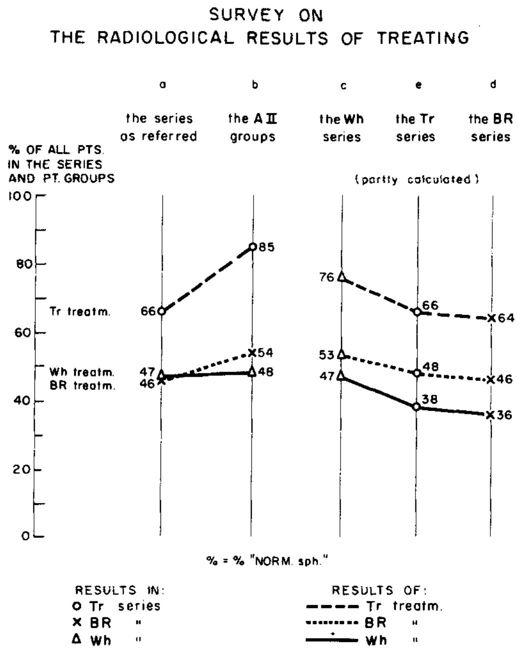


Diagram 10. Survey of the radiological results set out in Diagrams 8 and 9 (but excluding % "SPH.").

On this survey diagram each set of 3 columns from Diagrams 8 and 9 is replaced with a more simple symbol: a vertical line.

The 3 small symbols on the vertical lines signify the results in the 3 series as referred and their A II groups.

The oblique lines between the vertical ones connect the results of the same form of treatment.

(A total tabulation of the radiological results is given in the Appendix, Table 27. Abbreviations and symbols on p. 12).

to those in the A_{II} groups. Calculation of the differences in the traction and bed rest series even shows them to be somewhat greater (Diagrams 9–10), because the differences between the results in the other groups with bed rest and wheelchair treatment were *not* less than those in the A_{II} group. On the contrary, the difference is most marked in group B_I (Table 7).

Thus, the results of the three methods of treatment in the *wheelchair* series did not differ essentially from the results in the A_{II} groups. When calculated for the *traction* and *bed rest* series, on the other hand, the results of the three methods of treatment are on the whole somewhat inferior to those in the wheelchair series, simply because these are heavier series – the bed rest series most severe (Diagrams 9–10). However, as in the wheelchair series, the relative values of the results correspond quite well to those found in groups A_{II}.

In other words: The deviations from the results in the A_{II} groups found by including the results in all groups in the analysis are fully explained by the difference between the A_{II} groups and the total series.

The result of the calculations, then, has given no reason to believe that the results in the A_{II} groups are characterized by chance because of too small numbers of patients. According to the finding, the results in *the* A_{II} *groups afford* a reliable impression of the effect of the three treatments as to the radiological result in a group of medium severity.

It now remains to be seen whether the other source of uncertainty in analysing the results in the A_{II} groups – the heterogeneous sex ratio in the groups – has appreciably affected the results.

This uncertainty naturally applies to all results in groups and series comprising both sexes (mixed). Therefore, the study was carried out in the way that all analyses and calculations in such mixed series were performed *on boys only*. Thereafter, the results were compared with those in mixed groups.

As the therapeutic results are somewhat more favourable in boys than in girls, a study on boys alone would be expected to show rather better therapeutic results – and perhaps altered differences in results between the three treatments.

Diagrams 11, 12, and 13 as well as Tables 8 and 9 show that in all essentials they did.

But the percentage of "NORM.sph." for boys alone in the wheelchair series is nevertheless not essentially better than in the corresponding mixed groups of patients. This is because in the wheelchair series the results were equally good for girls and for boys. In the traction and bed rest

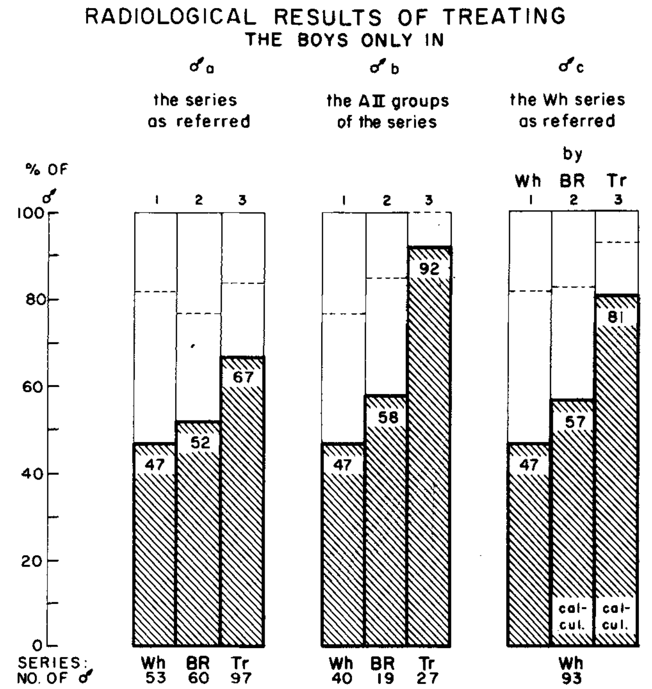
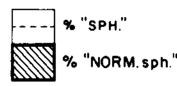


Diagram 11. Radiological results of treating the BOYS alone in

♂a	1: *the Wh series as referred by Wh*	*("SPH.": 82 %)*	
	2: *the BR series as referred by BR*	*(„ : 77 %)*	
	3: *the Tr series as referred by Tr*	*(„ : 84 %)*	
♂b	1: *the A II group of the Wh series by Wh*	*("SPH.": 77 %)*	
	2: *the A II group of the BR series by BR*	*(„ : 85 %)*	
	3: *the A II group of the Tr series by Tr*	*(„ :100 %)*	
♂c	1: *the Wh series as referred by WH*	*("SPH.": 82 %)*	
	2: *the Wh series as referred by BR (calculated)*	*(„ : 83 %)*	
	3: *the Wh series as referred by Tr (calculated)*	*(„ : 93 %)*	



(1, 2, and 3 signify Wh, BR, and Tr treatment respectively).

For comparison, Diagram 8 shows the results of treating GIRLS + BOYS in the corresponding mixed series and groups of patients.

(A total tabulation of the radiological results is given in the Appendix, Table 27. Abbreviations and symbols on p. 12).

Statistical calculations *concerning the results of treating BOYS only:*

There was a significant difference in the frequency of patients with "normally spherical" heads ("NORM.sph.") between

the ♂A II groups of the Tr series and Wh series ($p < 0.001$) and

the ♂A II groups of the Tr series and BR series ($p < 0.02$).

Moreover, there was a significant difference in the frequency of pts. with "spherical" heads ("SPH.") between the ♂A II groups of the Tr series and the Wh series ($p < 0.05$).

series, on the other hand, the results were poorer for girls than for boys, so that the results were improved by omitting the girls.

Thus, the boys' A_{II} groups are uniform, with regard to age and stage at institution of treatment as well as sex – the factors, apart from the treatment, which determine the results.

More uniform groups of patients cannot be set up.

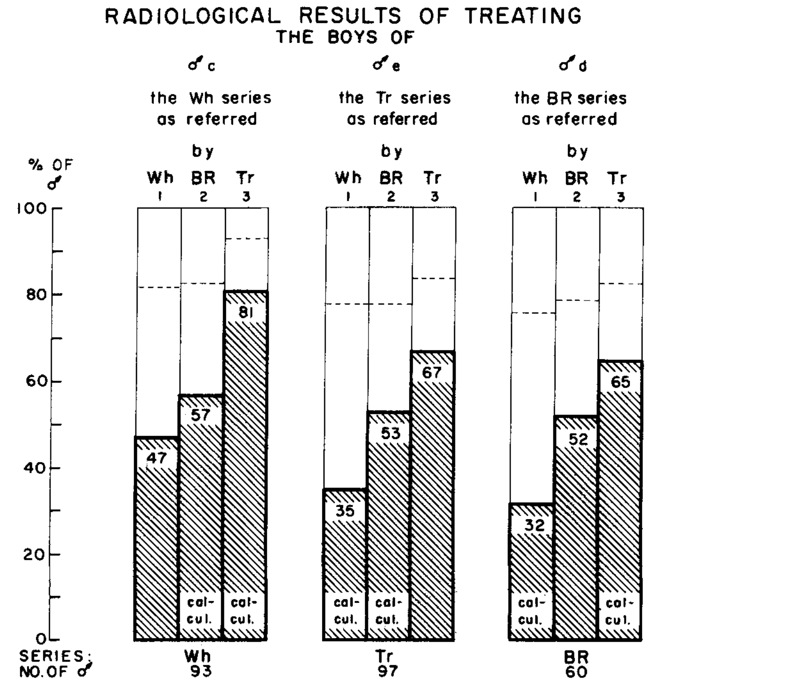


Diagram 12. Radiological results of treating the BOYS of

♂c	*1: the Wh series as referred by Wh*		*("SPH.": 82 %)*
	2: the Wh series as referred by BR	*(calculated)*	*(" : 83 %)*
	3: the Wh series as referred by Tr	*(calculated)*	*(" : 93 %)*
♂e	*1: the Tr series as referred by Wh*	*(calculated)*	*("SPH.": 78 %)*
	2: the Tr series as referred by BR	*(calculated)*	*(" : 78 %)*
	3: the Tr series as referred by Tr		*(" : 84 %)*
♂d	*1: the BR series as referred by Wh*	*(calculated)*	*("SPH.": 76 %)*
	2: the BR series as referred by BR		*(" : 77 %)*
	3: the BR series as referred by Tr	*(calculated)*	*(" : 83 %)*

The results of treating GIRLS + BOYS in the mixed series were given in Diagram 9.

(A total tabulation of the radiological results: Appendix, Table 27. Abbreviations and symbols, cf. survey p. 12).

Therefore, the results in these groups ought to afford the *most reliable impression of the relative efficacy of the three methods of treatment* in these special groups of boys – more reliable than the results in the less uniform mixed A_{II} groups.

Wheelchair, bed rest, and traction treatment in the *A_{II} groups of boys* gave *47 %, 58 %, and 92 %* "NORM.sph." respectively. The differences are somewhat more pronounced than in the *mixed A_{II} groups (48 %, 54 %, and 85 %).* The natural explanation is that the girls make up the "heavy" end of the mixed groups and therefore dampen the differences in the therapeutic results. It should be mentioned that in these optimally comparable groups the changes in the "SPH." percentage follow those in the "NORM.sph.", from the traction series through the bed rest series, to the wheelchair series; only, the fluctuations are less marked (Diagram 11) (cf. also p. 23).

The results of the three treatments of the boys in each of the three total series – wheelchair, bed rest, and traction series – bore exactly the same relationship to the results in the boys' A_{II} groups as did the corresponding results in the mixed total series to the results in the mixed A_{II} groups (Diagram 13). (For statistical calculation concerning the results in boys only, cf. legend to Diagram 11 and survey in the Appendix, Table 28).

Now, it has been attempted to control the drawbacks which indubitably attach to the *mixed* A_{II} groups – the small number of patients and the varying sex ratio – and which have distorted the results found in these groups: In part it has been attempted to base the analyses on a larger number of patients – all *patients in the total series* – and in part the studies have been carried out *solely on boys.*

True, the results have shown divergences from those found in the mixed A_{II} groups, but in all essentials such divergences have been explicable as a consequence of the different nature of the various patient groups – more "mild" and "severe" cases in the total series, the milder disease in the boys as compared with the girls.

It may, therefore, be rightly concluded that the results in the mixed A_{II} groups afford, by and large, a reliable impression of the relative efficacy of the three therapeutic methods in these groups of patients:

Wheelchair, bed rest, and traction give: 48 %, 54 %, and 85 % "NORM.sph." respectively.

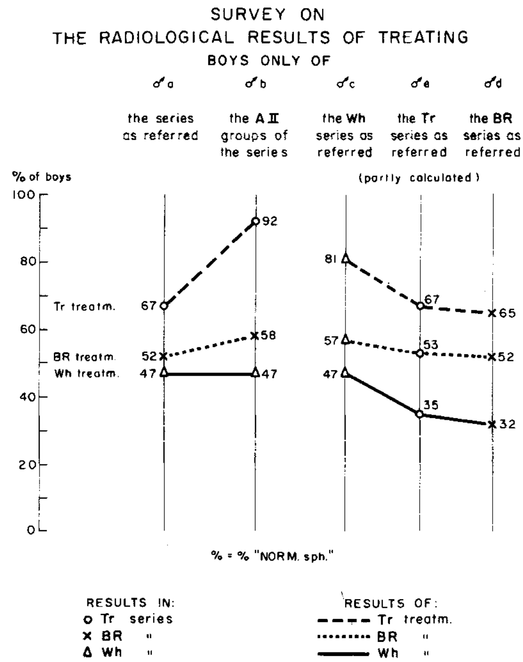


Diagram 13. Survey on all radiological results of treating BOYS set out in Diagram 11 (♂a, ♂b, ♂c) and Diagram 12 (♂c, ♂e, ♂d) (excluding % "SPH.").

On this survey diagram each set of columns from the two diagrams has been replaced with a more simple symbol: a vertical line.

The 3 small symbols on the vertical lines signify the results in the boys of the 3 series as referred and in their ♂A II groups.

The oblique lines between the vertical ones connect the results of the same form of treatment.

For comparison, Diagram 10 gave the corresponding results of treating GIRLS + BOYS, i.e. the results in the mixed series and groups.

(A total tabulation of the radiological results is given in the Appendix, Table 27. Abbreviations and symbols p. 12).

Table 8. Size of the age/stage groups at institution of treatment. The BOYS of the three series. (No. of boys, cf. Appendix, Table 26).
% = % of all boys in the series.

Boys	Age/stage groups					
Series treated by	A I	A II	A III	B I	B II	B III
	%	%	%	%	%	%
Wheelchair (93 pts.)	23	43	4	11	17	2
Bed rest without traction (60 pts.)	5	32	13	17	27	7
Traction in bed (97 pts.)	12	28	14	14	26	5

The fact that the differences observed in the relative efficacy of the treatments is naturally explained by the different nature of the patient groups must strengthen confidence in the present results. It demonstrates also that statements concerning efficacy must be accompanied by information as to *which* series they apply. For instance, it must be pointed out that in the mixed A_{II} groups the efficacy values apply only to these rather special groups and that the theoretically more reliable values in the boys' A_{II} groups – 47 %, 58 %, and 92 % "NORM.sph." after wheelchair, bed rest, and traction respectively – apply only in these even more special groups.

Therefore, most interest attaches to the relative efficacy of the three therapeutic methods in each of the three mixed total series – as referred. It is in series like these that the treatments should stand their test, and accordingly the results in such series are of direct practical significance:

In orthopaedic departments in this country the cases of LCPD referred will be of approximately the same nature with regard to age and stage at institution of treatment as the three series of the present study – in some departments milder like the wheelchair series, in others more severe like the bed rest series.

If, in such a department the clientele is known – and it is not likely to change in nature in the near future – it may be predicted, after studying Diagrams 9–10, which results can be obtained by traction and which results are obtainable by wheelchair or by bed rest treatment.

Briefly:

If the material referred is of the same nature as the present wheelchair series, *wheelchair* or *bed rest* therapy will afford about 50 % "good" results ("NORM. sph."), *traction* about 75 %.

If the materials are of a somewhat heavier nature – like the bed rest or traction series – the results will be somewhat less favourable, but their relative size will be the same.

The concrete values for the three efficacies in the wheelchair series are

47 %, 54 %, and 76 % "NORM.sph."

on wheelchair, bed rest, and traction treatment respectively.

These values – and the corresponding results in the bed rest and traction series – are the most perspicuous and in practice the most important result of the studies in the preceding radiological sections.

With respect to group "SPH." it may be added:

The size of this group is recorded on all diagrams simultaneously with that of "NORM.sph." with a view to the possibility of reducing the demands on a good radiological result, using "SPH." instead of "NORM.sph." as a criterion of the percentage of good results.

In the mixed series of different severity, as referred, the differences in the results, in terms of the percentage of "SPH." were not marked; in the wheel chair and traction series the results were the same. The analyses in the present chapter on more uniform groups of patients, on the other

Table 9. Results of treatment of age/stage groups in the BOYS of the wheelchair, bed rest, and traction series. (For No. of pts. in the groups, cf. Appendix, Table 26).
% = % "NORM.sph." in the groups.

Boys	Age/stage groups					
Series treated by	A I	A II	A III	B I	B II	B III
	%	%	%	%	%	%
Wheelchair (93 pts.)	81	47.5	0	40	25	0
Bed rest without traction (60 pts.)	67	58	37.5	70	37.5	50
Traction in bed (97 pts.)	100	92	21	71	56	20

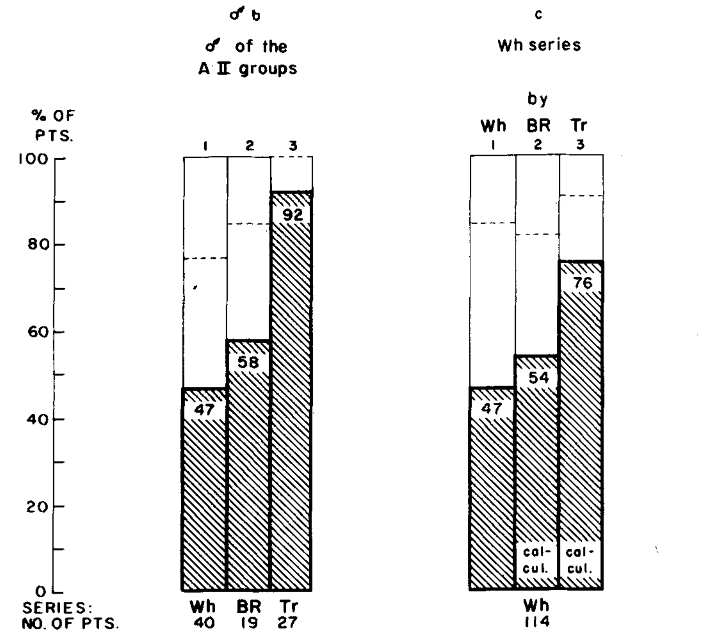


Diagram 14. Radiological results of Wh, BR, and Tr treatment in:

♂b The prognostically most uniform groups of patients in the 3 series: the ♂A II groups. (Results found – statistical assessment, cf. Diagram 11).

c One series – or 3 identical ones – composed like the Wh series. (Results of BR and Tr treatment calculated).

These two diagrams afford the simplest impression of the relative efficacy of the 3 methods of treatment. (A total tabulation of the radiological results is given in the Appendix, Table 27).

hand, disclosed that the "SPH." percentage was considerably higher with traction than with wheelchair and bed rest treatment: With the use of the *three therapeutic methods* in *one* series, composed like the *wheelchair* series, the differences were least marked in the total series, viz. 85 %, 82 %, and 91 % on wheelchair, bed rest, and traction respectively. Somewhat greater differences were found on treatment of only the boys of the wheelchair series (82 %, 83 %, 93 %) and the most marked differences on treatment of the *boys'* A_{II} group:

77 %, 84 %, 100 % "SPH."

In the last group, the percentage of "SPH." after traction (100 %) was then 30 % higher than after wheelchair treatment (77 %) – a difference which is statistically significant ($P < 0.05$).

All considered, however, the difference between the results as measured by "SPH." is smaller than that measured by "NORM. sph.".

This is not surprising.

If we reduce the demands on a good result to such an extent that they are fulfilled by the majority, possibly all patients of the three series, the differences between the results will be slight, possibly 0. The same applies, of course, if stricter demands are made on a good result, so that only a few, perhaps no patients can fulfill them. In that case too the difference between the results will be slight, possibly 0.

But if we use a criterion which entails a borderline between satisfactory and unsatisfactory results in the middle of the series – as when using the criterion "NORM.sph." – differences, if any, between the results obtained will be most clearly apparent.

However, a criterion of a satisfactory radiological result is not set up for the purpose of demonstrating the greatest possible difference between the results obtained, but exclusively with a view to ascertaining whether the *clinical result* corresponding to the radiological criterion is considered satisfactory. Above, the radiological criterion "NORM.sph." has been maintained as the one which most dependably leads to a satisfactory clinical result. In the following clinical sections it will be discussed whether this is too strict and whether the group "SPH." in fact comprises only patients having in practice a good and satisfactory clinical prognosis. However, this does not seem likely, considering the appreciable articular deformities in the group (Fig. 1).

When using the most reliable radiological criterion of a satisfactory clinical result – the percentage of "NORM.sph." – the main result of the radiological sections is (highly simplified):

In groups of patients selected from the three series as having the most uniform prognosis, treatment by traction afforded about 80–90 % satisfactory results, bed rest and wheelchair treatment about 50–60 % – according to the nature of the uniform groups.

In a series of a composition like e.g. the wheelchair series it may be predicted that traction will afford about 75 %, bed rest and wheelchair treatment about 50 % satisfactory results.

A collected survey of all the radiological results is given in the Appendix Table 27.

The group "NORM.sph." was singled out from the series by means of three quotients, determined by three measuring methods. Therefore, the assessment may be called a "3-quotient assessment". As to the possibilities of using a simpler "1-quotient assessment", based solely upon one measuring method, cf. Appendix, Comment 2.

B. CLINICAL CONSEQUENCES OF THE RADIOLOGICAL RESULTS

Introduction

The analyses in the present section are based mainly upon reports in the literature – in particular those dealing with follow-up studies of LCPD series and the development of secondary osteoarthritis in general.

Unfortunately, the data given in such reports are often incomplete and partly irrelevant with regard to the present problems. And – even worse – percentages and other values carry considerable uncertainty. They are seldom based upon precise definitions, and the substantiation may leave much to be desired.

Therefore, the entire present section is interpretable only as *an experiment* – an attempt at giving a picture of the development of secondary osteoarthritis on the basis of the available reports.

(Should the result be unsatisfactory, the analyses will at least demonstrate which shortcomings are responsible).

1. Follow-up Findings of Osteoarthritis in LCPD Series

In analysing the late sequelae to LCPD, the first thing to be done is to trace the studies having the longest follow-up period. I succeeded in finding only *5 reports* on follow-up studies conducted 25 years or longer after the institution of treatment – and in some cases the onset of the disease (Appendix, Charts 1–2, *age group III*, Nos. 1–5).

The follow-up period on these cases may seem long – averaging 30–35 years – but nevertheless the patients' mean age at follow-up has been only about 40 years. The dispersion is moderate: About two-thirds of the patients have usually been 40 years ± 5 – or possibly ± 7 years in series referred during an unusually long period (Danielsson & Hernborg). Thus, it is no great error saying – for the sake of brevity – that in these series patient age was around 40.

This mean age is unfortunately not as advanced as might be desired. So-called *primary* osteoarthritis in persons with no previous disease of the hips, usually manifests itself by the first symptoms at the age 50–70, rarely before 50, at an average age of about 55–60 (Danielsson 1964: 55 years). Strangely enough, it is usually stated that secondary osteoarthritis – often a sequel to *congenital* articular disease – indeed seems to manifest itself somewhat earlier than the primary type, but rarely more than 5–10 years earlier, i.e. at a mean *age of 45–50.*

It is extremely unfortunate, therefore, that the mean age of the patients followed longest has been only about 40. In four of the five materials listed only 7–8 patients were over 50 (30 in all). In Ratliff's material (5) the oldest patient was 52.

On the other hand, there have been many follow-up studies with a shorter follow-up period, a *mean patient age of only 20–25.* Seven of these studies are included in the present analysis, because they afford data suited for elucidating the development during the years between primary healing and the age of about 40 (Appendix, Charts 1–2, *age group II,* Nos. 6–12).

The state at *primary healing* is elucidated by the three series of the present study, Mose's series that received ambulatory treatment, and another three series from the literature (Charts 1–2, *age group I,* Nos. 13–19). This group includes only series in which the radiological deformity was determined *by measurements* on the X-ray films.

Thus, the entire analysis comprises 19 series. (Numbers and abbreviated names of authors, as listed in the Appendix, Chart 1, will be used below when expedient).

The object of analysing these 19 series is, in brief, to establish the relationship between the radiological joint deformity that the disease has left and the subsequent secondary osteoarthritis – its radiological signs as well as the clinical symptoms.

But if general conclusions are to be drawn from the analysis of so many series, it is a presupposition that the *primary radiological deformities* of the joint can be described according to the same principles in the different materials, i.e. so that the results are comparable.

To this end, it is essential to determine as far as possible in each series the size of at least one group well-defined with a view to primary radiological deformity. If this can be done, the primary radiological deformities in the series may be compared, in broad features.

A simple group suited to this purpose is perhaps our *group "SPH."* – which is moreover of particular interest as regards the development of osteoarthritis.

The initial task, then, was to try determining the size of this group in the 19 series. Of course, this has been possible only with approximation, but nevertheless in a way so that the results seem applicable, as I hope will be apparent from what follows.

Most of the *authors* have grouped their series into three, more rarely into four, groups according to the "primary deformity" of the hip joint, as a rule of the femoral head. The groups have received different designations: Good, fair, poor or – with a view to capital shape: "spherical", "flattened", or "irregular" (Appendix, Chart 4). In all late follow-up examinations, these groupings have been based on an estimate, as already mentioned, not upon objective measurements. Nevertheless, they have been according to certain criteria described by the authors in the text. These descriptions – as well as accompanying X-ray films and drawings, if any – permit a determination of the size of the "SPH." group without too wide a margin of error. I have tried to demonstrate this by a more detailed account of the assessment in the 5 series with the longest follow-up (Appendix, Comment 3).

The procedure was the same in series 6–12 with shorter follow-up periods, but a detailed analysis of these series would require too much space.

The 7 series used for elucidating the condition at *primary healing* were assessed by *objective measurement* of the articular deformity. Therefore, the size of the "SPH." group can be established with far greater certainty. In those series in which Mose's plate was used in the assessment, the value is simply given as part of the measuring results.

It is not possible to assess the size of the "NORM.sph." group in the 16 series from the literature. Only, it may be said that, according to the scanty experience so far of defining this group, it makes up about half of the "SPH." group when the latter comprises about 25–50 % of the total patients in a series. If the percentage of "SPH." increases beyond 50 %, the share of "NORM.sph." will rise, maybe up to the 100 % found in a normal material. If the percentage of "SPH." is below approx. 25 %, the share of "NORM.sph." drops right down to 0: In a series in which the result is very poor ("SPH. <7–10 %) there will be only cases healing with abnormally shaped femoral heads, viz. thé groups "PATH.sph." and "NON-sph." – perhaps even only cases with irregular, non-spherical heads ("NON-sph.").

In Helbo's series, in which the group "SPH." made up only $12\frac{1}{2}$ % only five patients had an *epiphyseal* quotient >60, and it is doubtful whether any of these patients had a *joint surface* quotient >85 and a *radius* quotient <115. In other words, it is questionable whether this series contained any case of the group "NORM. sph.".

But when relating the results in the many series to each other, it is of course also of the utmost importance that not only the "primary deformities", but also the concepts *"radiological osteoarthritis"* and *"clinical symptoms"* have been accurately defined, so that we know what we are talking about.

Regrettably, this wish is rather deficiently fulfilled in the majority of reports. The term "radiological osteoarthritis" is defined with some accuracy by only one author (Danielsson). Most authors seem to take it for granted that there is general agreement concerning the signs of "radiological osteoarthritis", and this is far from being so. For instance, Danielsson did not interpret "osteophytes" as a sign of osteoarthritis, whereas Wiberg (1939) considers them important. In return, Wiberg did not consider increased density of skeletal structure, as seen in the acetabulum in acetabular dysplasia and subluxation, a sign of osteoarthritis, but a reactive skeletal change and thus a precursor of osteoarthritis.

The most reliable *radiological sign* of osteoarthritis is probably narrowing of the joint space. But even this is a subject of discussion, and its frequency is mentioned in only two of the many series: Danielsson & Hernborg's and Gower & Johnston's.

However, it must be pointed out that all the signs of radiological osteoarthritis are objectively demonstrable phenomena. There may be disagreement concerning the significance of the individual components and, in mild cases, about the diagnosis. However, when several or all components are present there is usually not any major disagreement about the diagnosis. Accordingly, statements about the occurrence of radiological osteoarthritis at follow-up carry considerable objective accuracy.

This applies far less to the *clinical manifestations.*

"Clinical manifestations" refer, preliminarily, to all clinical symptoms from the hip, whether their cause is primary articular deformity or secondary osteoarthritis.

They consist in *objective signs* and *subjective complaints.* The former rarely give rise to disagreement. On the other hand, assessment of the latter, as indicated by the name, is highly subjective: What one patient considers a trifle may be a severe complaint to another. Some doctors, having an optimistic attitude, tend to minimize the patients' complaints, especially when unexplained by objective findings, while others attach much importance to the slightest complaints.

This uncertainty is all the more unfortunate as it is the subjective complaints and their influence upon the patients' lives that are of most interest in our context.

Despite the uncertainty, however, some main features concerning the subjective clinical symptoms may be deduced from the literature listed *(vide infra).*

The frequency of radiological osteoarthritis as well as of clinical manifestations has usually been stated as the percentage of all patients in the series. This requires a few comments, considering that one of the objects was to arrive at the proportion of the individual series definitely *without* osteoarthritis.

Most authors have classified their series into groups by first imagining the patients placed in one row according to increasing radiological deformity of the joint. This row is then divided into three or four groups, from the least deformed end of the series to the more severely deformed one. A statement thereafter that radiological osteoarthritis was present in 50 % of the patients of course does not mean that radiological osteoarthritis occurred exclusively in the most deformed half of the series, in which *all* patients were affected, whereas the remainder were unaffected. True, osteoarthritis is bound to be most common at the "most deformed end", but it will extend also into the less deformed end. In brief, the cases will spread over a larger part of the series than indicated by the percentage stated. This spread has been recorded by the authors of four out of the five series having the longest follow-up (Helbo, Sundt, Danielsson & Hernborg, Gower & Johnston) and by some of those with a shorter follow-up, by stating the percentage of radiological osteoarthritis in *each* of the deformity groups. In Ratliff's series, and in some series with a shorter follow-up period, I estimated the spread on the basis of other data given by the authors – in particular the size of the deformed groups. Of course, such an estimate of the percentage of the series within which the cases of osteoarthritis are spread will be somewhat uncertain. For this reason, the estimate was kept at the *lower end* of what is possible and should always be accompanied by the simple percentage of patients with osteoarthritis in the series.

The same reasoning applies to stating the percentage of subjective symptoms in the series (cf. also Appendix, Comment 4).

These more general remarks on the procedure of the analysis will now be followed by the results:

a *Primary Radiological Joint Deformities – in Particular the Percentage of "SPH." – in the 19 Series*

Diagram 15 and Charts 4–5 in the Appendix present my estimate of the sizes of group "SPH." or the measurements of the various authors in the 19 series, related to the authors' classifications. The very accurate figures (61 %, 74 %, etc.) in the series not measured might lead one to imagine an accuracy which is of course not present. The figures are merely a calculative consequence of the various authors' very exact numerical classification which, as already mentioned, carries a great uncertainty. Examples of how my figures are derived are given in the Appendix, Comment 3. The figures are of course used only with due regard to their estimative nature. Lastly, Chart 3 presents the treatment which had led to these radiological results.

On the diagrams and charts the series are then set up in three groups, mainly according to mean age at follow-up:

III: 40–45 years, II: 20–25 years, I: <20 years.

Within each group the series are arranged by increasing percentage of "SPH.", the lowest at the top.

In the lowest group I the percentage of "SPH." in all the series was determined by objective measurements on the X-ray films, in 6 of the 7 series even by the method of Mose. In this group, therefore, the percentage of "SPH." can be stated with great accuracy.

In the other two age groups the "SPH." percentage has been determined mainly in relation to the authors' estimated classifications and is, therefore, considerably more uncertain than in group I. An important goal of the studies is to decide, with the greatest possible accuracy, whether radiological osteoarthritis and subjective complaints occur also in the patients of group "SPH.". Therefore, the size of this group

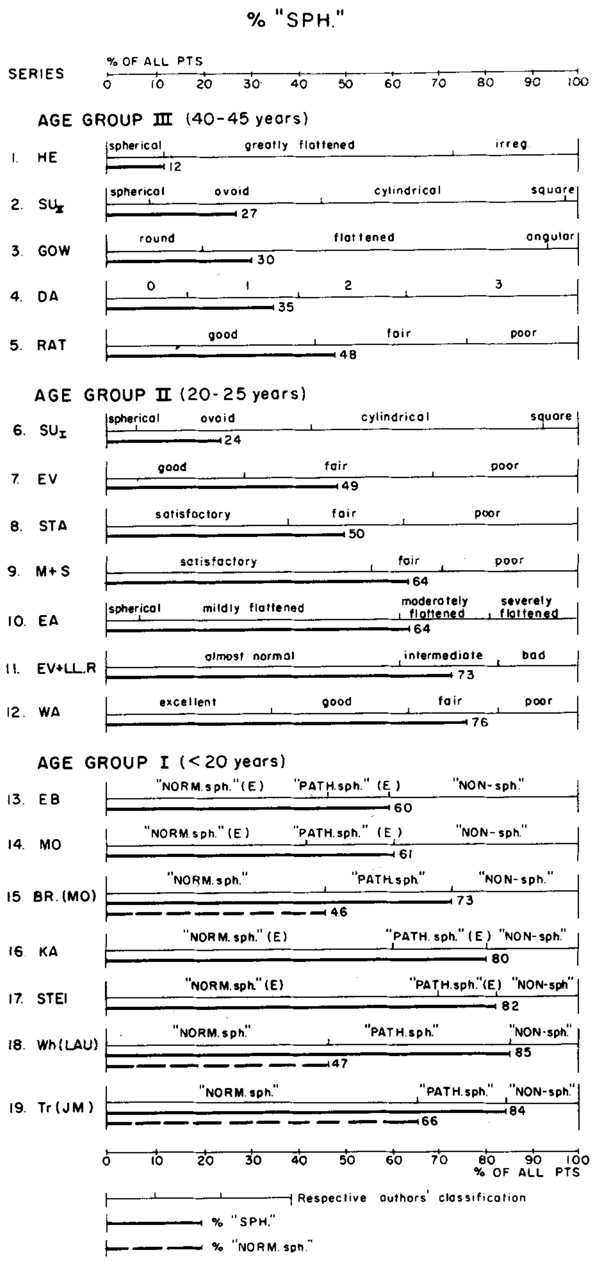


Diagram 15. % "SPH." as estimated by J.M. – or directly measured – in 19 followed LCPD series, listed in relation to the classification used by the respective authors, mainly according to the degree of primary radiological deformity.

In age groups III and II the classifications are estimated.

In age group I the classifications are based on measurements on the X-ray films, and group "SPH." appears as a direct link in the measured classification. In this group the terms used by the respective authors are replaced with those used in the present study (pp. 20 and 36).

The patients of the respective series are arranged according to increasing radiological deformity, from L to R.

(Percentages of the respective authors' classification, cf. Appendix, Chart 4.

J.M.'s estimate concerning size of group "SPH.": cf. Appendix, Comment 3.

For designation of series, number of patients, patient age, and other data concerning the respective series, cf. Appendix, Charts 1–3).

was set at *the lower end* of the inaccuracy range which is always present. This may be difficult. For instance, the "SPH." percentage in Evans' and in Gower and Johnston's series has possibly been set too low, but the data from their papers do not permit a higher minimum value. Therefore, these two series have to keep their place in the sequence.

To ascertain the *age distribution* of the series over the three groups may also be difficult because of incomplete information. Besides, the age criterion has deliberately not been strictly observed in some cases:

Some of the series in age group I maybe belong to group II (Katz, Steinhauser, Ebach), but were assigned to group I, as the "SPH." percentages in these series – as in the others of group I – have been based upon objective measurements and therefore are more reliable than the percentages in group II. Reversely, the series of Stamp et al. as well as of Evans and Lloyd-Roberts perhaps ought to be transferred from group II to group I, but they are kept in group II because the "SPH." rate is an estimate and therefore a minimum value.

On the whole, the grouping of the series in the system was done after thorough reflections and seems to be as reliable as it can be on the basis of the available data.

Indeed, this is confirmed by a glance at the treatment used in the various series (Appendix, Chart 3). As a standard of the efficacy of a treatment one may use e.g. that percentage of patients who have been treated by *effective relief from weight-bearing,* by ambulatory measures or in hospital (in bed with or without plaster, etc.) for 1–2 years, of course with reasonable regard to the treatment in the remainder of the material.

If this criterion is applied to the treatments in the various series, the main finding is that the more effective, in the above sense, the treatment has been the higher the rate of "SPH.". The lower "SPH." values in age group II, and especially in group III as compared with I, are explicable not only by the figures being minimum values. In the main, they are due to less effective treatment in the older series. However, the rule concerning the dependence of the "SPH." percentage upon non-weight-bearing does not apply always:

For instance, it is surprising, as already mentioned, that the "SPH." rate in Gower & Johnston's series could hardly be set higher than 30 %. The reason why this is surprising is that in this series the treatment was apparently rather effective – at least long-lasting. The explanation is presumably that the series was an *unusually "heavy" one,* i.e. having an unfavourable prognosis before institution of treatment, many patients being over 8 years of age and arriving late for treatment. In Ratliff's series too, a "SPH." rate higher than 48 % would have been expected considering the rather effective treatment in the majority of the cases. I have been unable to elucidate the cause of this apparent disproportion. There have also been several series treated by the *same* method, but obtaining *different* results, e.g. Evans' and Evans & Lloyd-Roberts' series of in-patients. Cause: The latter series was *particularly "light"* with respect to the age distribution, *no patient being over 8 years* at the institution of treatment.

Different treatments in series of *different* severity may also afford the *same* result in terms of the "SPH." rate. This applies to Lauritzen's "wheelchair series" and to my traction series. However, the results prove to differ very much as measured by the percentage of "NORM.sph." – and also when measured by the percentage of "SPH.", when correction is made for the difference in the severity of the series (cf. section on radiological assessment).

But on the whole the rule stands its test: The more patients of the series are treated by long-term effective relief from weight-bearing, the higher the "SPH." percentage.

This is no novelty. In 1966 the present author found, in four carefully studied series, an increasing percentage of "SPH.": 19 %, 61 %, 77 %, and 87 % with increasingly effective relief from weight-bearing.

The finding of the same relation in the 16 far less elucidated series from the literature must indicate that the estimated "SPH." percentages are credible – that they can be regarded as a real expression of the primary deformation of the joint left by the disease in these series.

b *Radiological Osteoarthritis*

Despite varying views on the radiological signs of osteoarthritis, the percentage of radiological osteoarthritis in the series must be considered to carry a considerable objective accuracy. This is confirmed int. al. by the development of radiological osteoarthritis in the series, from primary healing to the longest follow-up, showing a definite pattern, not characterized by chance.

Diagram 16 illustrates the distribution of radiological osteoarthritis in the series when arranged by increasing primary radiological deformity (from left to right). The small circle signifies the percentage of radiological osteoarthritis in the total series.

The pattern evident from Diagram 16 is then:

Investigation of the series at *primary healing*, or shortly after *(group I)*, revealed no radiological signs of osteoarthritis.

At follow-up, at an *age of 20–25 years (group II)*, mild signs of radiological osteoarthritis had started to manifest themselves in a few of the series. In others (the youngest two, Nos. 8 and 11) such signs are not mentioned, either because they were absent or were deemed of no importance. Only one of these series (No. 6) – that part of Sundt's material which had a follow-up period of <25 years after onset of the disease – exhibited radiological osteoarthritis in quite a number of patients (32 %). The explanation is that the patients of this material had received practically no treatment. Therefore, the disease left primary articular deformities entailing radiological osteoarthritis in an appreciable percentage of the patients as early as the follow-up examination at a mean age of 23 years.

Within Sundt's series the percentage of osteoarthritis is so high that the cases are distributed all over the group "NON-sph.", possibly a little into group "SPH." too. From the viewpoint of osteoarthritis, this series belongs rather to the older age group III.

In the other six series of age group II the cases of osteoarthritis were only distributed within the "heavy" part of the "NON-sph." group, viz. in the most deformed group of the authors' classification, not occurring at all in group "SPH.". The distribution of osteoarthritis in these series is, broadly speaking, inversely proportional to the size of group "SPH.".

The mean age in age group II of these series is 20–25 years, while the range is up to 30–40. However, there is but little preponderance of radiological osteoarthritis in patients above the mean age.

Regrettably, there are no suited materials of a mean age from 25 to 38 years, but when the mean age has reached *40–45 years (age group III)*, the number of cases having radiological osteoarthritis has increased so far, that in four of the five materials *they extend also into group "SPH."*. In this age group too the distribution is, broadly speaking, inversely proportional to the size of group "SPH.".

As far as may be assessed, the cases of osteoarthritis in "SPH." are localized exclusively in "PATH.sph.". The "NORM. sph." group seems to be entirely uninvolved.

In other words, the development of radiological osteoarthritis *in the 19 materials* is simple and clear: From no case at primary healing to cases not only in the "NON-sph." group, but also in "SPH." at the latest follow-up examinations (mean

RADIOLOGICAL OSTEOARTHRITIS

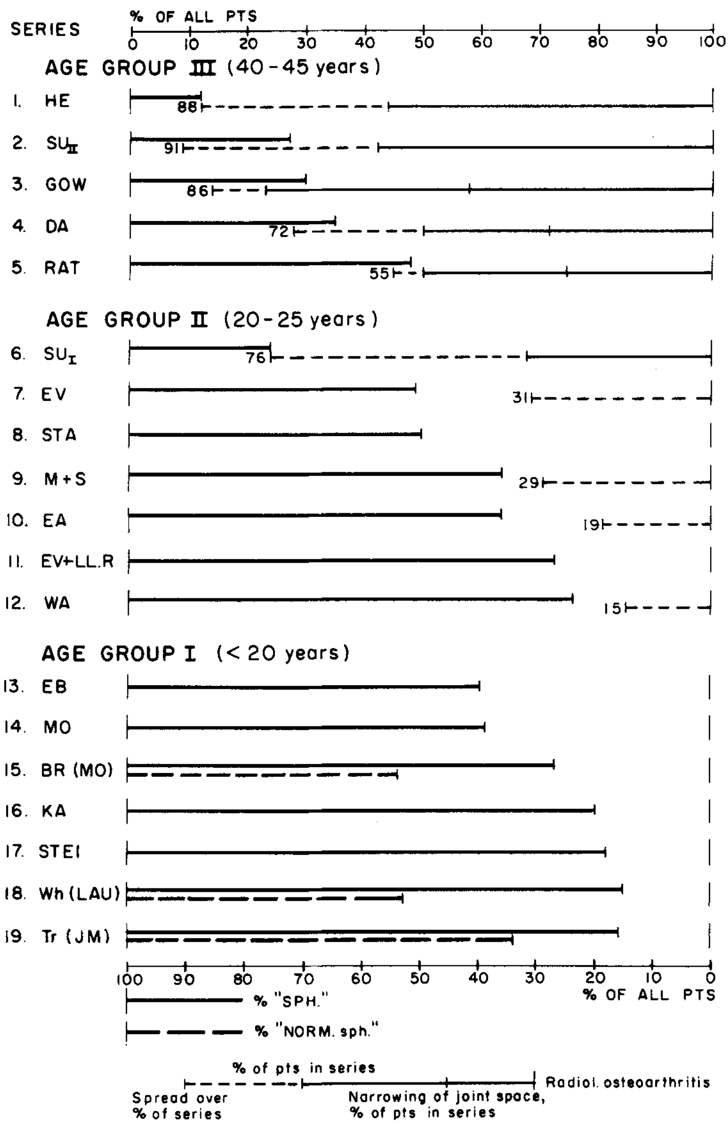


Diagram 16. **Radiological osteoarthritis** *in 19 LCPD series related to the group "SPH." (and in a few series to "NORM.sph.").*

Series arranged according to increasing primary radiological joint deformity, from L to R.

(Magnitude of "spread" apparent from the authors' reports, directly or indirectly (cf. Appendix, Comment 4).

Percentages apart from those listed, cf. Appendix, Table 29. Designation of series, cf. Appendix, Chart 1. Number of patients, patient age, treatment, cf. Appendix, Charts 2–3. Radiological abbreviations and symbols, cf. p. 12).

age 40–45 years). In the latter group ("SPH.") there are no doubt cases in the most deformed part of the group – "PATH.sph." – but presumably none in "NORM.sph.". The spread of radiological osteoarthritis in the series is, broadly speaking, inversely proportional to the size of the "SPH." group.

This pattern is very clearly apparent from Diagram 16.

c *Clinical Osteoarthritis*

But what about the relationschip of radiological osteoarthritis to clinical osteoarthritis?

What does the radiological osteoarthritis mean to the patients?

This question refers exclusively to the symptoms, the purely subjective ones as well as the complaints bound up with the objective signs of disease. Objective signs which are not noticed by the patients are of no interest in this connection.

The complaints consist in pain, a limp, articular stiffness, limitation of motion, fatigue in the limbs on minor exertion, etc. Thereamongst, pain is most apt to be recorded as a complaint at follow-up. This applies in particular to the *late* follow-up studies at which complaints of pain are predominant and therefore receive most attention. The other subjective complaints are often not recorded or recorded separately, so that it is impossible to analyse the number of patients having complaints of one kind or another.

The symptoms may be due to two causes, in part the *primary articular deformity* left by the disease and in part the *subsequent osteoarthritis.* It is an experience that pain and articular stiffness are usually late phenomena, occurring in step with the development of radiological osteoarthritis, whereas the other complaints are often present immediately after healing, due to the primary joint deformity. In most cases, however, there is a question of a mixed complex of symptoms whose causes may be difficult to elucidate.

In the following analysis *all* subjective symptoms will be recorded, mild as well as severe, regardless of their cause – and thereafter it will be attempted to elucidate their causes.

However, the causes are of less interest than the percentage and the distribution of the symptoms in the series, but even this is considerably more difficult to determine – owing to the subjective nature of the symptoms – than the occurrence of radiological osteoarthritis.

Nevertheless, a pattern appears on analysing the subjective symptoms in the series. True, it is not as simple as the pattern according to which radiological osteoarthritis develops, but still – a reasonable explanation can be advanced.

As in the analysis of radiological osteoarthritis, this pattern is most clearly apparent when the materials are analysed from group I, examined at primary healing, through group II, to group III examined at the mean age of 40.

Age Group I

In the introduction it was established that at primary healing the children were largely symptom free. This should not be taken quite literally, as in fact there *are* mild complaints. In the absence of radiological signs of osteoarthritis at this time, the complaints must be due exclusively to the primary deformity of the joint. They consist in a mild limp, fatigue in the leg after walking for rather a long time, etc., but pain is uncommon. These complaints will be disclosed by routine history-taking. As the children themselves do not attach much importance to them, it seems justified to call the condition "symptom free", at least as a preliminary designation.

The reason why these, previously ignored, symptoms are now attributed with essential importance despite their slight intensity is that their extent in the series is possibly interpretable as a measure of the maximum possible *final extent* of secondary osteoarthritis in the series concerned.

Indeed, such mild complaints were found among the patients of most group I series.

In analysing the "bed rest series" and "traction series" in 1966, I found mild complaints in 22 % of the patients of the bed rest series (Diagram 17, series 15) and in 13 % of the "traction series". These symptoms were spread over *all* radiological

CLINICAL SYMPTOMS

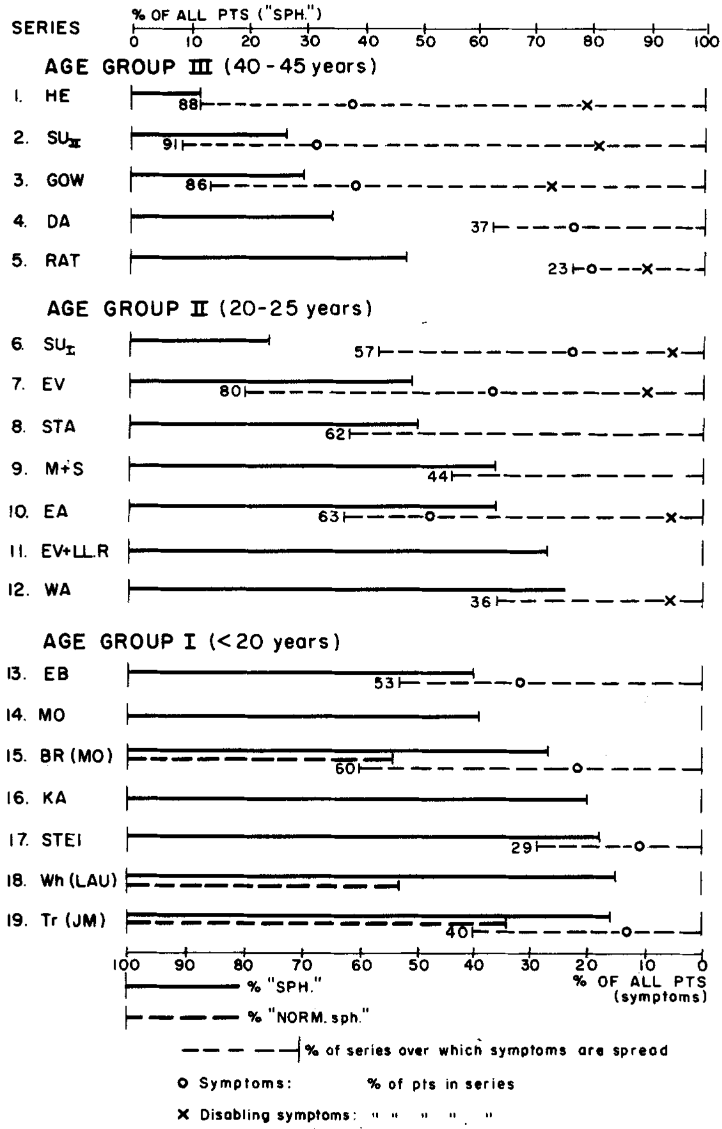


Diagram 17. **Clinical symptoms** *(cause: primary joint deformity or osteoarthritis) in 19 LCPD series set out in relation to the "SPH." group (or "NORM.sph.").*

Series arranged according to increasing primary radiological joint deformity, from L to R.

("Spread", cf. Appendix, Comment 4. Percentages apart from those listed, cf. Appendix, Table 29. Designations of series, cf. Appendix, Chart 1. Number of pts., patient age, treatment, cf. Appendix, Charts 2–3. Radiological abbreviations and symbols, cf. p. 12).

groups – occurring in the traction series even in 4 patients of group "NORM.sph." (6 % of the series). The traction series of the present paper (Diagram 17, series 19) is in all essentials identical with that from 1966, only extended by patients admitted in 1962 and 1963. Therefore, subjective symptoms indubitably also occur in the "NORM.sph." group of this series, although the symptoms in the patients from the two additional years were not analysed. In Steinhauer's series too (series 17) mild symptoms were reported by 11 % of the patients, distributed over 29 % of the series, and in Ebach's (series 13) in even 32 % of the patients. In Ebach's series it is difficult to ascertain the distribution, but mild complaints were no doubt also present in the patients of group "SPH.".

In the other series there were no doubt also mild symptoms scattered over the groups, but they have not been recorded, as evidently they have been considered of no consequence.

In general, it may be stated that in four of these seven series analysed at a very early date, the authors felt it would be reasonable to record mild symptoms. In all series, the complaints spread over all radiological groups, *also "SPH."* – in which they were of course rare and slight – occurring even in the group "NORM.sph." where this group could be defined.

Since, as already mentioned, radiological osteoarthritis could not be demonstrated in these series, it is reasonable to deduce that these mild complaints have been due exclusively to the joint deformity left by the disease.

Age Group II

In the intermediate age group (group II) there are seven series. However, one (series 6) differs so much in subjective symptoms from all the others that it has to be treated separately. This is perhaps not so surprising, as the occurrence of radiological osteoarthritis in this series was also outside the pattern which otherwise applied to the group.

Accordingly, the following refers only to the other six series.

A higher percentage of patients with symptoms had been recorded in two of the series (Nos. 7 and 10) in age group II than in age group I, and three series (7, 10 and 12) even comprised a small group of patients with fairly severe symptoms (marked x in Diagram 17). The *spread* in the series seems largely to be the same as in group I, as all these series too showed symptoms in group "SPH.", but the symptoms do seem to be more severe.

This accentuation of subjective complaints in group II may of course be due to a somewhat less sufficient treatment or to a longer follow-up period, but the main reason is probably that now we are no longer dealing only with primary deformity complaints.

A new element has been added.

At this early age, when the patients averaged only 20–25 years, *signs of radiological osteoarthritis* were recorded in four of the six series (Nos. 7, 9, 10, and 12). All were faint and mild signs restricted to the most deformed part of the series and therefore were far from reaching the same extent as the subjective complaints. No series had radiological osteoarthritis in "SPH." (Diagram 16).

In other words, the subjective complaints in group II show exactly the same spread – some way into "SPH." – as in group I, simply because it is still the same category of complaints that determines the spread: the mild deformity complaints. But the main explanation why the symptoms have become accentuated in group II (Diagram 17: x) is the radiologically demonstrable incipient osteoarthritis.

Thus, there are two reasons for the complaints in group II: *the joint deformity* and *the osteoarthritis* – but the deformity complaints still predominate.

However, this does not apply to series 6 (SU I). In this series the percentage of subjective complaints is all of a sudden strikingly low and scattered over a relatively smaller part of the series than in all the other series in age groups I and II: *The complaints do not reach into "SPH."*. This relatively favourable finding is all the more striking as the series is the most poorly treated one within the groups and has an extensive occurrence of radiological osteoarthritis quite up to group "SPH." – a far greater spread of radiological osteoarthritis than all other series of the group (Diagram 16).

Due to these peculiarities the series most naturally ranges with the lowest materials in group III. Therefore, it seems natural to consider it together with the group III series. Thereby, the causes of the apparently peculiar pattern are easier to elucidate.

Age Group III

The two bottom series of this group (Diagram 17) show exactly the same peculiarities as did series 6: The percentage of patients with complaints and their spread over the series in relation to "SPH." is *strikingly lower* than in all the other series. None of the three series showed subjective complaints beyond the most deformed radiological groups. This is in surprising contrast to the fact that now *radiological* osteoarthritis has extended to the greater part of the series, right up into group "SPH." (Diagram 16).

The most reasonable explanation of this change in the picture is that now the symptoms of osteoarthritis have increased so in intensity that *they divert attention from the milder primary complaints which have so far predominated.* Of course, these mild deformity complaints are still present, but they escape registration – like the mild symptoms of osteoarthritis – as attention is riveted on the more outstanding clinical symptoms of osteoarthritis.

The fact that this appears in series 6, despite the shorter follow-up period, is due to the very poor treatment and the consequent, considerable primary articular deformity. In series 4 and 5 the treatment had been more effective, but the follow-up period longer – and the result is the same.

In the three series at the top (1, 2, and 3) we have got to the stage at which subjective complaints are again recorded in a percentage and extent which is relatively the same as in groups I and II: into and up to group "SPH.". (In series 2 a limp was used as a measure of subjective symptoms; if pain is used, the extent is somewhat less, only 73 % of the series, i.e. up to group "SPH."). However, the intensity of the symptoms has essentially increased, manifesting itself in the relatively large groups of fairly severe symptoms in series 1, 2, and 3.

In these series with long follow-up and insufficient treatment, the cases of radiological osteoarthritis have evidently developed so far that invariably they give rise to subjective symptoms of an intensity great enough to be recorded. The milder primary deformity symptoms are no longer recorded.

The pattern of the development of subjective symptoms in the 19 series may then be described as follows:

In all series, from the shortest to the longest follow-up periods (with three exceptions), there is the same relative extent – spread – of the subjective symptoms in relation to the primary joint deformity: They are present in the entire group "NON-sph." and in part of the "SPH." group – i.e. at least in the group "PATH. sph." (Diagram 17).

In age group I (<20 years) the symptoms within the spread range are mild and rare – and caused *exclusively by the primary joint deformity.*

In age group II (20–25 years) the intensity of the symptoms within the spread range have increased. Now, they are of mixed cause: *due partly to the primary joint deformity and partly to incipient osteoarthritis.*

Lastly, the symptoms in age group III (40–45 years) are the most intense and the most dense ones within the spread range – and they are due *exclusively, or predominantly, to the ever increasing osteoarthritis.*

(The reason why three series (4, 5, and 6) apparently fall outside the pattern has been discussed above).

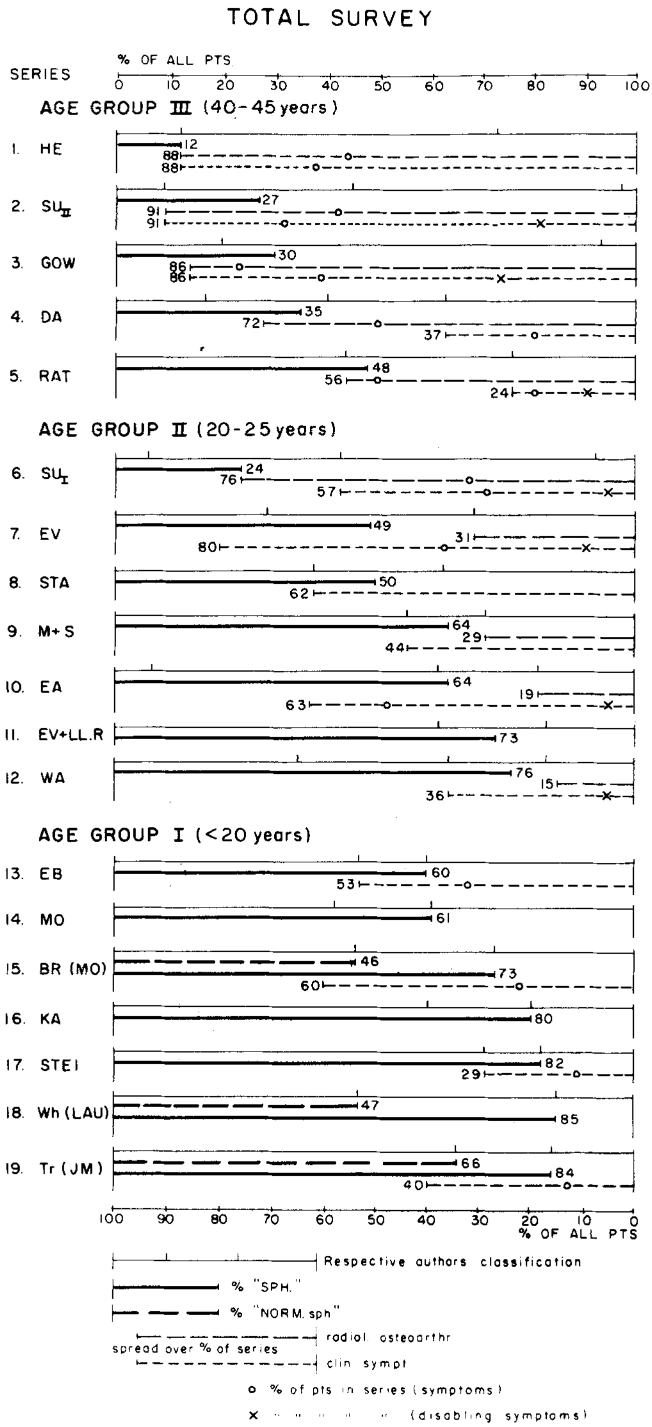


Diagram 18. 19 followed LCPD series.

Total survey.

Correlations between % "SPH.", % radiological osteoarthritis, % clinical symptoms, and the respective authors' classification of the series. Combination of Diagrams 15, 16, and 17.

(For percentages and other data apart from those listed, cf. these diagrams, Appendix, Charts 1–3, and Appendix, Table 29).

Thus, the analysis in this first clinical section – especially of age group III – has confirmed the preliminary assumption that signs of osteoarthritis, in particular the most reliable signs, viz. radiological osteoarthritis, *develop also in patients in radiological group "SPH."* – at least in group "PATH.sph.".

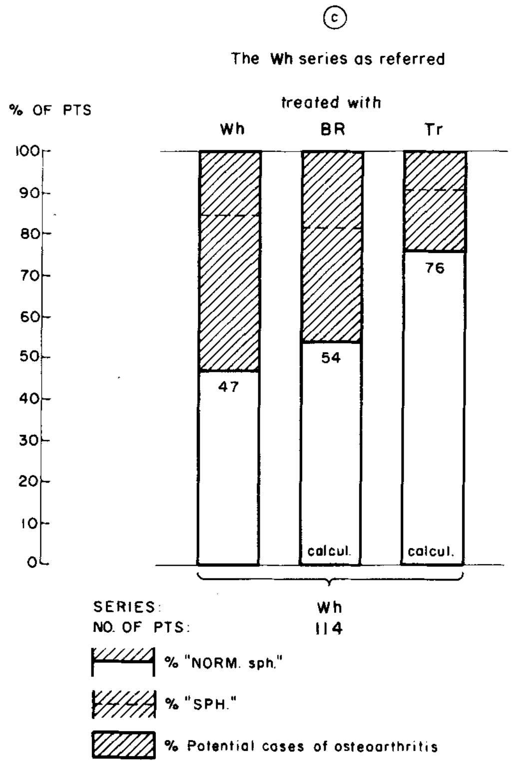


Diagram 19. Extent of potential osteoarthritis in a series composed like the Wh series (114 pts.) after 3 possible methods of treatment.

(Survey of radiological results (with percentages for "SPH."), cf. Appendix, Table 27).

The question now is whether cases of osteoarthritis occur also in *"NORM.sph."*.

The mild subjective symptoms which appear to be present in this radiological group already at the time of primary healing might be interpreted as a sign that some patients of the group were potential osteoarthritics. However, this cannot be confirmed, as the group "NORM.sph." cannot be separated in the series in age group III. Only, it may be said that in these radiologically so greatly deformed series the group "NORM.sph." *must be very small.* Therefore, cf. Diagram 18, the cases of osteoarthritis will probably not "enter" this group.

This can hardly be excluded – but if patients who will escape osteoarthritis are to be picked out at the time of primary healing, there is – according to the findings so far – at least no *major error in selecting the patients* of group *"NORM.sph." and in expecting that patients of "PATH.sph." and "NON-sph." are potential osteoarthritics.*

Should subsequent follow-up studies reveal that all patients of "NORM.sph." cannot go on escaping osteoarthritis, the radiological criteria for cases that escape osteoarthritis may easily be restricted.

Finally, it may be mentioned that *all* the cases of osteoarthritis observed so far must be designated as secondary, having been demonstrated with certainty only in hip joints deformed by disease.

Primary osteoarthritis – by definition – occurs only in previously non-deformed joints and is rarely diagnosed before the age of 50. Above the age of 50 the incidence is low up to an advanced age. According to Danielsson, it is only $1/2$ % at 60.

But even though there had been a question of persons with previously healthy hips, there would not have been any major possibility of encountering a single case of primary osteoarthritis: The number of patients is too small and their age is at most around 40.

Diagram 18 (and Appendix, Table 29) give a survey of the investigations in the present section. Diagram 19 exemplifies the extent of potential cases of osteoarthritis in one series after three possible methods of treatment.

2. Clinical Significance and Calculated Subsequent Development of Osteoarthritis Found in the Series Followed Up

Two problems still await clarification:

1. In the above assessment all degrees of severity of radiological and clinical osteoarthritis are included – even the mildest ones. No further evaluation of its clinical importance was carried out: *How much does it in fact mean to the patients?*

2. Moreover, the investigations reviewed above suffer from the deficiency that the development of osteoarthritis has never been followed in an LCPD series longer than up to a mean patient age of 40 years. What about the development of the osteoarthritis beyond this mean age?

An attempt will be made to elucidate these two problems.

In the three series that had received the poorest treatment (1, 2, 3) radiological and clinical osteoarthritis (of all degrees of severity) was present at the mean age of 40 in almost two-thirds of the patients – spread over almost 9/10 of the series. But it was in only just over 1/5 (22 %) of all the patients that it could be called disabling and at that only to a moderate degree. All such cases occurred in the group with the most deformed hip joints, viz. "NON-sph." and in only just over one-quarter (28 %) of the patients in this group. Of all the cases of osteoarthritis, only one-third (33.7 %) caused symptoms severe enough to be moderately disabling (Diagram 20).

In brief: Osteoarthritis was widespread in these series, but caused only moderate symptoms.

This low intensity of symptoms was in definite contrast not only to the pronounced radiological signs, but also to the very considerable "primary" joint deformities in these very series.

This, then, was the appearance of osteoarthritis secondary to LCPD in the follow-up of patients in the three series when they had reached a mean age of 40.

It is remarkable that for osteoarthritis secondary to other diseases of the hip, congenital or arising in childhood, the findings are, in principle, exactly the same.

Jerre has reported a follow-up study of 137 patients with a history of slipped femoral capital epiphysis (in 183 hips) during puberty and treated by various conservative methods (Acta orthop. scand. suppl. 6, 1950).

Follow-up at a mean age of 30 showed frequent and extensive radiological osteoarthritis – 75 % spread over 91 % of the series – accompanied by predominantly mild symptoms of the same extent. Only 23 % of the patients had "disabling" symptoms. This percentage was 22 in the three LCPD series. Incidentally, the "disabling" symptoms in Jerre's patients do not seem to have been of serious nature and were present chiefly in those with the longest follow-up (mean age 35 years).

Briefly: Exactly the same findings as in the LCPD series – only in patients who were on the average 10 years younger.

Jerre concluded: "In the present series taken as a whole the discrepancy between the subjective symptoms and the roentgenological arthrosis deformans was often remarkably large – – – – – (and) this discrepancy was always in one and the same direction, namely that the roentgenologically manifest arthrosis deformans was more severe than was expected by the symptoms".

This conclusion, in its exact wording, might be drawn from the late follow-up studies of LCPD series by the three authors (Nos. 1, 2, 3 and, with even greater justification by Nos. 4 and 5).

It may be objected that it is not permissible to transfer conclusions from the nature and development of osteoarthritis secondary to other diseases of the hip during childhood to osteoarthritis following upon LCPD, and that therefore the agreement found is due to chance. Such scepticism, however, is hardly justified. In reported studies on the clinical picture of secondary

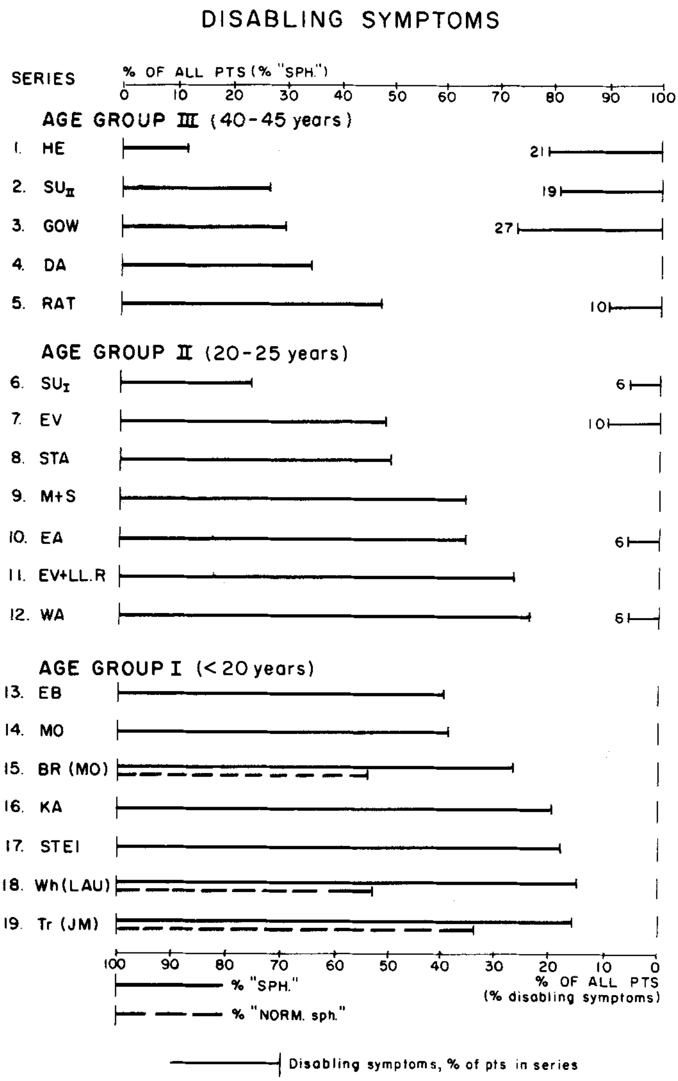


Diagram 20. Disabling symptoms in 19 LCPD series related to the group "SPH.".
The number of cases having disabling symptoms is stated in only 8 of the 19 publications.
The series are arranged according to increasing primary radiological joint deformity, from L to R.
(Percentages, apart from those stated, cf. Appendix, Table 29. Designations of series, cf. Appendix, Chart 1. Abbreviations and symbols, cf. p. 12).

osteoarthritis, this condition is always considered a characteristic disease whose clinical nature and development (qualitatively) are independent of its primary cause. Its severity and – to some extent – the time of its onset, on the other hand, depend upon the degree of the primary joint deformity. The symptoms set in somewhat earlier and sooner become more marked in the presence of severe joint deformities. However, this of course also applies to osteoarthritis following upon *one* disease which leaves different degrees of articular deformity.

In principle, the nature and development of secondary osteoarthritis is the same following different primary causes.

Accordingly, Jerre's finding that osteoarthritis secondary to slipped epiphysis is strikingly mild clinically in relation to the radiological lesions supports the validity of similar findings concerning osteoarthritis following upon LCPD.

However, his series was followed up only to a mean age of 30. Therefore, the findings throw no light upon the other problem: *The development of secondary osteoarthritis beyond the mean age of 40.*

In another study from the literature patients with congenital hip disease were followed up at a mean age of *51 years* with a view to the development of osteoarthritis. I am referring to Wiberg's study of patients with congenital subluxation and acetabular dysplasia (Wiberg 1939).

Wiberg's study is better suited for elucidating the further development of osteoarthritis. Its main drawback is its small size (only 17 patients – 14 girls and 3 boys).

In the files from two Stockholm hospitals from the period 1908–1925 Wiberg found 44 patients (aged 13–60 years) with definitely diagnosed congenital subluxation (or dysplastic acetabulum), but without signs of osteoarthritis.

In 1937–38 Wiberg wanted to examine these patients to ascertain whether secondary osteoarthritis had developed. Regrettably he succeeded in tracing only 16 (to which he added yet another patient in whom the absence of osteoarthritis at primary examination was perhaps in doubt).

At follow-up in 1937–38 – when their mean age was 51 – all 17 patients had signs of osteoarthritis. In two, however, only radiological signs were present, so that they are not included as cases of osteoarthritis. In all cases the radiological signs were appreciable, whereas little information is given on the nature of the clinical manifestations at follow-up – in particular their subjective role.

Wiberg's 17 patients appear to represent

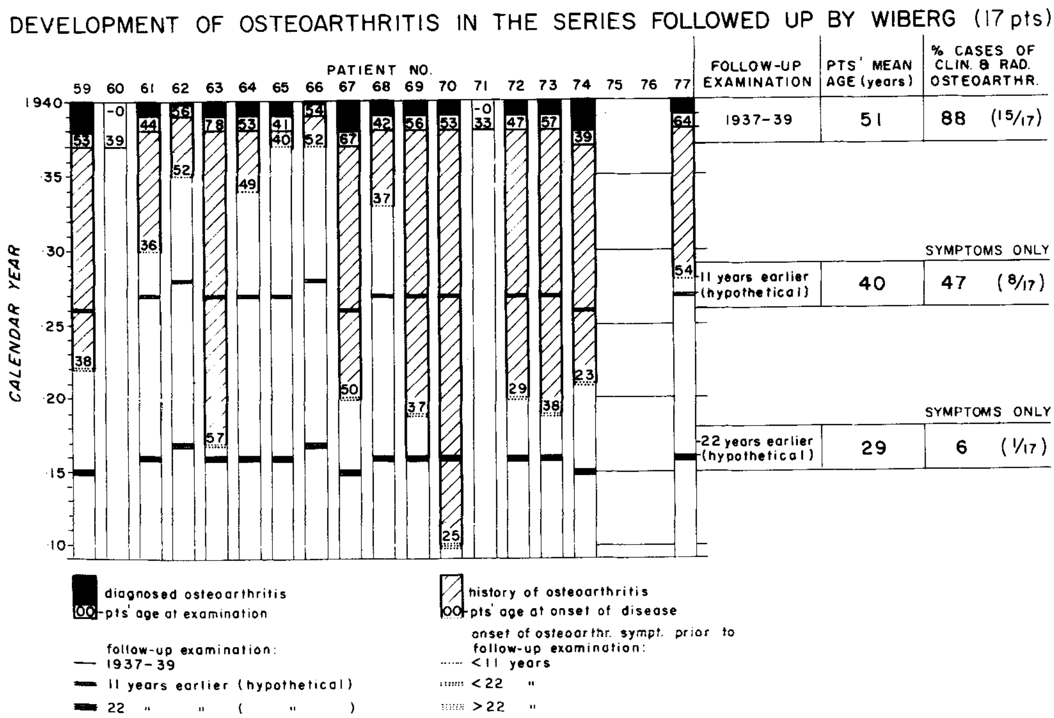


Diagram 21. Development of osteoarthritis in the series followed up by Wiberg (17 pts. with subluxation).
The result of the follow-up examination performed in 1937–39 and the results which would have been found in two hypothetical follow-up examinations 11 years and 22 years earlier.

a "heavy" selection of subluxations. As a rule, a large number of such patients escape osteoarthritis (Lance). The explanation is possibly that owing to the low follow-up rate (17/44) he got hold of mainly those patients who had essential complaints on account of their osteoarthritis.

At follow-up all the patients were questioned about the *time of onset* of what Wiberg considered subjective clinical symptoms of osteoarthritis: Limitation of movement and stiffness in the hip joint with increasing pain. All the patients but the two mentioned above were able to state this time with sufficient accuracy.

The radiological course is insufficiently elucidated, as the patients had not been X-rayed regularly during the course.

Diagram 21 gives the results.

The advantage of this diagram is that it affords information about the percentage of osteoarthritis (subj. sympt.) that would have been found, had the patients been examined *11 years earlier* – i.e. when they averaged 40 years of age – and if they had been examined *22 years earlier,* i.e. at a mean age of 29 years.

The rate of osteoarthritis is shown in Table 10.

Table 10. Series followed up by Wiberg (17 pts.). Percentage of clinical osteoarthritis at increasing mean age (subjective symptoms).

Mean age (years)	Percentage of osteoarthritis
51	88 %
40	47 %
29	6 %

Thus, at follow-up when the patients' mean age was 40 the osteoarthritis rate (47 %) would have been lower than the mean rate of *all* clinical cases of osteoarthritis in the three LCPD series (64 %), presumably because Wiberg's definition of osteoarthritis is somewhat stricter. However, it is of course impossible to tell what the radiological and subjective severity of

Table 11. Development of osteoarthritis in Ruelle's total material of secondary osteoarthritis (I +II).

This material comprises 271 patients who applied for treatment of symptoms of secondary osteoarthritis of the hip. Here, then, "osteoarthritis" means clinical osteoarthritis causing symptoms which have, sooner or later, reached a severity making the patients present themselves for institutional treatment (cf. also text and Appendix, Comment 5).

% = The percentage of all cases developing symptoms before the ages stated.

(The 5–year values are the result of interpolation between the 10–year values found – or fixed graphically on the basis of Diagrams 22 and 23).

(Detailed list in the Appendix, Table 30).

Age (years)	%
80	100
75	99.5
70	99
65	96
60	93
55	81
50	70
45	53
40	36
35	23
30	10
25	3 (graphic)
20	2 (graphic)

the osteoarthritis was in fact at a mean age of 40.

But it is apparent from the diagram that when the patients had grown 11 years older the percentage of osteoarthritis had almost doubled (47 %–88 %).

From our point of view, this is the most important result of Wiberg's study.

Whether the clinical severity of the osteoarthritis had increased correspondingly in the course of the 11 years is not directly stated. But reading the follow-up data on each patient gives an impression of radiological changes which were at that time on the whole severe and clinical symptoms of a nature which must have given rise to considerable complaints.

Wiberg's series, however, has the essential drawback of being small. For instance, the onset of the symptoms is very uneven in the course of the years. In some years there had been an accumulation of cases –

in others none (Diagram 21). A continuous distribution and a distinct pattern would require a larger material.

Fortunately the literature contains a report on a far larger material from which corresponding information about the development of secondary osteoarthritis may be deduced – even far beyond the mean age of 40.

This series, *Ruelle's from 1961,* does not afford as many details as Wiberg's, but owing to the far larger number of patients the conclusions carry much greater weight.

Ruelle reviewed the records for 271 patients who had consulted a rheumatological clinic in the course of some years for secondary osteoarthritis of the hip due to: Slipped epiphysis, LCPD, dislocation and subluxation of the hip, etc.

For each patient he recorded the onset of what he regarded as clinical symptoms of osteoarthritis: Painful limitation of movement in the joint. Thereafter, like Wiberg, he could tabulate the development of secondary osteoarthritis in his material.

This is a study of a nature somewhat different from those reviewed above which were based upon *a given hip disease,* congenital or acquired during childhood, and designed to investigate the development of osteoarthritis after this given disease. Ruelle, on the other hand, considered the secondary osteoarthritis a well-defined disease entity, and regardless of its primary causes he tried to elucidate its development. The causes of osteoarthritis in his material, then, were manifold – mild to severe deformities of the joints left by *different diseases* – and not as in the studies quoted so far deformities after one, well-defined hip disease during childhood. However, the material is so large that Ruelle could divide it up according to the different causes.

Still, the main advantage of Ruelle's material is its size. No other study on secondary osteoarthritis comprises 271 cases.

In the material as a whole Ruelle found the values listed in Table 11 and Diagram 22. Unlike the values in Table 10 from Wiberg's study, the osteoarthritis rates do not refer to a *mean age,* but to the rate of osteoarthritis which the patients had developed at the age stated.

Ruelle found that about one-third (36 %) of the 271 patients developed their subjective symptoms of osteoarthritis before the age of 40 and about two-thirds (70 %) before the age of 50 – i.e. a duplication of the cases within the decade 40–50.

Extracting corresponding values from Wiberg's material shows conformity:

Just over one-third (35 %) of Wiberg's patients developed symptoms of osteo-

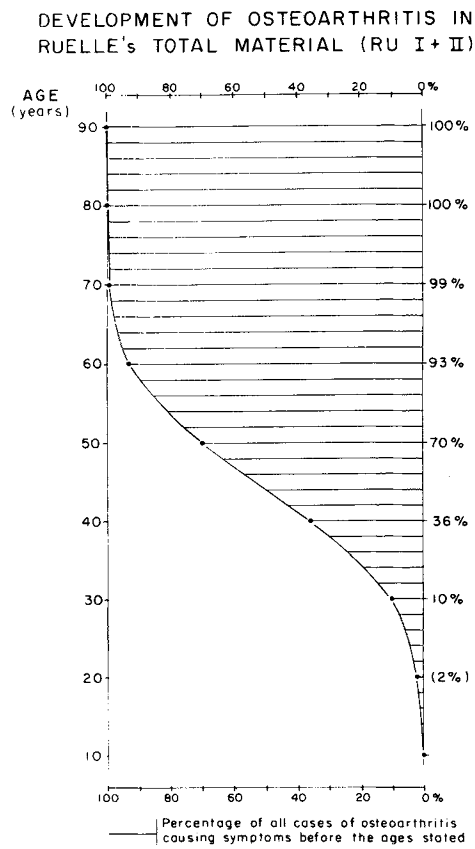


Diagram 22. Development of osteoarthritis in Ruelle's *total material (I–II) comprising 271 patients.*

Graphic presentation of Table 11. (Cf. legend of that table).

arthritis before the 38th year of age (6/17) and almost two-thirds (65 %) before the age of 51 (11/17), i.e. very close to a duplication during the age 38–51. (The longer interval 38–51 is due to the irregular distribution of the cases in Wiberg's small material).

As to the clinical severity of the osteoarthritis in Ruelle's series we know only that it caused such inconvenience that *sooner or later the patients applied for treatment.* No information is given about the radiological development or about the nature of symptoms existing before the patients presented themselves for treatment.

But the pattern of development of osteoarthritis in Ruelle's and Wiberg's series is found also in other studies.

The mean age at onset of secondary osteoarthritis was 41 years in Wiberg's material, and in Ruelle's it could be calculated to be about 44.

In Falconnet and Vignon's series comprising 78 cases of secondary osteoarthritis following subluxation and acetabular dysplasia, the first symptoms of osteoarthritis appeared at the mean age of 44 in the patients with subluxation and at 48 years in those with acetabular dysplasia.

In Lloyd-Roberts' series (1955) of 23 cases of severe secondary osteoarthritis requiring operation the first symptoms had appeared at a mean age of 47. In his material of osteoarthritis Danielsson found 18 cases of secondary osteoarthritis of different causes (not subluxation, but LCPD, coxa vara, etc.). These 18 patients had noted the first hip pain at a mean age of 44.

Lastly, it has been reported by Lance that osteoarthritis following upon subluxation begins in the late forties: at 45–50 years.

This is indeed surprising agreement – all the more so as these uniform results have appeared in studies of widely different age groups: Wiberg's mean 51 years, Danielsson's 62 years. If the spread in the onset of secondary osteoarthritis is no wider than in Ruelle's series – and there is nothing to indicate that it is – these means signify that the onset of secondary osteoarthritis is localized especially, as in Wiberg's and Ruelle's series, within the decade 40–50 years of age.

Wiberg, Lance, and others have expressed this briefly by stating that in women secondary osteoarthritis develops during and around the menopause and in men a little later.

Lloyd-Roberts (1955) feels that *primary* osteoarthritis is "a disease of the aging, rather than old age", stating that the symptoms generally set in at the age of 50–55 years, mean 52.5 years, rarely sooner or later. Danielsson has reported a mean age of 54.7 years at onset of *primary* osteoarthritis.

However, Lloyd-Roberts' view on *primary* osteoarthritis as a disease of the aging may evidently be transferred to *secondary* osteoarthritis – only the latter sets in 5–10 years earlier, at an age of 40–50.

Thus, on the basis of a given series of osteoarthritis it was possible to elucidate in retrospect the development of the osteoarthritis (Ruelle).

If we had a corresponding material of osteoarthritis following LCPD, also comprising patients of advanced age, it would be possible to elucidate the development of osteoarthritis following LCPD up to a far advanced age.

However, no such material is available at present.

The development of osteoarthritis following LCPD might also be elucidated by following a pure LCPD series up through the years. This has not so far been done beyond the age of 40.

Accordingly, there does not seem to be a possibility, at the moment, of completely elucidating the development of osteoarthritis after LCPD.

But perhaps there is a way out.

In Wiberg's, Jerre's, and Ruelle's investigations it was found that on the whole the development of secondary osteoarthritis was entirely uniform, regardless of the primary cause: Slipped epiphysis, LCPD, subluxation, congenital dislocation, acetabular dysplasia, traumas, infection, etc.. Of course, the severity of the osteoarthritis may vary, as after LCPD, but the pattern of its development is in all essentials the same.

Therefore, it was attempted to use the values from the material based upon the largest number of patients, and carried up into the oldest age groups, viz. Ruelle's, to gain an idea of the further development of osteoarthritis in three of the LCPD series with the longest follow-up periods (Helbo's, Gower & Johnston's, and Danielsson & Hernborg's).

However, Ruelle's values are not directly applicable to an LCPD series.

All patients of Ruelle's series had osteoarthritis (and were presenting themselves for treatment). Thus the osteoarthritis rates at the different ages signify the percentage of the final number of osteoarthritis which in Ruelle's material is equal to *the total number of patients.*

But if these values are used for determining the osteoarthritis rate in a given LCPD series at a given time, the results also signify the percentage of the *final number* of cases of osteoarthritis in the series. If, for instance, it can be predicted that half the patients of the series are likely to escape osteoarthritis, the calculated rates have to be divided into half to apply to the total number of patients in the series.

When thus applying Ruelle's values to an LCPD series, it is therefore of the utmost importance to know the expected final maximum possible – or likely – percentage of osteoarthtitis in the series.

It is this maximum possible osteoarthtitis rate which the present author has tried to establish in the preceding radiological and clinical sections, as apparent from the conclusions at the end of the radiological section and from Diagram 19: At the time of primary healing of an LCPD series the risk of osteoarthritis is present only in patients in deformity groups "PATH.sph." and "NON-sph.". The size of these groups indicates the maximum part of the series in which final, full-blown osteoarthritis may occur. Osteoarthritis does not necessarily develop in all patients within the range – or in them only – but the deviations are not great (Appendix, Comment 5).

But are we to use the values from Ruelle's *total series* of secondary osteoarthritis in the attempt at calculating the osteoarthritis rate in the LCPD series – or are values from one of his *special subgroups* better suited?

Ruelle divided his material into the following groups according to the primary causes of the osteoarthritis:

Ru I: Deformities of the head-neck following slipped epiphysis, LCPD (only a few), traumas, or infection.

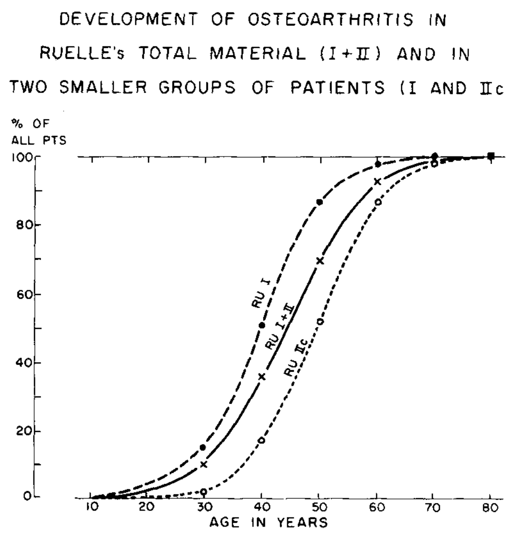


Diagram 23. Development of osteoarthritis in Ruelle's *(RU's) total material of secondary osteoarthritis (I + II) and in two smaller groups of patients (IIc and I) having milder and more severe primary joint deformities.*

The points on the curves indicate the % of all pts. – in the total material or in the special groups – in whom symptoms of osteoarthritis set in before the age stated on the abscissa.

(Percentages and meaning of I + II, etc. cf. Table 12, p. 60. For further explanations of this diagram cf. also Appendix, Comment 5).

Table 12. Development of osteoarthritis in Ruelle's total series (designated I +II) and in the special groups of patients: I, II a, II b +c, II c.
% = Percentage of all cases of osteoarthritis – in the total material and in the various groups of patients – causing symptoms before the ages stated.
As to the designation osteoarthritis, cf. Appendix, Comment 5.

	Total material	Groups			
		Sites of joint deformities			
		Head/neck	Acetabulum		
			Congen. disloc.	Sublux. and acetabular dysplasia	Acetabular dysplasia
Ruelle's designation	I + II	I	II a	II b + c	II c
No. of pts.	271	68	38	165	120
Age (years)	%	%	%	%	%
80	100			100	100
70	99	100		99	98
60	93	98	100	89	87
50	70	87	90	59	52
40	36	51	58	24	17
30	10	15	21	6	2
Degree of deformity	Moderate	Fairly severe	Most severe	Fairly mild	Mildest

Ru II: Acetabular deformities left by (a) congenital dislocation, (b) subluxation, (c) acetabular dysplasia.

True, group I does contain cases of LCPD, but apparently few – and the group is incidentally of an extremely mixed nature.

The group II cases clearly differ in essence from LCPD.

In these different groups the osteoarthritis develops according to the same fundamental pattern (Diagram 23, Table 12):

In the total material (I + II) the development of osteoarthritis gradually starts at the age of 30, but does not really gain impetus until the decade 40–50 years; thereafter, the tempo slows down towards the age of 60 (cf. also Diagram 22). In the groups with the most severely deformed joints (e.g. I) the development is under way already at the age of 30, while in groups with less deformed joints (II c) it does not start until the age of 40, but then continues at an undiminished rate until the age of 60.

When considering the groups together, the development of osteoarthritis takes place between the ages of 30 and 60, and a particularly rapid rate between 40 and 50 is common to all groups.

As it is difficult to assess the relation between the severity of the articular deformities in Ruelle's groups and in the LCPD series with late follow-up, the osteoarthritis rate for Ruelle's *total material* will be used, for the time being, for calculating the expected rate of osteoarthritis in the LCPD series.

Thereby it is possible to base the calculation upon the largest possible number of patients – and to attain the greatest possible certainty.

The procedure is as follows:

First, the osteoarthritis rate in the LCPD series is calculated at the time of follow-up – and this calculated value is then compared with that *found*.

If this form of calculation proves satisfactory, it will be used to form an impression of the expected development of osteoarthritis beyond the time of follow-up.

This may be exemplified by a brief description of the calculation in the series followed up by Helbo.

In his series the patients (47) were distributed at follow-up on the age groups shown in Table 13.

Table 13. Age distribution in Helbo's series at follow-up. Mean age 42 years.

Age groups (years)	No. of pts.
50–60	5
40–50	24
30–40	18

First, the calculation in the age group 40–50 years:

If the age of all 24 patients in this group is just over 40, the expected osteoarthritis rate in the group will correspond approximately to Ruelle's rate at 40: 36 % (Tables 11 and 12). But if the majority are closer to 50, the osteoarthritis rate in the group will correspond approximately to Ruelle's rate at 50: 70 %. As a rule, and especially in the middle groups, the patients are evenly distributed over the age range 40–50 years, and if so the osteoarthritis rate in this age group corresponds approximately to the mean of Ruelle's rates at 40 and 50, i.e. the osteoarthritis rate at 45 is 53 %. (In the extreme groups, under 30 and over 60, the mean value has to be corrected a bit (shown graphically in Diagram 23)).

According to Ruelle's values, then, one would expect finding in the age group 40–50 years $\frac{24 \times 53}{100}$ = 13 patients with osteoarthritis.

A similar calculation may be performed in the other age groups. Addition will show that of all 47 patients of the material 21 will – according to Ruelle – have subjective symptoms of osteoarthritis at the time of follow-up, i.e. about 45 %.

However, the presupposition that this value is correct is that *all* patients of Helbo's series are potential osteoarthritics – and they are presumably not. According to the review of the literature in the preceding section, etc., it is predominantly likely that the patients of the primary radiological group "NORM.sph." will escape osteoarthritis – whereas all patients of the other groups are at risk. Therefore, the percentage size of these groups combined ("PATH.sph." + "NON-sph.") ought to indicate the maximum rate of osteoarthritis in the material.

But in Helbo's series – and the other series followed up – the size of the group "NORM.sph." cannot be definitely ascertained. Therefore, that part of the series in which there is a risk of osteoarthritis cannot be definitely singled out. However, major errors are not made – at least not in series having small "SPH." groups – by fixing the size of the part risking osteoarthritis by an estimated division of group "SPH.", int. al. with regard to any spread of osteoarthritic symptoms into this group as *found at follow-up* (cf. e.g. Gower & Johnston's series).

In Helbo's series, however, the size of group "NORM.sph." may be estimated with somewhat greater accuracy, as he had measured epiphyseal quotients. On that basis the groups "PATH.sph." + "NON-sph." were estimated at *95 %*. Accordingly, the expected rate of osteoarthritis at follow-up is $\frac{45 \times 95}{100} = 41$ %.

Similar calculations may be carried out in Gower & Johnston's and in Danielsson & Hernborg's materials, but not in Sundt's (II) and Ratliff's, as the age distribution at follow-up is not stated.

The results are shown in Table 14.

It is a common feature to all patients of Ruelle's series that sooner or later after onset of symptoms they *applied for treatment* in a "rheumatic" clinic.

Table 14. Percentage of osteoarthritis, calculated and found at the time of the latest follow-up examination in the series of Helbo, Gower & Johnston, and Danielsson & Hernborg.

Values calculated on the basis of those in Ruelle's total material (I + II), the maximum possible osteoarthritis rate being fixed as 95 % in Helbo's series, 86 % in Gower & Johnston's, and 72 % in Danielsson & Hernborg's.

	Calculated	Found			
Author	Clinical osteoarthritis (subj. sympt.)	Clinical osteoarthritis (subj. sympt.)			Radiological osteoarthritis
		Total	"Treatment requiring" (Helbo)	Disabling	
	%	%	%	%	%
HE	41	62	34	21	56
GOW	42	61		28	77
DA	28	pain 20 severe compl. 17		0	50
HE + GOW + DA	39.6				

The values in Ruelle's analysis (Table 11) are based upon data concerning the *time of onset of the symptoms,* but in the summation groups used in the calculation – patients developing osteoarthritis prior to the age of 30, 40, 50, etc. – the symptoms must have started in most cases many years earlier. Therefore, the majority of patients in the groups have applied for treatment long ago. In only a small number of cases the symptoms have set in a short time before the ages for which the osteoarthritis rates were calculated, so that at that time the patients have not yet applied for treatment. Regrettably, Ruelle does not give any data regarding the interval between the onset of symptoms and the presentation for treatment.

In fact, therefore, the values in Ruelle's analysis concern patients *the majority of whom had applied for treatment,* because *they felt* that their symptoms *required treatment.*

Thus, if values from Ruelle's material are used for calculating the osteoarthritis rate in a given LCPD series at a given time, the calculated rate will *express mainly the percentage of patients who had applied for treatment* – i.e. patients with "treatment-requiring" osteoarthritis *in the sense stated.* But as the calculated percentage will include a small number of patients who have not yet applied for treatment, it must be expected to be a little higher than the actual percentage of patients who have applied for treatment.

In the above analyses of osteoarthritic symptoms found at follow-up in various materials, all, even the mildest, symptoms recorded have been included. Therefore, the stated rate of osteoarthritis is a maximum.

From among these cases we can now (possibly) single out a smaller group of patients who had applied for treatment (having "treatment-requiring osteoarthritis") and from among them an even smaller group with "disabling" osteoarthritis.

In other words, the percentage of patients who had applied for treatment will be between that of patients with "disabling" osteoarthritis and that of all recorded cases.

From Table 14 it may be seen that if the values from Ruelle's total series are applied to Helbo's and Gower and Johnston's, the *calculated* percentages fit the *found* ones well:

In both series the calculated rate of osteoarthritis is between that of "disabling" osteoarthritis and all recorded cases of osteoarthritis.

Helbo even recorded a rate of "treatment-requiring" osteoarthritis (corresponding to our term) which is exactly where it would be expected: a little lower than the calculated rate, viz. 34 % as compared with 41 %.

In Danielsson's and Hernborg's series it is difficult to compare the calculated and found values, because evidently Danielsson's evaluation of the symptoms differs from that in other materials (Diagram 17).

For instance, Danielsson and Hernborg's percentage of *all* clinical cases of osteoarthritis (including a limp 23 %) seems to correspond largely to Helbo's percentage of "treatment-requiring" osteoarthritis (cf. Appendix, Comment 5) – and his percentage of patients with "more troublesome symptoms" to Helbo's and Gower & Johnston's percentage of patients with "disabling" symptoms.

When this is taken into consideration, the calculated osteoarthritis rate (28 %) is in reasonable conformity with the findings in the other two series.

From the agreement between the calculated and found values in Helbo's and Gower & Johnston's series it is apparent that in fact the development of osteoarthritis in their series has been like that in Ruelle's *total material* of secondary osteoarthritis.

But if we apply values from Ruelle's *"more severe" groups* (e.g. group I) to Helbo's and Gower & Johnston's series, we get calculated rates of osteoarthritis *too high* in relation to those found. The fact is that in these groups the development of osteoarthritis starts earlier. In the *"mild" groups* (e.g. II c) the osteoarthritis develops later – and the use of values from these groups will make the calculated osteoarthritis rates *too low*.

It is a presupposition for the above calculation that the patients' age distribution at follow-up is known: Only then can the expected rate of osteoarthritis be calculated on the basis of Ruelle's values. If we know the age distribution in the materials at follow-up, we also know the age distribution at *any time before and after* (normal mortality does *not* essentially alter *the age distribution)* – and it ought to be easy to calculate the rate of osteoarthritis expected, according to Ruelle, at any time.

This involves int. al. the possibility of calculating the *future* development of osteoarthritis in the three series with reasonable accuracy: When calculation of the osteoarthritis rate in the series, more than 25 years after onset of the disease, fits the actual one so relatively well, calculation of the future osteoarthritis rate ought to show reasonable agreement with the development of osteoarthritis which is going to take place.

Therefore, such a calculation will be attempted.

The procedure is as follows – using Helbo's follow-up series as an example:

The age distribution in Helbo's series at follow-up was as shown in Table 13. When adding 10 years to the age groups we get the age distribution in the material *10 years after the follow-up* (Table 15).

By means of Ruelle's values, the rate of osteoarthritis at this time may now be calculated as described for Helbo's series at follow-up.

Table 15. Age distribution in Helbo's series 10 years after the follow-up examination.

Age groups (years)	No. of pts.
60–70	5
50–60	24
40–50	18

Table 16. Calculated *development of clinical osteoarthritis presented for treatment from 1930 to 1980 in the series followed up by Helbo and the percentage* found *at Helbo's follow-up examination in 1950.*

"Presented for treatm.": Osteoarthritis in patients who have applied for physiotherapy, orthopaedic treatment, radiotherapy, or the like.

The calculations were done using values from Ruelle's total material (I +II). Starting from the number and age distribution of the patients seen at follow-up in 1950, they were carried out at 10–year intervals before and after the follow-up examination.

The calculated percentages are equal to the osteoarthritis rate in patients surviving at the times stated (cf. Appendix, Comment 5).

The maximum possible osteoarthritis rate in the series is fixed at 95 %. (Appendix, Comment 5).

Mean age	Calendar year	Clinical osteoarthritis in Helbo's series (I–HE) Found All cases of clinical osteoarthritis	Calculated Presented for treatment	Found Presented for treatment	Found Disabling osteoarthritis
		%	%	%	%
72 years	1980		93		
62	1970		85		
52	1960		67		
42	**1950**	62	41	34	21
32	1940		18		
22	1930		6		

Corresponding calculations may be carried out 20 years, 30 years, etc. after follow-up – and also 10 and 20 years before.

The role of *normal mortality* in the older age groups may be taken into consideration – but it has proved of no major importance owing to the moderate age scatter in the materials.

The result is given in Table 16 and Diagram 24.

In exactly the same way, the future development of osteoarthritis in Gower &

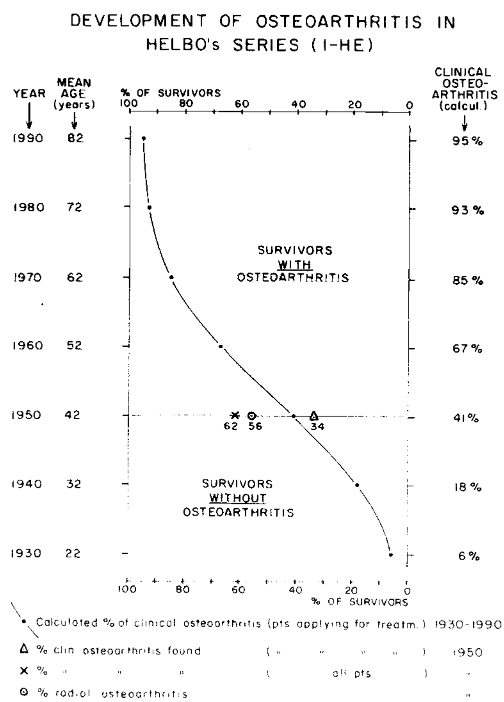


Diagram 24. Calculated *development of clinical osteoarthritis (pts. applying for treatm.) in Helbo's follow-up series (I–HE) performed by using figures from Ruelle's total material (I +II).*

% = % of survivors at the times stated (with corresponding mean ages).

The % of osteoarthritis found *at Helbo's follow-up examination in 1950 is also listed (+ % radiol. osteoarthr.).*

In other words, the diagram is in all essentials a graphic presentation of Table 16 (cf. legend of that table).

It will be seen that the % of clinical osteoarthritis (pts. applying for treatm.) calculated for 1950 – 41 % – is, as expected, somewhat higher than that found – 34 %, (because the calculated percentage comprises a small number of patients who had not yet applied for treatment).

Table 17. Development of clinical osteoarthritis presented for treatment in the series followed up by Helbo, Gower & Johnston, and Danielsson & Hernborg calculated *using figures from Ruelle's total material (I + II) based upon the age distribution at the time of follow-up.*

% = % of clinical osteoarthritis in the survivors at the time stated (Appendix, Comment 5). Maximally possible osteoarthritis rates: HE 95 %, GOW 86 %, DA 72 %.

	Calculated percentage of patients who have applied for treatment with symptoms of osteoarthritis					
	HE		GOW		DA	
	%	Mean age (years)	%	Mean age (years)	%	Mean age (years)
30 years later	93	72	85	75	69	71
20 years later	85	62	80	65	61	61
10 years later	67	52	65	55	46	51
At latest follow-up examination	41	42	42	45	28	41

Johnston's and in Danielsson & Hernborg's series may be calculated.

The total result of the calculations in all three series may be seen in Table 17.

Thus, if the follow-up is repeated 10 years after that which has been performed – when the patients have attained a mean age of 50–55 years – the percentage of patients who had applied for treatment of osteoarthritis in Helbo's and in Gower & Johnston's series must be expected to have increased from about 40 % at a mean age of 40–45 years, to about 65 % – or to almost two-thirds of the patients – in Danielsson & Hernborg's material presumably to one-half.

The development of osteoarthritis does not approach its maximum until the patients have attained the mean age of 60–65 at follow-up 20 years later. At follow-up at a mean age of 70–75 years the percentage of osteoarthritis has increased only slightly from the age of 60–65.

In other words: The follow-up examinations by the various authors have disclosed

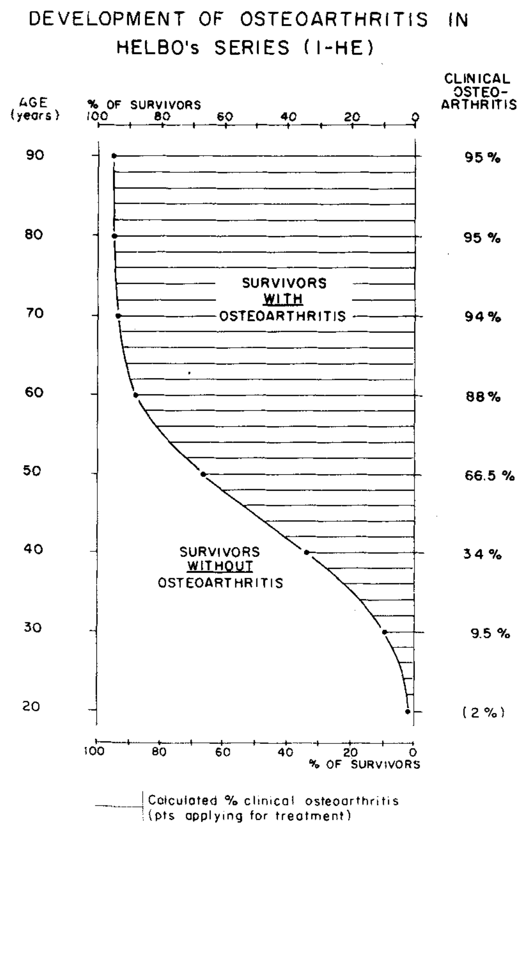


Diagram 25. Development of clinical osteoarthritis (pts. applying for treatm.) in Helbo's series, calculated by using figures from Ruelle's total material (I +II), the maximum possible osteoarthritis rate in the series being fixed at 95 %.

The percentages signify % osteoarthritis among survivors at the ages stated.

These values do not correspond quite to those in Table 16, as the osteoarthritis rates on this diagram are birth date *values, i.e. the osteoarthritis rate when the patients pass the stated birthdays, whereas the values in the table are the osteoarthritis rate when the* mean age *in the series is as stated.*

Calculation of the birth date values affords a possibility of a combination with the mortality curve, as visualized in Diagram 26.

only half the patients applying for treatment of osteoarthritis who will be found at a follow-up examination at a mean age of about 60.

The calculated percentages express the number of cases of osteoarthritis in per cent of survivors (cf. Appendix, Comment 5).

If the number of cases of osteoarthritis in survivors is to be expressed as the percentage of the original number of patients in a series, the mortality has to be taken into consideration (cf. Diagrams 25 and 26).

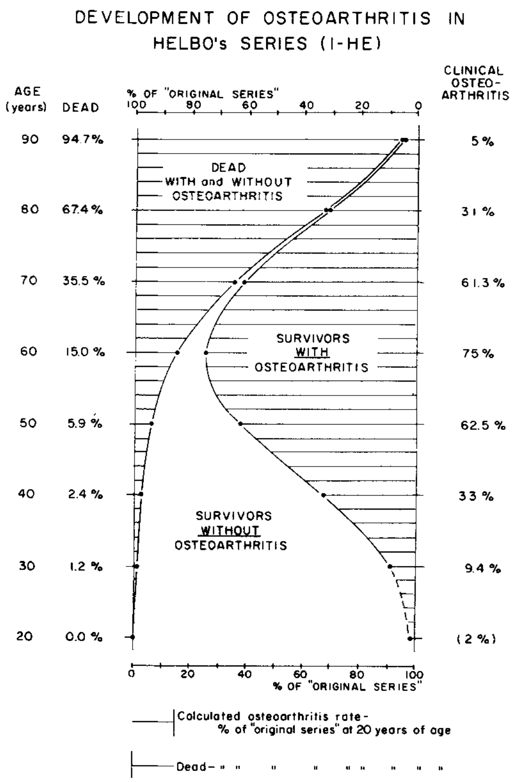


Diagram 26. Development of clinical osteoarthritis (pts. applying for treatm.) in Helbo's series calculated by using figures from Ruelle's total material (I +II), the maximum possible osteoarthritis rate being fixed at 95 %.

The calculated osteoarthritis rates signify osteoarthritis in the survivors when they pass the birthdays stated, expressed as % of the "original" series, *i.e. the number of patients at 20 years of age – not, as in Diagram 25, as* % of survivors.

(Mortality curve in relation to 20 years of age: Statistisk Årbog, Denmark 1968. As to the use of Ruelle's figures, cf. Appendix, Comment 5).

3. Calculated Clinical Long-term Prognosis for the Three Series Not Yet Followed Beyond Primary Radiological Healing: Wheelchair, Bed Rest, and Traction Series

When the future rate of osteoarthritis in the LCPD series with late follow-up can be calculated, it is of course also possible to calculate the subsequent development of osteoarthritis in the LCPD series treated in the 50's and 60's and only followed up to the time of primary healing – viz. the wheelchair, bed rest, and traction series.

The only condition is to know – as in the series seen at follow-up – the age distribution in one given calendar year after primary healing. In the followed series this condition was fulfilled, as the age distribution at follow-up was known. In the three series not followed, however, the age distribution at a given time after primary healing may be determined on the basis of knowing the ages and the calendar year when the patients were started on treatment. This is clearly apparent from Diagram 27 setting out the *traction* series. The age distribution in this series can be found for any calendar year after 1963. (As already mentioned, the normal mortality does not essentially alter the *age distribution,* as the age dispersion is relatively slight).

Similar diagrams can be set up for the *bed rest* and *wheelchair* series.

Incidentally, the same method is applicable to Helbo's followed series in which patient age and calendar year at institution of treatment are known. The development of osteoarthritis has been calculated on this basis – of course with practically *the same result* as when based upon age distribution at follow-up. Thus, if Ruelle' study had been known, it *would have been possible, already at primary healing in the 20's, to predict the development of osteoarthritis in the series, so that follow-up more than 25*

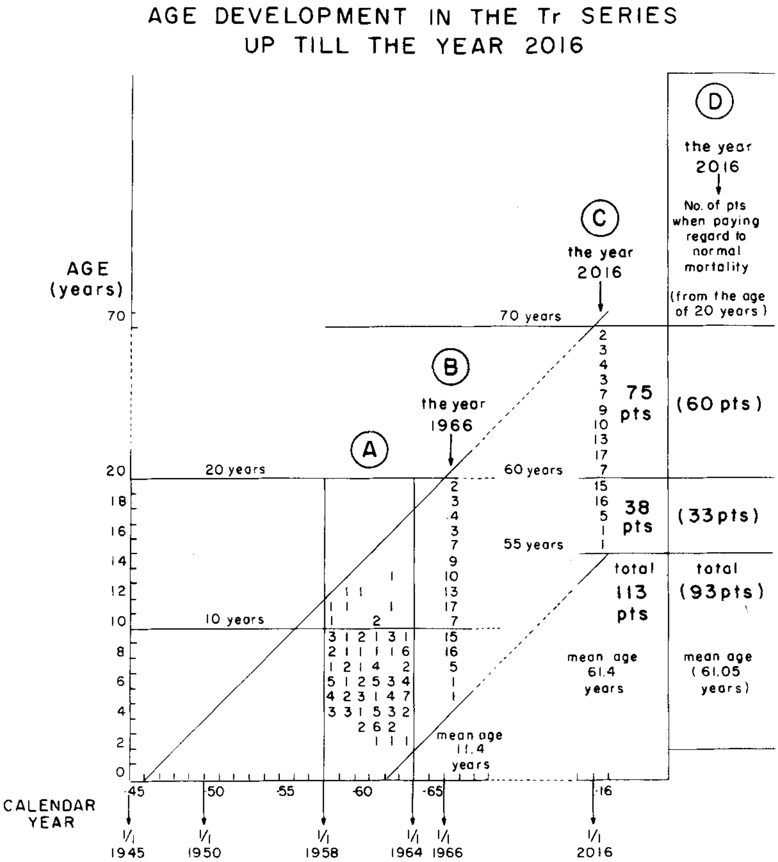


Diagram 27. Age development in the traction series up till the year 2016.

A: No. of pts., age, year at admission.
B–C: Age distribution in the Tr series in 1966 and in 2016.

On the diagram – within the two diagonal lines – no regard is paid to normal mortality.
Normal mortality (Stat. Årbog 1968) reduces the number of patients from 113 in 1966 to 109 in 1996, but the age distribution – and thereby the osteoarthritis rate – is practically unaltered (1966: mortality not included: osteoarthritis rate 8.4 % – included about 8.4 %). Up to the year 2016 the number of patients is reduced to 93, but the calculated osteoarthritis rate is reduced only from 29.5 to 29.4 % (little age dispersion).

D: This special column gives the age distribution and the mean age in 2016, paying regard to normal mortality, since the age of about 20 (1976).

years later would have confirmed what had been predicted.

In the three more recent series the maximum possible osteoarthritis rate may be determined with far more accuracy than in the followed series, as the size of the threatened groups "PATH.sph." + "NON-sph." has been established by direct measurements. (The percentages indicating the maximum possible rate of osteoarthritis will probably never come quite true, unless some patients of the "NORM.sph." group also develop osteoarthritis – which is of course not out of the question. For further details concerning the "max. possible" rate of osteoarthritis, cf. Appendix, Comment 5.

In the followed series figures from Ruelle's *total* material (I + II) were used for calculating the expected rates of osteoarthritis. In the three more recent series, treated far more energetically, the joint

Table 18. Development of clinical osteoarthritis presented for treatment in the Wh, BR, and Tr series as referred calculated *using figures from Ruelle's group II c.*

% = % of osteoarthritis in survivors at the mean ages stated.

The maximally possible osteoarthritis rate was fixed at 53 % in the Wh series, 54 % in the BR series, and 35 % in the Tr series.

Mean age	Expected rate of clinical osteoarthritis					
	Wh series (as referred)		BR series (as referred)		Tr series (as referred)	
(years)	%	Calendar year	%	Calendar year	%	Calendar year
71	51	2026	53	2019	34	2026
61	45	2018	46	2009	28	2016
51	30	2006	32	1999	20	2006
41	13	1996	14	1989	8	1996
36	6	1991	4	1984	4	1991
26	1.3	1981	0.7	1974	0.6	1981

deformities left by the disease are probably far less pronounced than in the poorly treated, followed series. Therefore, in calculating the *future* development of osteoarthritis in the wheelchair, bed rest, and traction series, the author used figures from *Ruelle's mildest group* of osteoarthritis (II c), viz. those following upon acetabular dysplasia (120 patients) instead of from his total material. Possibly, the joint deformities in Ruelle's group II c were somewhat milder than in our three series. Using the figures from Ruelle's total material, we get somewhat higher osteoarthritis rates. But the difference is not great. Only, the figures are shifted roughly 5 years downward in age – i.e. the osteoarthritis develops 5 years earlier – but otherwise according to the same pattern as when using the figures from Ruelle's group II c (Diagram 23).

Table 18 gives the result of the calculations based upon the values from Ruelle's group II c.

The expected rates of osteoarthritis at a mean age of 40 are low: 8–14 %. Between 40 and 50 the percentages double, and between 50 and 60 they rise by 50 %. After the age of 60 the increase is slight.

(The osteoarthritis rate may also be calculated in relation to the patients' 40th, 50th, and 60th *birthday* instead of the *mean age* of 40, 50, and 60 in the series. This shows trebling of the osteoarthritis rate between the 40th and 50th birthday, as by this method we avoid the masking of the development of osteoarthritis caused by the use of the mean age. The fact is that the osteoarthritis rates in the older and younger cases of the series alter less in the course of this decade than in the group around the mean age).

Of course the concrete figures in the table are fairly uncertain, but the *relations* between the results obtained in the three series and the pattern of the development through the years are probably correct.

Table 18 shows the clinical long-term prognosis in the three *series as referred,* calculated by the aid of Ruelle's values on the basis of the joint deformities present at primary healing.

On the other hand, it does not afford reliable information about the *relative* efficacy of the three therapeutic methods, which is masked by the different severity of the series at referral.

It is possible to throw light upon this aspect only by analysing the radiological and the consequent clinical results of the three methods in uniform parts of the three series – which affords small groups of patients – or in one series composed either as the wheelchair series, the bed rest series, or the traction series.

In the radiological sections the author

arrived at the result that the latter method was more reliable. Therefore, the calculated radiological results of the three therapeutic methods in *one* series of *the same* composition *as the wheelchair series* – or more correctly in three identical series thus composed – were used for determining the efficacy of the three therapeutic methods with a view to late clinical results. The result may be seen from Table 19.

In this table the development of osteoarthritis is naturally according to the same pattern as in Table 18. The order of magnitude of the figures has also not changed, but the picture of the relative efficacy of the three therapeutic methods is more distinct, not masked by the difference in severity between the three treated series.

It is apparent that in this table the rate of osteoarthritis after *bed rest treatment* and *traction treatment* is lower in relation to that after *wheelchair treatment* than it was in Table 18 – after traction treatment only half that after wheelchair treatment.

This seems a striking difference – but if the results are expressed in the percentage of cases *without* osteoarthritis it is not quite so outstanding: At the mean age of 41 years 87 % are without osteoarthritis after wheelchair treatment and 94 % after traction, a fairly unimportant difference: At this mean age *all* three forms of treatment have given good results. The relation between the few poor results is not of major practical importance.

The difference between the percentage of cases *without* osteoarthritis (after the three methods) does not really manifest itself until the mean age of 51 years: 70 %, 74 %, and 86 % after wheelchair, bed rest, and traction respectively. Thus, after treatment by traction there are 23 % more cases without osteoarthritis than after treatment in wheelchair and at the mean age of 61 years 44 % more. All this is clearly evident from Diagram 28 which affords a good survey of the expected late clinical results of the three methods of treatment.

Using the figures from Ruelle's total material (I + II) gives a somewhat lower percentage of cases without osteoarthritis at the ages of 51 and 61, as the osteoarthritis develops 5 years earlier.

However, the use of Ruelle's mild group (II c) probably affords the more correct results.

Then, Table 19 and Diagram 28 afford the final answer to the object of this study: To establish the late clinical result of the three methods of treatment, when applied under uniform conditions.

The *course of the study* which led to this result was: First a description of the *radio-*

Table 19. Calculated *development of clinical osteoarthritis presented for treatment in a series composed like the Wh series treated by Wh or BR or Tr.*

% = % of osteoarthritis in survivors at the mean ages stated.

In the calculation figures from Ruelle's group II c were used.

The maximally possible osteoarthritis rate was fixed at 53 % after Wh treatment, 46 % after BR treatment, and 25 % after Tr treatment.

Mean age	Calendar year	Expected rate of clinical osteoarthritis in a series composed like the Wh series treated by		
		Wh treatment	BR treatment	Tr treatment
(years)		%	%	%
71	2026	51	45	24
61	2016	45	39	21
51	2006	30	26	14
41	1996	13	11	6
36	1991	6	5	3
26	1981	1.3	1	0.6

CALCULATED DEVELOPMENT OF OSTEOARTHRITIS IN THE Wh SERIES AT 3 DIFFERENT METHODS OF TREATMENT

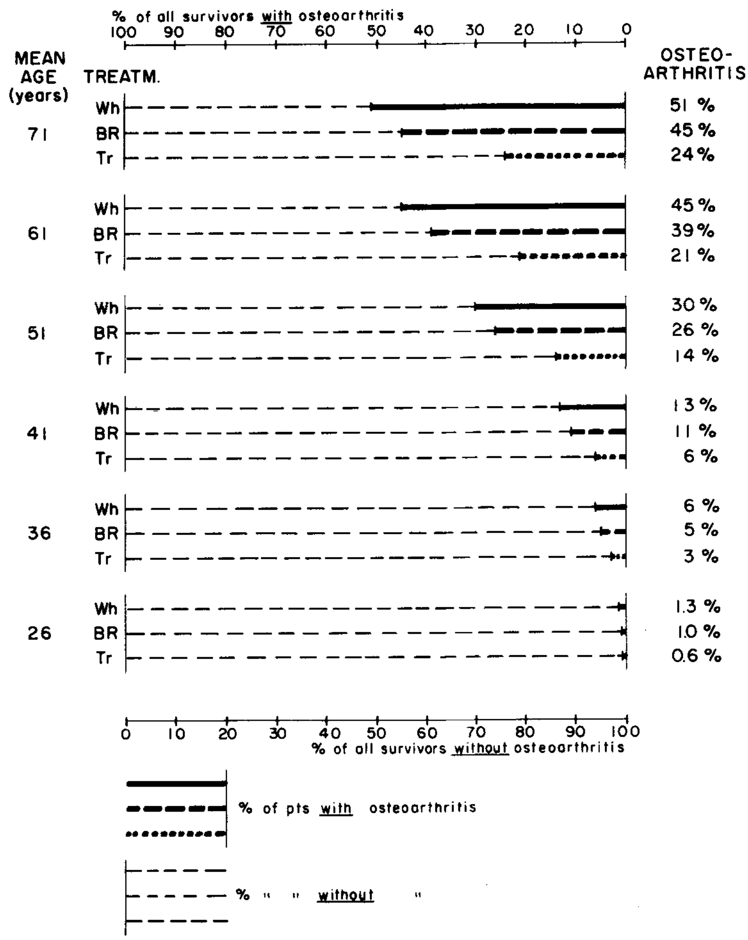


Diagram 28. Expected (calculated) clinical osteoarthritis (pts. applying for treatm.) in a series composed like the Wh series (with regard to age and stage at institution of treatment) after 3 different methods of treatment (Wh, BR, and Tr).

% of survivors calculated by using figures from Ruelle's group II c.

The series are arranged according to – –→ + osteoarthritis, from L to R.

logical results obtained by the three methods – paying particular regard to the fact that the methods had been applied to series of different severity.

Thereafter, a review of the available *follow-up reports of LCPD series.* This afforded a picture of the actual development of radiological and clinical osteoarthritis in more or less effectively treated series up to the mean age of approx. 40.

Finally, studies of special *series of osteoarthritis* (int. al. Ruelle's) supplied information as to how symptoms of secondary osteoarthritis developed up to an advanced age after different degrees of articular deformity.

By a combination of these three groups of data – *radiological and clinical* – the author arrived at the figures set out in Tables 18 and 19.

The figures in these tables were obtained by calculation – and they are stated in exact figures (31 %, 47 %, etc.). This numerical accuracy does not reflect the real uncertainty – which is appreciable.

The sources of error are numerous, and it is difficult to assess their role:

The calculations are based upon different figures: *Measurements* on X-ray films of varying accuracy, *figures* from reports in the literature, often of regrettable brevity and questionable relevance.

Lastly, the correctness of the calculation depends entirely upon whether these uncertain figures are interpreted and *used in the right way*.

En route to these final tables – and others similar to it in the clinical section – there are in short so many factors of uncertainty and so many pitfalls that it may be asked whether the efforts were worth while.

To this scepticism it may be rejoined that at present at least there is no other possibility of elucidating these problems.

Moreover, the uncertainty is hardly *so* great that the results can be dismissed as being of no major interest.

True, the concrete figures should no doubt be regarded with a great deal of reserve. However, the *relations* between the tabulated figures, vertical as well as horizontal, are based upon so much consistent evidence, obtained by different methods of measurement and calculation, that in broad features they will probably prove to correspond to the actual findings at the time when sufficiently late follow-up studies can be performed – i.e. when the mean age is at least 60 years.

In the case of our three series this will not be until the years 2009–2016.

POSTSCRIPT 1974 TO CLINICAL SECTION

Attempt at Checking the Calculated Late Development of Osteoarthritis in HELBO's *Series*

A Follow-up After a Minimum of 50 Years

After completing the work described above, the present author, in collaboration with Mose et al., – conducted a follow-up examination in 1974 of those who could be traced of Helbo's patients who had attended follow-up already in 1950. Regrettably it was possible to trace only 25 of the 36 who are presumed to be still alive. From a statistical point of view, therefore, the results are very uncertain.

In 1974 all 25 patients had been followed for more than 50 years – mean follow-up period 57 years. Their mean age was 65, approximately the same mean age and age distribution that might be expected if all survivors had been traced.

A detailed account of the total result will be published later by Mose et al. Here follows merely a brief report of that part of the results which bears relation to the problems of the present study.

It must be pointed out first that what characterizes Ruelle's patients is that sooner or later all *applied for institutional treatment* of their arthritic symptoms. No mention is made of any other characteristic of their osteoarthritis.

Therefore, if the osteoarthritis rates *calculated* on the basis of Ruelle's figures are to be compared with those actually found, they have to be compared with the percentage of patients found who had applied for treatment of their osteoarthritis (Appendix Comment 5).

However, Ruelle's figures comprise also a small number of patients who had not yet applied for treatment at the ages stated – though decreasing as time went by (Appen-

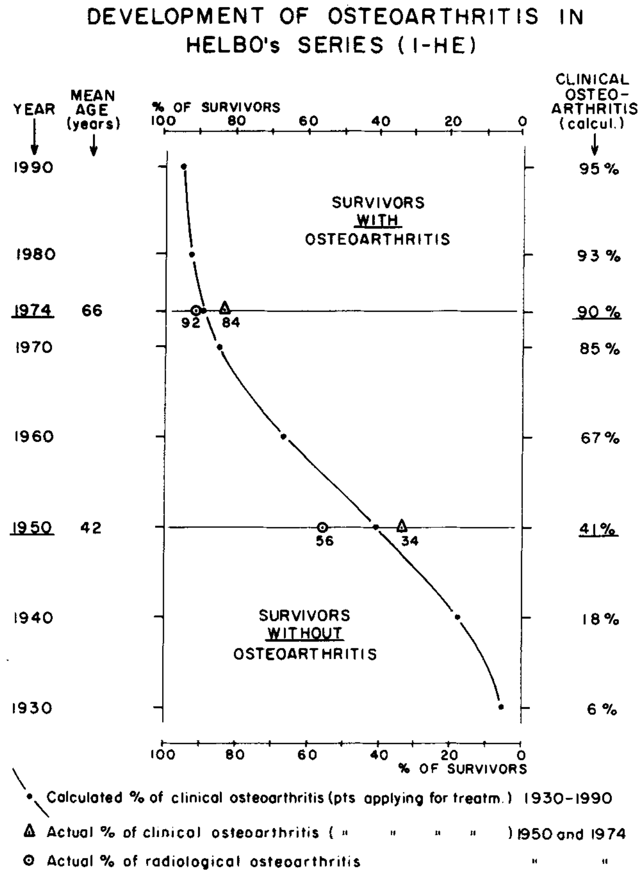


Diagram 29. Calculated *development of clinical osteoarthritis (pts. applying for treatm.) in Helbo's series (1–HE) performed by using figures from Ruelle's total material (I + II).*

% = % of survivors.

The diagram also lists the osteoarthritis rates found *at Helbo's follow-up examination in 1950 and at the follow-up examination in 1974.*

It will be seen that the clinical osteoarthritis rates calculated for 1950 and 1974 (pts. applying for treatm.), 41 % and 90 % are – as might be expected – somewhat higher than those found (34 % and 84 %), because the calculated rates comprise a small number of patients who have not yet applied for treatment.

Comment: Diagram 29 is not quite correct. The curve was traced on the presupposition that the follow-up examination in 1974 comprised all survivors from Helbo's 1950 follow-up examination, but it comprises only part of them (25/36 pts.). However, if the calculation for 1974 is performed with the correct mean age and age distribution, the result will be only a trifle lower than the figures on the curve (88.5 %/90 %).

Thus, it seems permissible to trace the curve together with the results of both follow-up examinations.

This renders the diagram more instructive.

dix Comment 5). Thus, osteoarthritis rates calculated on the basis of Ruelle's figures must be expected to be somewhat higher than the percentages of patients who had applied for treatment found at follow-up.

From Table 14 it is apparent that at follow-up in 1950–1951 Helbo found signs of *radiological* osteoarthritis in 56 % of the patients and that 34 % had applied for treatment because of its symptoms.

Calculation using Ruelle's figures resulted in 41 % who had applied for treatment of osteoarthritis – indeed, as expected, a somewhat higher rate than that actually found.

This was an agreement as close as could

be demanded. I therefore ventured to use Ruelle's figures for calculating the size of the group of patients who had applied for treatment up to an advanced age.

According to Table 16, this group would be expected to make up 85 % of all survivors in 1970, 20 years after the follow-up examination, and in 1974 90 %. If the relation of this calculated percentage to the percentage of patients who had applied for treatment actually found was the same in 1974 and in 1950, 75 % of the survivors would be expected to have applied for treatment of osteoarthritis in 1974.

But as already mentioned, it must be anticipated that the older the patients get, the higher a percentage of the calculated number – and incidentally of all patients with radiological osteoarthritis – will have applied for treatment of their symptoms. In other words, it must be expected that the number of patients with osteoarthritis who had applied for treatment will approach the calculated rate with advancing age – and that in 1974 it ought to be somewhere between 75 % and 90 % of the surviving patients.

The actual finding was 84 per cent.

Thus, the rate was 93 % of the calculated rate as compared with only 83 % in 1950.

It may be added that the majority of the 84 % patients who had applied for treatment of osteoarthritis were also more or less disabled (76 % of the total patients).

Diagram 29 clearly sets out the relations between the calculated and found values – in *1950* and in *1974* (cf. also the legend).

However, the values listed in the diagram require a comment:

All the percentages, *found* and *calculated*, in 1974 are *maximum values.*

Of the cases of *radiological* osteoarthritis found 2 or 3 must be said to be questionable, even to experienced radiologists (Helbo's Cases 58, 112, and 119). They are included as radiological osteoarthritis, because the presence of radiological osteoarthritis cannot be excluded.

The number of patients found with *clinical* osteoarthritis (21) is also at the upper limit.

It is common to them all that at some time or other they had applied for *treatment of their symptoms.* In other respects they fall into several groups.

The largest group (12/21) had symptoms and signs of *osteoarthritis of the hip* only – and no complicating features. All could indubitably be called cases of secondary osteoarthritis of the hip.

But a smaller – but nevertheless a surprisingly large – group (9/21) had, in addition to symptoms and signs of osteoarthritis of the hip, also low-back pain, lumbago, stiffness of the back with limitation of movement, radiating pain in the legs, etc.

Some had only backache *without* objective signs of vertebral disease – evidently merely pain radiating from the hip disease – but the majority had *radiological changes of the spine,* indicating that in fact the back complaints originated from the spine. There might be merely static changes in the shape of the spine, scoliosis, lordosis, etc. or signs of actual diseases: Spondylarthritis, degeneration of intervertebral discs, spondylolisthesis, etc.

In these cases the back complaints usually appeared later than – occasionally at the same time as – the symptoms of osteoarthritis of the hip. When also considering the striking frequency of back complaints in the material, this rendered it likely that an essential proportion of the vertebral lesions had developed *secondarily* to the osteoarthritis of the hip, possibly to the primary LCPD.

In cases where the back complaints were merely a superstructure on well-defined osteoarthritis symptoms from the hip (5 patients), they could rightly be assigned to the group osteoarthritis of the hip. The back complaints – and the underlying vertebral lesions – were in fact merely a further development of pure "secondary osteoarthritis of the hip". Yet, it must be conceded that in these cases the term osteoarthritis of the hip embraces a more comprehensive syndrome than indicated by the name. A more apt term might be *"secondary hip-back syndrome"*, perhaps only "late secondary syndrome". It is indeed by no means certain that the late sequelae to LCPD are restricted to these two skeletal sites.

In a small number of patients (4) the radiological signs of osteoarthritis in the hip were not marked, but indubitable, and the hip symptoms were so mild that the *back complaints were predominant.* In such cases it was more doubtful whether the term osteoarthritis of the hip was justified.

However, in a couple of these patients the back complaints were evidently due essentially to static abnormality of the spine, caused by the *primary hip deformity* following upon LCPD. However, the temporal occurrence – and exacerbation – of the back symptoms does not seem unrelated to the development of the mild *osteoarthritis* of the hip. *Therefore, these hip-back syndromes might also be interpreted as secondary osteoarthritis of the hip* in an extended sense. At least they were secondary to LCPD.

In the *remaining two patients* with mild symptoms and signs of osteoarthritis, the relation of the vertebral disease to that of the hip – the primary LCPD or the osteoarthritis – was more questionable. There might be a chance coincidence of hip and back disease, but a relation to the hip disease could not be excluded in either case.

Experience has shown that LCPD is not merely a local hip disease, but is associated with a generally altered state of the entire skeleton – manifesting itself int. al. in delayed development of the ossification centres in the carpus, reduced longitudinal growth, and the not uncommon occurrence of "aseptic necroses" in other epiphyses – "multiple aseptic epiphyseal necroses".

Apart from this, LCPD, or LCPD-like radiological changes are not uncommonly encountered as part of certain, familial "enchondral dysostoses" (Mau 1958), in particular dysplasia epiphysialis multiplex and Morquio's symdrome (Rubin, Fairbank). *In mild and early cases of these two syndromes the differential diagnosis against pure LCPD may even be difficult* (Fairbank 1951).

Morquio's syndrome usually involves considerable deformities of the vertebrae – dysplasia epiphysialis multiplex more rarely. The question now arises whether some of our combined hip-back syndromes might be examples of such combined *skeletal diseases* on a constitutional basis, especially the cases in which the back disease was not likely to be secondary to the hip disease.

In *one of these cases* (Helbo's Case 1) the hip disease was combined with a congenital spinal defect and an atypical disease of the central nervous system (CNS) "presumably" disseminated sclerosis.
With regard to the latter complication, it is enlightening that five familial cases of such combined disease of the hip, pelvis, spine, and CNS have been reported by Jequier and Streiff (1947). In their opinion the disease of the hip represented the sequelae to LCPD; the diseases of the CNS had features of congenital spastic paraplegia as well as of disseminated sclerosis.
The other case (Helbo's Case 107) is spondylolisthesis of the type which is familial (Newmann 1963). Newmann feels that the cause of this type is most probably stress fracture arising in constitutionally weakened bony tissue (+ ligaments).
In both cases the symptoms were of late onset.

These two cases might be interpreted as combined hip-back diseases on a constitutional basis – and the possibility that such cases *may* develop in a LCPD material *must* *be said to constitute a risk to LCPD patients.*

Let it be added that these cases of mild, but typical LCPD had healed with *"spherical heads".* In other words, they afford examples that healing with spherical heads is no guarantee against the development of radiological osteoarthritis of the hip and late hip-back symptoms.

Yet another case (HE No. 85) had healed with a spherical head. In this case there were no radiological signs of osteoarthritis, and the patient was symptom free.

From this review it is apparent that the great majority of these cases of secondary osteoarthritis of the hip, hip-back symdrome, and late symdromes in general may be collected under the designation secondary osteoarthritis of the hip in an *extended sense,* as described above.

The few cases – at an estimate two or three – in which there could be some doubt were nevertheless assigned to this group. This means of course that the percentage of patients with clinical osteoarthritis *found* in 1974 and depicted in Diagram 29 must be regarded as a maximum percentage – just like that of patients with radiological osteoarthritis.

The *calculated* percentage of patients with clinical osteoarthritis is also a *maximum value.*

All calculations are based upon the radiologically estimated "maximum possible percentage" of osteoarthritis in the material = 95 %, i.e. the radiological groups "NON-sph." and "PATH.sph." combined. It was found however, that this percentage had to be reduced, at least somewhat – probably to about 90 % – as 4–6 per cent of the *potential* cases of osteoarthritis will die before they develop osteoarthritis. In addition, a few of the numerous potential osteoarthritics will indubitably not develop the expected osteoarthritis, even though they live to a ripe old age. When considering the relation of the *calculated* percentage to that *found* at Helbo's follow-up study *in 1950* – whose correctness we are unable to check and therefore must accept – such further reduction cannot, however, exceed about 5 % (to approx. 85 %) – at least not if figures from Ruelle's total material (RU I + II) are to be used in the calculation. (If the reduction is to be greater, figures from one of Ruelle's smaller groups have to be used in the calculations (e.g. RU I)).

It must be pointed out that a possible reduction in the final maximum osteoarthritis rate cannot alter the fact that all patients in 95 % of the material – i.e. in the patient groups "NON-sph." and "PATH.sph." – are at risk, since the reduced, final percentage of cases of osteoarthritis will spread over 95 % of the material.

However, it is extremely difficult to fix the correct magnitude of such a reduction. Therefore, the more accurately defined 95 % will be maintained as a basis for the calculations.

This makes the rate of clinical osteoarthritis in Helbo's material *calculated* for 1974 also a *maximum percentage* – like the radiological and clinical rates of osteoarthritis actually *found.*

Of course, the *calculated* and the *two found* maximum values may be reduced (by approx. 8–12 % for all three rates) to values which are perhaps more realistic, but the reduced values will presumably prove even more uncertain than the maximum ones.

And this does not essentially alter the relation between the rates.

After these comments the result of the follow-up study may be briefly worded as follows:

92 % of the patients exhibited definite – or possible – signs of radiological osteoarthritis.

84 % had applied for treatment of secondary sequelae to LCPD – as a rule secondary osteoarthritis of the hip. A number of

these elderly *patients*, however, had developed a hip-back syndrome, in a few of them even with predominance of the back complaints.

Nevertheless, all could be assigned to the group with secondary osteoarthritis of the hip on the grounds stated above.

The main object of the follow-up study was to check the calculated percentage of patients who had applied for treatment of secondary osteoarthritis up to 1974.

According to the calculation 90 % of the patients would be expected to belong to this group. At follow-up the rate was found to be 84 %.

As it had been anticipated that the calculated rate was somewhat higher than that found, it must be concluded that the pre-calculated percentage afforded reasonably good guidance concerning the percentage that would be found in 1974.

Diagram 29 then affords a perspicuous survey of the agreeement between the calculated and found rates of osteoarthritis in Helbo's material at the follow-up studies in 1950 and in 1974.

Despite all uncertainty, such an agreement ascertained at repeated late follow-up studies of Helbo's patients – most recently with a follow-up period exceeding 50 years – must strengthen confidence in the calculations performed to predict the development of osteoarthritis in the three more recent series treated *by wheelchair, bed rest without traction*, and *bed rest with traction.*

However, as already mentioned, the correctness of these predictions cannot be checked until at follow-up of the patients after the year of 2000.

CONCLUDING REMARKS

1. Out-patient and In-patient Treatment

The main result of the present study is that in-patient treatment with traction affords better results than bed rest in hospital without traction and out-patient treatment in wheelchair. This is apparent from the X-ray films already at primary healing – but does not manifest itself clinically until an age of almost 50.

Thus, the choice between in-patient treatment with and without traction is not difficult.

It is a different matter when choosing between in-patient treatment with traction and out-patient treatment in wheelchair. During the 1950's and 1960's there have been constant paediatric warnings against treating children in hospital. It is claimed that a stay in hospital is a greater strain and psychlologically far more harmful than treatment carried out at home. The most convinced adherents of these views are even prepared to accept an essentially poorer somatic result, if only the treatment takes place at home.

Therefore, before choosing between in-patient and out-patient treatment, one must make up one's mind about these still widely held views on the harmful effect of hospital treatment upon children.

Are they based on realities?

To me it is doubtful.

At the Seaside Hospital, Refsnæs, about 500 children with LCPD have been treated. Of them I have seen 300–400.

Children with LCPD are put into 4–8 bed wards, and all are so to speak "in the same boat", where nobody can feel "odd man out" in the environment. They are surrounded by an experienced and large staff of doctors, nurses, nurses' aides, occupational therapists, and teachers to look after their correct treatment, entertainment, occupation, and instruction.

Nothing amuses children more than being with other children in the same situation and of the same age. Throughout the day, this companionship – indoors and out of doors – is full of diversions and fun. The result has been largely a collection of happy and well-adapted children with whom it has been a daily encouragement to associate.

I have followed all the children until they were 16–18 years of age, and neither their parents nor I have found that they differed in any way mentally from a corresponding group of children and adolescents who have never been ill.

On this background I try to visualize out-patient treatment with crutches or wheelchair at home – possibly in a flat – among healthy sisters, brothers, and mates under the responsibility of anxious parents. I must confess that I have some difficulty in convincing myself that treatment at home is on the whole less of a strain on the children than treatment in hospital.

On the basis of my, somewhat one-sided, experience, I can only say with certainty: The majority of the children adjust surprisingly well to hospital life. This may seem surprising, but it remains a fact. The explanation is probably that children have an amazing ability to put up with and remain unaffected even by the most peculiar circumstances.

To me, therefore, it is difficult to perceive the harmful effect of hospital treatment upon children – on the understanding that it takes place in a well-suited institution. As the somatic results of traction in hospital are – according to what has been stated above – definitely superior to those of out-patient treatment in wheelchair, I find no difficulty in concluding that:

Children with LCPD should, as far as possible, be treated by traction in hospital.

But of course it must be admitted that this is not always possible.

In the first place a small number of children cannot put up with treatment in hospital and a small number of parents cannot do without their children at home. Under such circumstances it should naturally be endeavoured to carry out home treatment as effectively as possible.

In the second place, a suited institution is not at disposal everywhere. This is probably the most common motivation for choosing out-patient treatment.

From my 1966 publication, the present study, and Jørgen Lauritzen's it is apparent that out-patient treatment in wheelchair is considerably more effective than out-patient treatment with a Thomas caliper. It has the great advantage, among others, that it permits non-weightbearing in *both* hips. Therefore, bilateral cases can also be treated – and in unilateral cases the very regrettable secondary development of LCPD in the "good" hip is avoided.

I doubt that a more effective out-patient treatment is available.

2. Radiological and Clinical Evaluation by Two Examiners

The radiological evaluations in the present study are of little value, if the measurements on which they are based cannot be reproduced with approximately the same result by others without a knowledge of J.M.'s measuring results.

Therefore, as already mentioned, the X-ray films of all patients in the three series were measured not only by J.M., but also, independently, by Lauritzen (LAU), who reported his results in 1975 (Diss.).

A total of about 4000 measurements were performed by both examiners – plus reading of 112 films showing non-spherical heads – for which the only "measurement" needed was ascertaining the absence of a spherical shape by means of Mose's plate.

In a large number of cases the examiners measured on the same film, but owing to the shift in the time of measurement in several cases, on different films of the same patient. I even did an extra series of measurements in the traction series to adapt the observation periods to LAU's.

Therefore, direct comparison of the measurements for each individual patient is of less interest – but can be done by comparing J.M.'s and LAU's patient lists. The patients of the traction and bed rest series have identical numbers in both publications. A list of the corresponding numbers in the wheelchair series may be seen in the Appendix, before the patient lists.

What is of interest is the comparison of the two sets of evaluation *results* obtained by the use of the independent measurements by the two examiners – in particular to ascertain whether agreement exists between the results affording the most reliable picture of the relative efficacy of the three methods of treatment: The results in the same series or in 3 identical series –

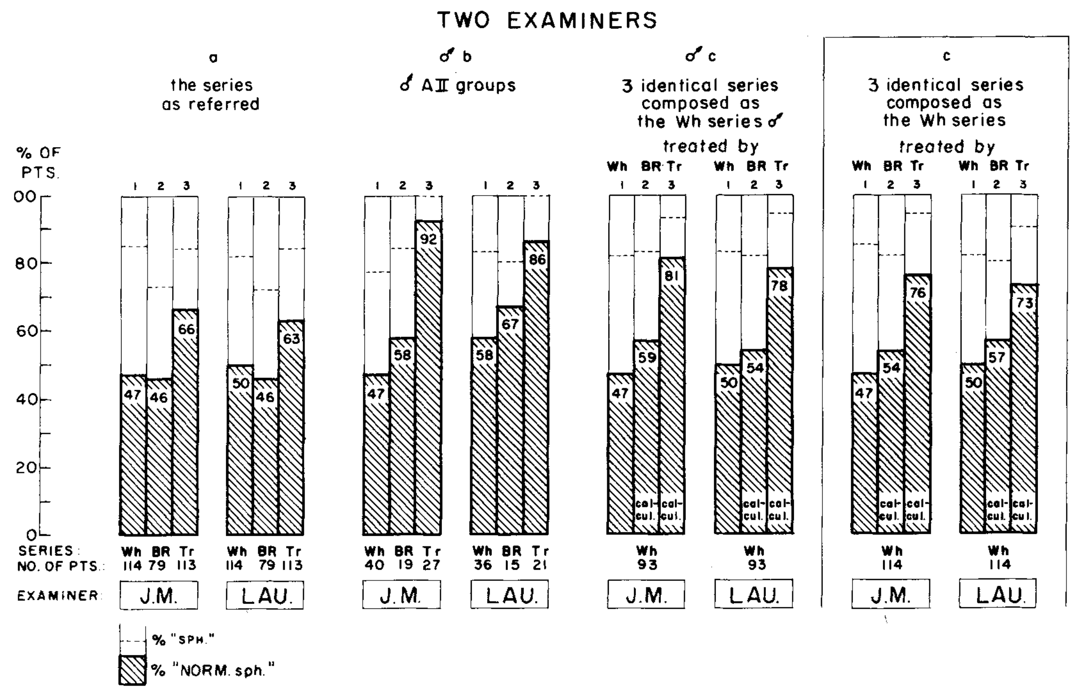


Diagram 30. Radiological results of treating the listed series and groups of patients by Wh, BR, and Tr, based upon measurements on X-ray films performed by 2 examiners *independently of each other.*

The columns show the result of treating:

				JM[1])	LAU[2])
a	1:	*the Wh series as referred by Wh*	("SPH.":	85 %	82 %),
	2:	*the BR series as referred by BR*	(,, :	73 %	72 %),
	3:	*the Tr series as referred by Tr*	(,, :	84 %	84 %).
♂b	1:	*the ♂A II group of the Wh series by Wh*	("SPH.":	77 %	83 %),
	2:	*the ♂A II group of the BR series by BR*	(,, :	84 %	80 %),
	3:	*the ♂A II group of the Tr series by Tr*	(,, :	100 %	100 %).
♂c	1:	*the ♂ of the Wh series as referred by Wh*	("SPH.":	82 %	83 %),
	2:	*the ♂ of the Wh series as referred by BR (cal.)*	(,, :	83 %	82 %),
	3:	*the ♂ of the Wh series as referred by Tr (cal.)*	(,, :	93 %	94 %).
c	1:	*the Wh series as referred by Wh*	("SPH.":	85 %	82 %),
	2:	*the Wh series as referred by BR (cal.)*	(,, :	82 %	80 %),
	3:	*the Wh series as referred by Tr (cal.)*	(,, :	91 %	90 %).

A total survey of the radiological results (JM) is given in the Appendix, Table 27.

The 3 groups of patients designated ♂b are the prognostically most uniform ones that can be singled out of the series, but the results in group c are probably of most practical interest.

1)JM: % calculated using JM's measurements by JM. *2)LAU: % calculated using LAU's measurements by JM.*

(Abbreviations and symbols p. 12).

which may be calculated from Lauritzen' as well as from my figures.

As a main example Diagram 30 (c) shows the results of the 3 therapeutic methods in a series composed like the wheelchair series, as these results have some practical perspective. (Of course, series composed like the traction or bed rest series would

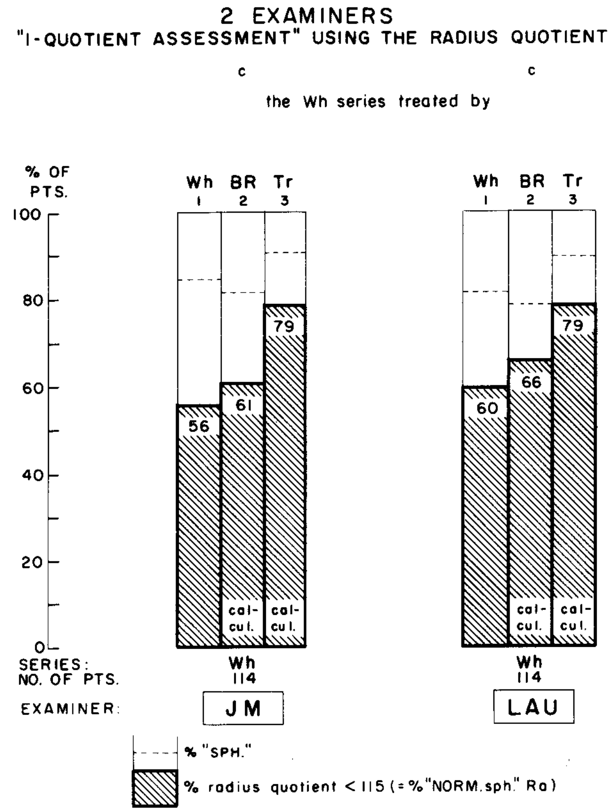


Diagram 31. Radiological results when treating the Wh series as referred by Wh, BR, or Tr (the results of BR and Tr calculated).

The assessment was exclusively by the aid of the radius quotient *("1-quotient assessment") measured by* 2 examiners *independently of each other.*

Radiological result of treating:

			JM[1]	LAU[2]
c	1: The Wh series as referred by Wh	("SPH.":	85 %	82 %)
	2: The Wh series as referred by BR	(,, :	82 %	80 %)
	3: The Wh series as referred by Tr	(,, :	91 %	90 %)

[1] *JM: % calculated using JM's measurements by JM.*

[2] *LAU: % calculated using LAU's measurements by JM.*

(% "NORM.sph. Ra", cf. p. 20. Other abbreviations and symbols on p. 12).

have served just as well). As a supplement, the two examiners' results in other series and groups of patients are shown (a, ♂ b, ♂ c). Particular interest perhaps attaches to the direct results in the three series as referred (a).

According to the diagrams, the agreement between the two examiners' results in all series and groups of patients is in fact amazing: In the main example (a) the percentages of "NORM.sph." differ by at most 3 % and of "SPH." by at most 5 % (of all patients).

In other words, two examiners, working independently, can perform the numerous measurements with such a degree of agreement that they arrive at practically the same evaluation of the efficacy of the three therapeutic methods.

In consequence, any clinician treating LCPD has a possibility of comparing, by the use of the measuring methods described, the efficacy of his treatment with that of wheelchair, bed rest, and traction treatment as described in the present study.

Such a possibility of comparison must facilitate the efforts at arriving at therapeutic methods affording an even better radiological result.

Similar agreement between two examiners can be obtained also by means of simpler methods of evaluation, the "one-quotient methods" mentioned above.

Diagram 31 is an example (cf. also Appendix, Comment 2).

But the *radiological* result is not the essential thing, only a basis for the evaluation of the *final clinical result,* which is decisive. The agreement between LAU and J.M. comes to an end, at least partially, in predicting the clinical consequences of the radiological results, i.e. in deciding which radiological group of patients will presumably not develop secondary osteoarthritis even at an advanced age and which groups are at risk.

My investigations led to the conclusion that only patients in the radiological group called "NORM.sph." (= LAU's "excellent") obtained a radiological result preventing in all essentials the development of secondary osteoarthritis. LAU, on the other hand, feels that all patients of the "spherical" group (= J.M. "SPH.") will remain free of osteoarthritis (LAU: Thesis 1975, p. 36).

LAU as well as J.M. have based their conclusions concerning the clinical implications of the radiological result mainly on the review of a number of reports in the literature on follow-up of patients with a history of LCPD during childhood – but they have not arrived at the same result.

In a detailed review of 19 reports on follow-up studies (described in the present publication, pp. 39–52) on which I based my conclusion, it was evident that several difficulties were involved in drawing a conclusion regarding the relation of the *primary radiological result* to *subsequent development of osteoarthritis.* These difficulties have not quite manifested themselves in LAU's review of the literature used by him. But of course they are present also in these reports, all the more so as they are largely the same as those reviewed by J.M.

First, the majority of the follow-up studies on which LAU based his conclusion were carried out at too early an age – in the early or middle twenties. As secondary osteoarthritis usually does not properly start until the forties, it is not surprising that LAU found osteoarthritis only in cases with the most severe deformities. The latest follow-up studies were in fact also too early – the mean age being only about 40.

Secondly, "spherical" and "round" in the literature usually means "golf-ball-shaped" or more correctly "3/4 golf-ball shaped", i.e. exactly "NORM.sph." – in LAU's terminology "excellent" – and certainly not "spherical" as defined by Mose and used by LAU himself – and J.M. – to characterize the cases in the "spherical" group – J.M.'s "SPH.".

The group "spherical" ("SPH.") in LAU's, J.M.'s, and Mose's sense is a *far more comprehensive* group than the "spherical" in the literature, comprising several appreciably deformed cases, cases with mushroom-shaped heads, but with a circular outline as defined by Mose (cf. Fig 1 a and b).

Therefore, although the "spherical" group from the literature seems to avoid osteoarthritis, LAU cannot draw the conclusion that *his* "spherical" group will avoid it. As substantiated by the present author, the conclusion that can be drawn from the literature is that only patients of the group "NORM.sph." ("excellent") remain free of osteoarthritis.

But when LAU applied *his* criterion – that all patients of the "spherical" group remain free of osteoarthritis – to evaluating the efficacy of the various therapeutic methods, he arrived in fact at the same *main* conclusion (LAU Thesis 1975: pp.

Table 20. Radiological results of wheelchair and traction treatments in the ♂A II groups of the series, assessed by % "SPH." and by % "excellent" (LAU) ("NORM.sph." J.M.), calculated on the basis of Lauritzen's as well as of J.M.'s measurements.

The ♂A II group of the Wh series includes only patients whose treatment had been carried out, according to Lauritzen, "perfectly" or "well". In the Tr series the ♂A II groups include only patients whose Tr treatment has been carried through for 12 months or longer.

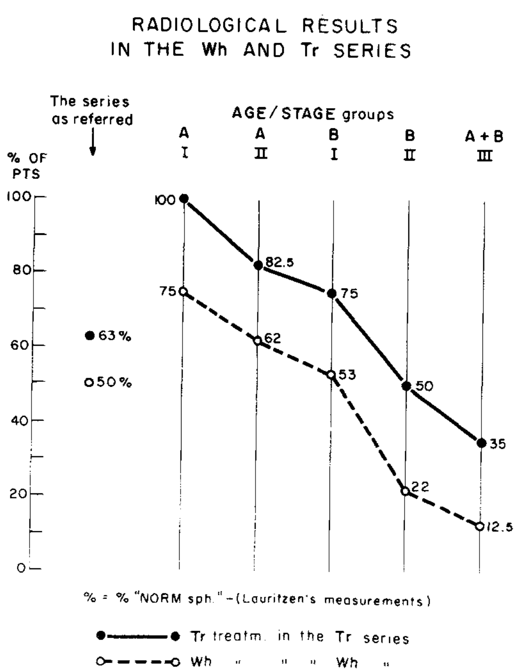
		% "SPH."	No. of pts.	% "Excellent"[1]) equal to % "NORM.sph."[2])	No. of pts.
LAU's measurements	**Wh treatment** of the ♂A II group of the Wh series carried out "perfectly" or "well"	88 %	(28/32)	58 %	(21/36)
	Tr treatment of the ♂A II group of the Tr series carried out ≥12 mo.	100 %	(17/17)	89 %	(16/18)
J. M.'s measurements	**Wh treatment of the ♂A II group of the** Wh series carried out "perfectly" or "well"	80 %	(28/35)	49 %	(17/35)
	Tr treatment of the ♂A II group of the Tr series carried out ≥12 mo.	100 %	(25/25)	92 %	(23/25)

[1]) (LAU), [2]) (J. M.)

128–129) as I did on the basis of my conclusion:

The result of traction *is* better than that of the other two methods of treatment.

On the other hand, there is not agreement as to *how much better.*



By the use of J.M.'s criterion it will be found, for instance, that *traction* treatment of a series composed like the wheelchair series gives a satisfactory result in about 60 % more patients than does *wheelchair* treatment (with traction: 76 % "NORM. sph.", with wheelchair treatment 47 % "NORM.sph.") – according to LAU's criterion in about 7 % (with traction 91 % "SPH.", with wheelchair treatment 85 %). This corresponds to LAU's evaluation that the result of traction is "slightly better" than that of wheelchair treatment).

As regards the corresponding differences in other groups of patients, using LAU's as well as J.M.'s measurements, cf. Diagram 30 a, ♂ b, ♂ c, and Table 20.

Diagram 32. Radiological results – only % "NORM.sph." – in the Wh and Tr series as referred and, in the age/stage groups of these series, calculated using Lauritzen's *radiological measurements.*

For comparison, cf. Diagram 4: The corresponding radiological results calculated using J.M.'s *radiological measurements.*

(Abbreviations and symbols, cf. survey p. 12. No. of pts. cf. Appendix, Table 26).

Thus, LAU's optimistic evaluation of the clinical sequelae in group "SPH." leads to an underestimate of the difference between the efficacy of traction and wheelchair treatment – and thereby to recommendations for treatment differing from those in the present publication. LAU states, for instance, in his thesis p. 129, that it is relatively immaterial how the patients of the oldest and youngest age group are treated, the results of traction not being essentially superior to those of wheelchair treatment. In only one, special group of patients in the middle age group does LAU feel that traction is a definite advantage.

The use of J.M.'s criterion of a good result – % "NORM.sph." – gives the results in the age/stage groups as shown in Diagram 4 (J.M.'s measurements). In all age/stage groups there is an appreciable difference in the results between wheelchair and traction treatment. This difference is, moreover, accentuated in the oldest and especially the youngest age group when using LAU's own measurements (Diagram 32).

The conclusion drawn from these results must be that as a general rule all age groups – also the oldest and youngest – should be treated by traction. (Of course, individual contra-indications may exist).

In brief: The two examiners LAU and J.M. measured the X-ray films with identical results – but evaluated the clinical consequences of the radiological results differently.

However, it must be emphasized that according to its wording, LAU's *main conclusion,* that traction gives the best primary radiological results and thereby the most favourable late clinical results, is in accurate agreement with J.M.'s evaluation.

The disagreement concerns only *how much better* the results are after traction.

J.M. of course feels that the predictions concerning the late clinical results of the three methods of treatment found in the present study have better foundations and therefore will come true. But the final decision must await the very late follow-up examinations – and even from such examinations it is empirically difficult to form a definite opinion, cf. Postscript p. 71.

SUMMARY

An attempt was made to evaluate the efficacy of three non-operative methods in the treatment of Legg-Calvé-Perthes Disease (LCPD).

The criterion was the long-term clinical result.

The following methods had been applied:

1. Out-patient non-weightbearing in a *wheelchair* – duration about 2 years.
2. Non-weightbearing in hospital by *bed rest without traction* for about 18 months, followed by ambulatory non-weightbearing for about 6 months – about 2 years in all.
3. Non-weightbearing in hospital by *bed rest with traction* for about one year, followed by bed rest without traction for about 6 months, and another 6 months of ambulatory non-weightbearing – about 2 years in all.

The starting point, and the basis of the study were three different series (comprising 114, 79, and 113 patients) each treated by one of the three methods.

The late clinical result depends largely upon *the primary radiological result.*

At first, therefore, the radiological result of each treatment was described by measurements on X-ray films and assessed according to the radiological joint deformity left by the disease: The less the deformity of the femoral head, the better the radiological result. Any joint deformities outside the femoral head were interpreted as secondary to the deformity of the head.

The procedure of measurement in a series was as follows:

First the X-ray films were divided into *two groups* according to whether the femoral head, measured with Mose's plate, proved to be *spherical* or *non-spherical.* The groups were designated "SPH." and "NON-sph.". Therafter, the group "SPH." was sub-divided – according to fixed measuring criteria – into two groups: normal spherical and pathological spherical, called "NORM.sph." and "PATH.sph.", whose nature is apparent from the designations.

According to the measurements on the X-ray films each series was thus divided into three groups of patients: "NORM. sph.", "PATH.sph.", and "NON-sph." according to the radiological shape and size of the femoral head.

Without a knowledge of the clinical consequences of the joint deformities in the three groups of patients, the size of the group "NORM.sph." was preliminarily considered a measure of the quality of the result: According to the X-ray films, it had to be assumed that only patients of this group would be likely to remain free of osteoarthritis.

Thus, the larger this group in a treated series, the better the result.

But now it was discovered that the three series differed mutually with regard to *factors*, apart from the treatment, *which affect the radiological result.* In other words: Differences in the radiological results between the three series reflected not only differences in the efficacy of the treatment, but also differences in the nature of the series.

Three factors were operative:

1. The *stage of the disease* at the institution of treatment: The earlier the stage, the better the result.
2. Patient *age* at institution of treatment: The younger, the better.
3. *Sex:* Boys attain – ceteris paribus – better results than girls.

With regard to these three factors the wheelchair series proved to be more favourable than the other two, which did not differ much mutually.

With a view to eliminating the influence of these three factors, the author picked out from each series a group – i.e. three in all – that was as far as possible uniform with respect to the named factors at the institution of the treatment. (Designation: ♂ A II – boys of the middle age group (II = 5–8 years) – who arrived for early treatment = A).

Now, the radiological result in these three groups of patients ought to afford a reliable picture of the relative efficacy of the three therapeutic methods.

Only, there was a drawback of this means of evaluation, viz. that the number of patients in each group was regrettably small (40, 20, and 27 pts.).

However, this drawback could be remedied:

Each series was divided into six age/stage groups (disregarding the sex ratio which was of minor importance) in the way that the cases in identically designated groups of the three series must be presumed to have a uniform prognosis prior to the institution of treatment.

Thereafter, the efficacy of the three therapeutic methods in the these groups was analysed. (Table 7, p. 26).

By transferring, for instance, the percentage results in the groups of the traction series to the corresponding groups of the wheelchair series, it was possible to ascertain which result would be obtained *by traction treatment of a series composed like the wheelchair series.*

Table 21. Radiological results – % "NORM.sph." – after 3 different methods of treatment (Wh, BR, and Tr)

A: in three groups of patients having a uniform prognosis when referred (the ♂A II groups).

The differences between the results of Tr and Wh treatm. and between Tr and BR treatm. in the groups are statistically significant (p <0.001 and p <0.02 respectively). (Cf. also legend of Diagram 11 and survey in the Appendix, Table 28).

B: in a series composed like the Wh series.

Diagram 33 is a graphic presentation of this table.

	Radiological results – % "NORM.sph." – of		
A	Wheelchair treatment in ♂A II group of the Wh series	Bed rest treatment in ♂A II group of the BR series	Traction treatment in ♂A II group of the Tr series
	47 %	58 %	92 %
B	Wheelchair treatment	Bed rest treatment	Traction treatment
	in a total material composed like the wheelchair series		
	47 %	54 %	76 %

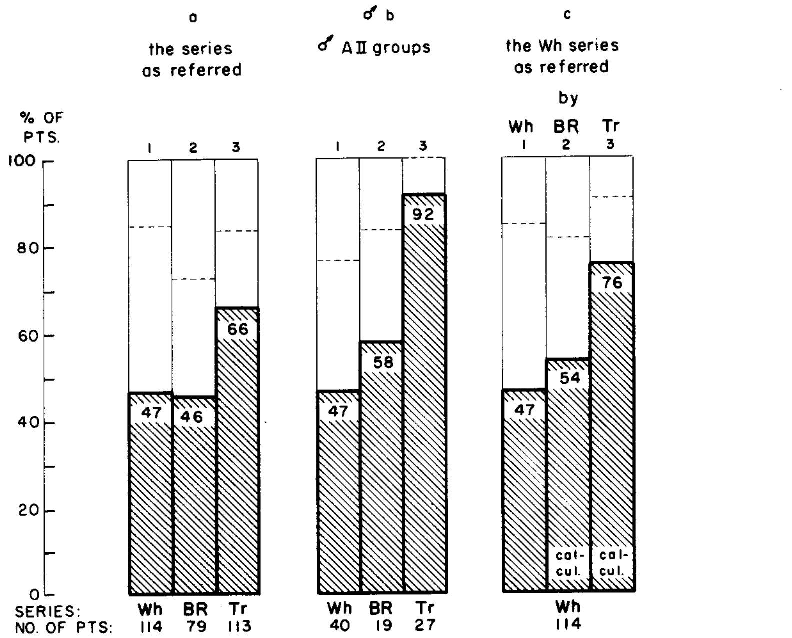


Diagram 33. Radiological results of treating:

a	*1: The Wh series as referred by Wh*	*("SPH.":*	*85 %)*
	2: The BR series as referred by BR	*(" :*	*73 %)*
	3: The Tr series as referred by Tr	*(" :*	*84 %)*
♂b	*1: The ♂A II group of the Wh series by Wh*	*("SPH.":*	*77 %)*
	2: The ♂A II group of the BR series by BR	*(" :*	*84 %)*
	3: The ♂A II group of the Tr series by Tr	*(" :*	*100 %)*
c	*1: The Wh series as referred by Wh*	*("SPH.":*	*85 %)*
	2: The Wh series as referred by BR (calculated)	*(" :*	*82 %)*
	3: The Wh series as referred by Tr (calculated)	*(" :*	*91 %)*

(For a total survey of the radiological results cf. Appendix, Table 27. Abbreviations and symbols on p. 12).

In other words, it was possible to determine the efficacy of the three methods in the same total material (e.g. the wheelchair series) and thereby obtain a wider statistical basis: Thus, the inaccuracy in the individual smaller groups ought to be equalized to a certain extent.

The result of this method for determining the radiological efficacy of the three forms of treatment is shown in Table *21 B.*

For comparison Table *21 A* sets out the result of the evaluation performed in the three small uniform groups of patients (♂ A II) (cf. also Diagram 33).

The reason why the difference in efficacy between the therapeutic methods is less marked in a total material than in the small uniform groups of patients is that a total material comprises cases with a very favourable and others with a very unfavourable prognosis – groups in which the results will be, broadly speaking and regardless of the treatment, *good or poor* respectively. In the small uniform groups of patients, on the other hand, all cases are sensitive to changes in the efficacy of the treatment.

Briefly, the main result of the radiological evaluation is:

Application of the 3 methods in series composed like the wheelchair series (or like the bed rest or the traction series) gives on treatment with *traction* $1^1/_2$ times as many satisfactory (and only half as many poor) radiological results as bed rest or *wheelchair* treatment.

(*Two examiners* measured the radiological deformities, quite independently of each other. Calculation of the radiological results on the basis of these two sets of measurements gave practically the same result (cf. p. 78, in particular Diagram 30)).

What now are the *clinical consequences* of these radiological results?

Perusal of 19 previous reports on more or less late follow-up studies of LCPD series treated by different methods revealed that radiological and clinical osteoarthritis was observed first and foremost in radiological group "NON-sph." and in small numbers, *but indubitably*, also in group "SPH." (presumably only in "PATH.sph.") – in the latter it is true, not until the patients had reached a mean age of about 40.

Later follow-up studies of LCPD series are not available at present (yet: vide infra).

The preliminary estimate that *only the group "NORM.sph." would remain free of osteoarthritis* (at least up to the mean age of 40) *was thus confirmed.*

At the same time, however, the investigation had shown that the cases of osteoarthritis that were found were mild and thus did not cause essential complaints – only about one-third of the arthritic patients being more or less "disabled".

Now, the problem was to ascertain the prognosis *beyond the latest follow-up study* at a mean age of 40.

Direct studies of LCPD series beyond this age were not available. However, investigation of large series of cases with secondary osteoarthritis – comprising also secondary osteoarthritis following upon diseases other than LCPD – showed in retrospect that in general secondary osteoarthritis develops according to a fairly uniform pattern, regardless of the nature of the primary disease:

The first symptom appeared:

in 1/3 of the cases before the age of 40,
in 1/3 of the cases between 40 and 50,
in 1/3 of the cases after the age of 50.

The time schedule shifts somewhat: In the event of *severe* joint deformities the osteoarthritis sets in earlier – in more cases before the age of 40 – and in the event of *mild* deformities later – in more cases after 50.

The largest material of osteoarthritis from which these data can be deduced is *Ruelle's (1961).* Indeed, it also proved a good exponent for the result of the studies of others (Jerre 1950, Wiberg 1939, Danielsson 1964, Lloyd Roberts 1955, Lance 1937, and others).

Ruelle's material comprises 271 patients *who applied for treatment* of secondary osteoarthritis due to different causes. (Thus, the rate of osteoarthritis in his material is 100 %).

The time of onset of clinical symptoms of osteoarthritis (joint pain, joint stiffness) could be mapped in retrospect with reasonable accuracy. Thus, it was possible to ascertain the percentage of the total cases of osteoarthritis developing prior to the 30th year of age and thereafter in the age groups 30–40, 40–50, 50–60, etc.. Thereby, a total picture of the development of osteoarthritis could be obtained.

This picture applies to Ruelle's mixed series, but the values can be used also for drawing a picture of the development of osteoarthritis in pure LCPD series – provided that the deformities in these series, with respect to arthritogenic effect, are comparable with those in Ruelle's total, mixed material or with those in one of his special groups. Of course, they are not

EXPECTED DEVELOPMENT OF OSTEOARTHRITIS IN 4 LCPD SERIES AT 6 DIFFERENT TREATMENTS

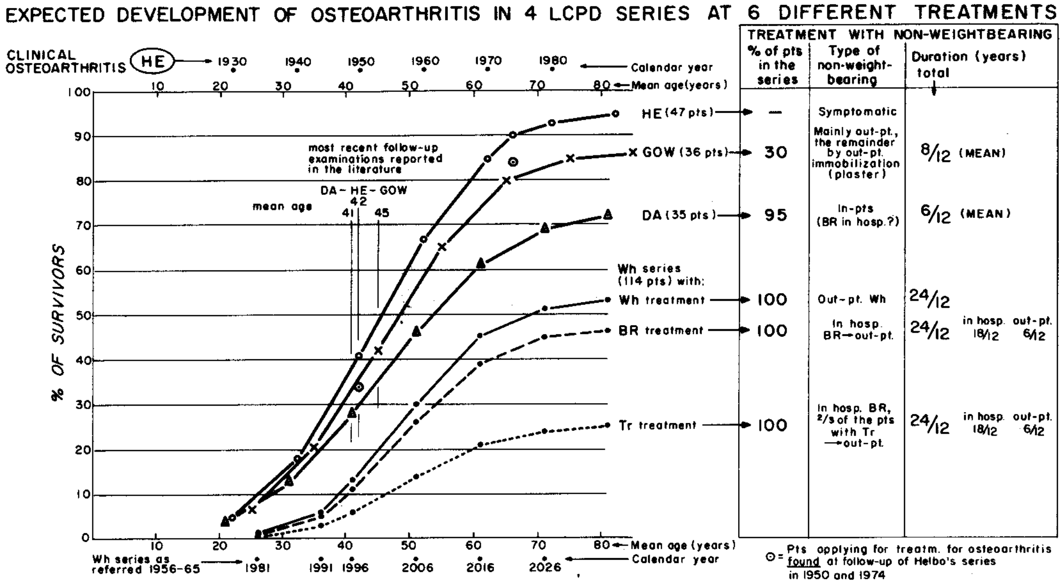


Diagram 34. Expected *development of osteoarthritis (presented for treatment) in the series of Helbo, Gower & Johnston, and Danielsson & Hernborg, calculated by using figures from Ruelle's total material (I + II) and in 3 identical series composed like the Wh series having Wh, BR, or Tr treatment, calculated by using figures from Ruelle's group II c.*

% = % of survivors at the mean ages and calendar years stated.

For comparison, the diagram gives the actual *% of survivors in Helbo's series who had applied for treatment of osteoarthritis at follow-up in 1950 and 1974.*

On the right of each series the % of patients in the series concerned who had received treatment *by non-weightbearing – and the type of such treatment (in-patient/out-patient) as well as its duration.*

I preferred showing the development of osteoarthritis with Wh, BR, and Tr treatment in 3 series composed like the Wh series, as this clearly sets out the relative efficacy of the 3 treatments – the main problem of the present study.

If the three curves at the bottom illustrated the development of osteoarthritis in the 3 series as referred, their shape and situation would be affected by the fact that at institution of treatment the Wh series was prognostically more favourable than the BR and Tr series.

The development of osteoarthritis in the Wh, BR, and Tr series as referred is shown in Table 18.

directly commensurable, but the comparison used ought to be reasonably probable.

Knowing fairly well the maximum possible percentage of osteoarthritis in an LCPD series (e.g. the size of the groups "PATH. sph." + "NON-sph."), one can determine, by the aid of Ruelle's figures, the percentage of patients who have applied for treatment of osteoarthritis at a given time – provided that the age distribution at that time is known (Appendix, Comment 5).

This possibility was first utilized for calculating, by the aid of Ruelle's figures, the expected osteoarthritis rate *at the time of follow-up* in 3 of the latest follow-up studies of LCPD series – Helbo's, Gower & Johnston's, and Danielsson & Hernborg's. Thereafter, the calculated and actual values were compared.

As this showed reasonable agreement between the *calculated* and *actual* value, it was felt justified to carry the calculations further into the future and fix the expected osteoarthritis rate 10, 20, and 30 years after the latest follow-up.

At last, the author arrived at *the central problem:* The future development of osteoarthritis in the *wheelchair, bed rest,* and *traction series* which had been observed only up to the time of primary healing. These calculations were carried out – and could even be carried out with greater accuracy than in the above-mentioned series, as the age distribution and joint deformity could be determined more precisely. To avoid the effect of the different severity in the three series, the development of osteoarthritis may be calculated int. al. as it would be after the use of the three therapeutic methods in three quite identical series composed like the wheelchair series.

Diagram 34 gives the result of these calculations, whose absolute presuppositions are the preceding sections on radiological and clinical evaluation.

This diagram sets out, in a perspicuous way, *the main result of the present study:*

The relative clinical efficacy of the three therapeutic methods in identical series of known composition – compared with the results of less effective methods in less known series.

The relative – and absolute – efficacy of the three methods may be worded as follows:

If a series of LCPD, of approximately the same composition as the "wheelchair series", is referred through a period of time to an orthopaedic department in this country, the radiological joint deformities left after the treatment, be it wheelchair, bed rest, or traction treatment, will be so mild that no essential number of cases of clinically significant osteoarthritis will develop before the patients have attained the mean age of about *40* (cf. also Diagram 28).

But after that age the development of osteoarthritis gains impetus. At a mean age of about *50,* almost *one-third* of the surviving patients must be expected to have applied for treatment of osteoarthritis after *wheelchair treatment,* rather more than *one-quarter* after *bed rest treatment,* and about *one-seventh* after *traction treatment.*

Thereafter, the development is slower. After *wheelchair and bed rest* treatment osteoarthritis develops in a *maximum* of *one-half* of the patients, after *traction* in *one-quarter* – and this *maximum* is not reached until the age of almost 70.

In other words, the number of patients who sooner or later have to apply for treatment of secondary osteoarthritis *after traction* is only half that after *wheelchair* treatment and *bed rest treatment.* But the number of patients with osteoarthritis among the survivors does not reach a magnitude of essential importance, after all forms of treatment, until the patients have reached the mean age of *50.*

In the present publication attention has constantly been drawn to the numerous pitfalls encountered while performing the calculations and the general uncertainty attaching to them.

Therefore, the apparently very precise predictions can only be taken with considerable reserve.

Only the ratio between the values will presumably stand its test at late follow-up studies (about the year of 2025)!

Several clinicians and child psychologists have claimed that the better results of traction therapy are too dearly bought by the long hospital treatment away from home.

On the basis of considerable experience, the present author does not agree – provided that the treatment is carried out in a suited institution (Appendix, Comment 1).

The reason why ambulatory forms of treatment are preferred, despite their indubitably poorer somatic results, is most probably that such well-suited institutions are not available everywhere.

After completion of the study reported above, a *further follow-up examination* (in collaboration with Mose et al.) *was performed in 1974 of Helbo's previously followed patients.* Regrettably only 25 could be traced. These patients had at that time a follow-up period of *more than 50 years.*

According to *calculations,* it would be expected that almost *90 %* of the patients surviving in 1974 would have applied for treatment because of osteoarthritic symptoms – which in these elderly patients would often have developed into a hip-back syndrome.

The actual finding was 84 %, cf. Diagram 29.

This agreement is so close that it must support confidence in the calculations concerning the development of osteoarthritis in the three series treated with wheelchair, bed rest, or traction.

As already mentioned, the correctness of these predictions cannot be checked until after the year of 2000.

(A more detailed report of the results of this follow-up study will be published elsewhere by Mose et al.).

APPENDIX

COMMENTS

COMMENT 1

"Normal" Range of the Quotients

"The normal range of the epiphyseal quotient" is usually interpreted as the variation of the epiphyseal quotient *in normal children* – with normally shaped femoral heads – and thus the expression *can* be interpreted.

However, normally shaped femoral heads are found not only in *normal children,* but also in sick children, even in children with a history of hip disease – e.g. in *children with sequelae to LCPD.*

But it is the variation in cases with normally shaped femoral heads which is of interest in our context. Therefore, the term "normal range of the epiphyseal quotient" is interpreted here in a somewhat wider sense, viz. as:

The *variation of the epiphyseal quotient in children with normally shaped femoral heads.*

However, the "normal range of the epiphyseal quotient" in this sense is not the same in a series of normal children and in a series of children having sequelae to LCPD: In *normal children,* all of whom have normally shaped femoral heads, the epiphyseal quotients come down to 85. In an *LCPD series* the epiphyseal quotients, in cases with *normally shaped femoral heads,* come down as far as 60. (*All* cases with epiphyseal quotient >60 – *and only these* – have normally shaped femoral heads).

Therefore, the term "normal range of the epiphyseal quotient" is used in the present paper only in the special sense:

Range of the epiphyseal quotient in children with normally shaped femoral heads in an LCPD series.

It is only a knowledge of this range which is of interest in evaluating the therapeutic results in an LCPD series.

The range of the *joint surface quotient* in LCPD patients with normally shaped femoral heads and the range of the *radius quotient* in LCPD patients with femoral heads of normal shape and size, on the other hand, are equal to the ranges in normal children (>85 and <115 respectively).

Thus, in an LCPD series the quotients are "within the normal range" when the *epiphyseal quotient >60,* the *joint surface quotient >85,* and the *radius quotient <115.*

COMMENT 2

Comparison of the Evaluations of Radiological Results of Treatment by 1 Measuring Method ("1-quotient assessment") and by a Combination of 3 Measuring Methods ("3-quotient assessment")

In the present study the radiological assessment was done by dividing the series into three groups of patients: "NORM.sph.", "PATH.sph.", and "NON-sph.".

First, the series were divided, by the aid of Mose's plate, into two groups – "SPH." and "NON-sph.". Thereafter, "SPH." was sub-divided into two groups "NORM.sph." and "PATH.sph." by means of *three* measuring methods determining three quotients for each patient: joint surface quotient, epiphyseal quotient, and radius quotient.

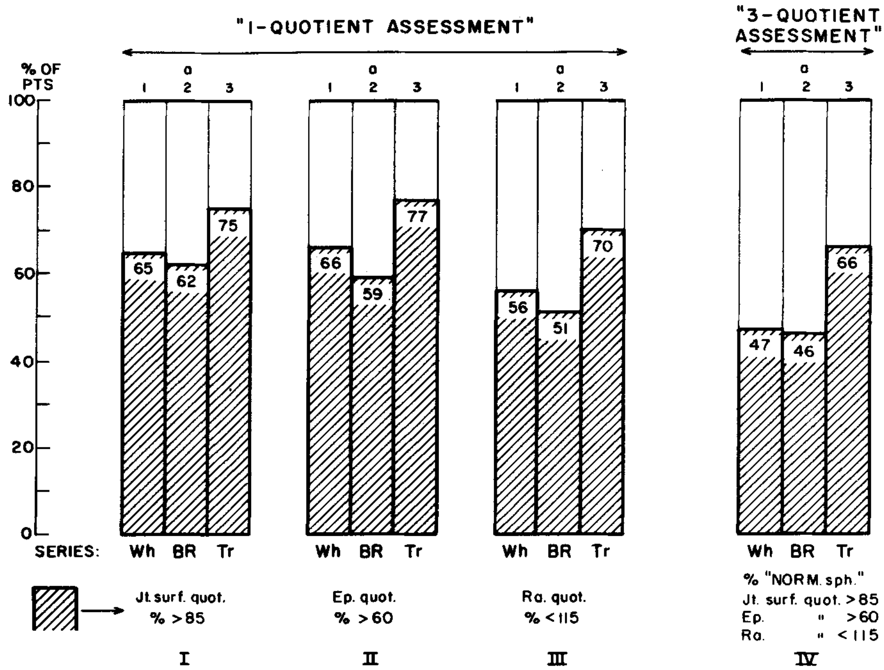


Diagram 35. Results in the series as referred (a) assessed by only one measuring method – "1-quotient assessment" – *and by a combination of 3 measuring methods –* "3-quotient assessment".

a { *1: Wh series as referred (114 pts.) treated by Wh,*
2: BR series as referred (79 pts.) treated by BR,
3: Tr series as referred (113 pts.) treated by Tr.

I: Assessment by the joint surface quotient,
II: Assessment by the epiphyseal quotient,
III: Assessment by the radius quotient,
IV: Assessment by a combination of all 3 measuring methods – % "NORM.sph.".

Tables 22, 23, and 24 in the Appendix set out the joint surface, epiphyseal, and radius quotients in the three series.

When all three were within the normal range, the case was assigned to "NORM. sph.".

This sounds fairly complicated – and may indeed deter a clinician who wants to assess his results.

Considerable simplification would be obtained by performing the assessments exclusively by the aid of *one* quotient instead of three.

Diagram 35 gives the results in the three series as referred, when the cases with normally spherical heads are singled out by using 1 quotient (I–II–III) and by using 3 quotients (IV).

It will be seen that the results of the "1-quotient assessment" are on a higher level than those of the "3-quotient assessment" and that the differences between the results in the three series appear to be less marked. This is particularly evident from Diagram 36 which shows the results only for the wheelchair and traction series. Diagram 35 shows that this pattern may be broken: The differences between the bed rest and wheelchair results in the 3-quotient assessment are less marked than expected.

These differences between the results of "1-quotient assessment" and "3-quotient assessment" are naturally explained by the fact that in the "1-quotient assessment" the demands on a satisfactory result have been reduced. Therefore, as in the assessment using "SPH.", the results appear to be better (higher percentages) and the differences between the therapeutic methods get less marked than in the stricter 3-quotient assessment.

These *differences* are easy to spot, but the *similarity* of the results found by the four assessments is perhaps even more striking: The four diagrams (I–IV) are of a striking uniformity, all showing considerably better results of traction than of wheelchair or bed rest treatment, and the differences between these therapeutic results are at least of approximately the same magnitude with all four evaluations.

The reason why the more complicated "3-quotient assessment" was preferred in the present study is that it is more reliable:

Three criteria secure much better than one that cases singled out as "NORM.sph." really live up to their name. With the use of 1 criterion the most peculiar femoral heads *may* at times slip into the group.

Besides, the effect of special difficulties of measurement and other sources of error attaching to the individual measuring methods will be to some extent equalized by a combination of three measuring methods.

Nevertheless, the "1-quotient assessment" may be highly applicable as an easy, preliminary orientation at primary healing.

For such assessment the radius quotient is perhaps best suited: In the first place, measurement of the radius quotient is so simple that the risk of measuring errors must be less than in the other, more complicated methods. In the second place, it is apparent from Diagrams 35 and 36 that the results of assessing by this quotient alone is – quantitatively – closest to the results of the "3-quotient assessment". The slight difference is due to the fact that, apart from the cases in "NORM.sph.", the "NORM.sph." (RA) comprises cases with a change in the shape of the head without any increase in growth.

However, it is a presupposition for using the radius quotient that the *age distribution* and *follow-up periods* are *approximately the same* – as in the present series. *And this is a demand which is not so easy to fulfill.*

But if this condition is fulfilled, the measurements needed for this 1-quotient assessment must be said to be very simple: A basis for an evaluation is obtainable merely by placing Mose's plate over the femoral head on the X-ray film and recording the length of the radius for the spherical heads.

It can hardly be simpler.

The above may perhaps urge busy clinicians to attempt a *preliminary* evaluation of their therapeutic results. However, it must be emphasized that the 3-quotient

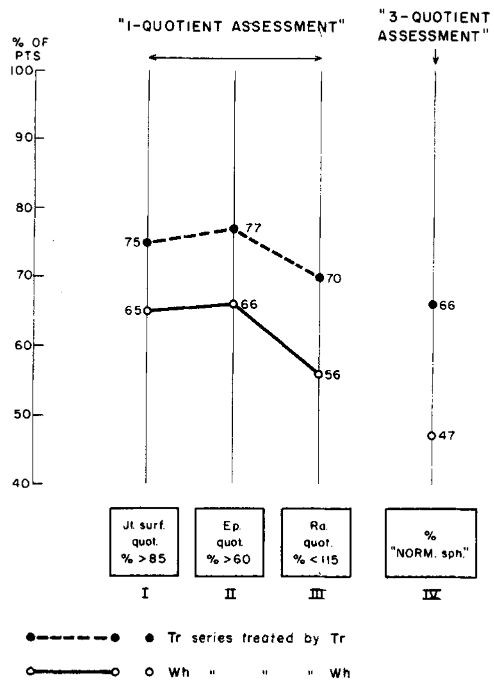


Diagram 36. Results in the Wh and Tr series as referred, assessed by 1 measuring method – "1-quotient assessment" (I, II, III) and by a combination of 3 measuring methods – "3-quotient assessment" (IV).

I: Assessment by the joint surface quotient,
II: Assessment by the epiphyseal quotient,
III: Assessment by the radius quotient,
IV: Assessment by a combination of all 3 measuring methods – % "NORM.sph.".

This diagram is a more instructive and perspicuous edition of Diagram 35 (omitting the BR results).

method used in the present study is more reliable – and it sets out the difference in the efficacy of the treatments better than do the less strict 1-quotient assessments. At least, this has been observed in the present three series.

COMMENT 3

Fixing %"SPH." in Series Nos. 1–5 Seen at Follow-up (Helbo, Sundt II, Gower & Johnston, Danielsson & Hernborg, and Ratliff)

Series No. 1: The percentage of "SPH." in Helbo's series was fixed as about *12–13 %.*

Helbo and I have previously used the same measuring methods for evaluating the therapeutic result in one series treated by bed rest and have thereby arrived at the same result (Meyer 1966). Accordingly, I was able to evaluate Helbo's classification of his series. This showed that the groups "greatly flattened" and "irregular" combined correspond to my group "NON-sph.", whereas his group "spherical" corresponds to my "SPH." – which makes up about 12.5 % of his total series.

Series No. 2: The percentage of "SPH." in Sundt's series was estimated at *about 27 %.*

According to the text of Sundt's paper the group "spherical" corresponds approximately to my "NORM.sph.". The group "ovoid" is characterized as "favourably healed". As Sundt cannot have used this term for cases which had healed with irregular, non-spherical heads (the group "NON-sph."), which are invariably greatly deformed, at least the greater part of his cases in the "ovoid" group must belong to "SPH.". To arrive at a minimum value, only half the "ovoid" group was assigned to "SPH." which thus makes up about 27 % of the total series (between 20–35 %).

Series No. 3: The percentage of "SPH." in Gower & Johnston's series was estimated at *about 30 %.* This assessment is uncertain. According to the X-ray films shown (and the group designation) the cases of the "round" group (20 %) correspond to the better part of "SPH." (approximately to "NORM.sph."). It is difficult to say how many of the large group "flattened" (73 %) have "poorly" spherical heads with a long radius. I have calculated 10/73 "SPH." in this group – presumably too low. Thus, out of the entire series "SPH." ought to make up (at least) 30 %.

Series No. 4: The percentage of "SPH." in Danielsson's and Hernborg's series was estimated at *about 35 %.* Their classification is illustrated by 4 X-ray films showing the least deformed joint of each group. According to the appearances, there is no doubt that group "0" and at least part of the cases in group "I" have healed with spherical heads ("SPH."). Judging by the X-ray films (and the small drawings from the films of each case) it may be estimated that 3/4 of the cases in group "I" belong to "SPH." – so that the percentage of "SPH." in the entire series is about 35 %.

Series No. 5: The percentage of "SPH." in Ratliff's series was estimated at *about 48 %.* His series is not classified according to purely radiological, but according to a combination of radiological and clinical criteria. However, it is explicitly mentioned in Ratliff's first publication that in 52 % of the cases the femoral head was "appreciably deformed" and in 40 % practically normal. As the deformity of the heads in the selection of patients who were seen at a second follow-up 12 years later was somewhat less pronounced (Ratliff's second publication), the percentage of "SPH." was fixed as about 48 % – somewhat higher than the percentage of practically speaking normal heads in this selected group of patients: about 44 %.

COMMENT 4

"Spread". Fixing the Percentage of the 19 Series Over Which Cases of Radiological Osteoarthritis and Subjective Arthritic Symptoms Spread, When the Series Are Arranged by Increasing Primary Joint Deformity – e.g. as in Diagram 18 – from Left to Right

For each series, then, two spread rates are to be fixed – one for radiological osteoarthritis and one for subjective symptoms.

Below, the procedure in the five series with longest follow-up will be described. In principle, it is the same as in fixing the "spread rate" in the remaining 14 series, but space does not permit a detailed description of the procedure in these 14 series.

In the five series, thus, there are 10 spread rates to fix.

Series No. 1: Helbo
(a) *Radiological osteoarthritis.* 56 % of the patients exhibited signs of radiological osteoarthritis. According to Helbo himself, these 56 % were distributed ("spread") over two of the groups into which he divided his material and classified by him – according to the primary radiological deformity – as "greatly flattened" and "irreg.". On the other hand, Helbo found no signs of radiological osteoarthritis in his third group designated "spherical". The two groups "greatly flattened" and "irreg." combined make up 88 % of the total series. Accordingly, the 56 % patients having radiological osteoarthritis are "spread" over 88 % of the series.

In other words, the spread rate of radiological osteoarthritis is *apparent direct from Helbo's data.*

(b) *Subjective symptoms.* The spread rate of such symptoms is found on the basis of exactly the same reasoning as that of radiological osteoarthritis: 62 % of the patients had symptoms (mostly joint pain), distributed – like the signs of radiological osteoarthritis – over 88 % of the series, whereas 12 % (the group "spherical") were symptom free.

For the remaining 4 series a total of 8 "spread rates" have to be determined.

Thereamongst 5 can be determined as in Helbo's series, *directly on the basis of data given by the four authors.*

However, a comment is required with respect to series No. 3, (Gower & Johnston's). In this series radiological osteoarthritis and subjective symptoms were found to be "spread" over *all* groups, although in the "round" group with least deformity there was only one patient with radiological osteoarthritis and one with subjective symptoms (pain), i.e. each making up one-sixth of this group. The "spread" in this group, then, was taken to be one-third – giving a "spread rate" for the entire series of 86 %.

The last three spread rates in these four series cannot be determined *direct* on the basis of information given by the authors, the percentage of osteoarthritic patients being stated only for the total series – not for individual groups.

This applies to subjective symptoms in Sundt's series II and to radiological osteoarthritis as well as subjective symptoms in Ratliff's.

SU_{II}: Symptoms, in the form of *joint pain,* were found in 55 % of the patients of this series – i.e., without spread in all patients of the groups "cylindrical" and "angular" (which total exactly 55 %). It is beyond doubt, however, that there must be a "spread" of patients with symptoms – and that this spread must then comprise at least half the group "ovoid" which makes up, together with the two groups mentioned above, 73 % of the entire series. This is then the spread rate of subjective symptoms in the form of *joint pain.* Since, however, the percentage of these subjective symptoms in the entire series is practically the same as that of radiological osteoarthritis (55 %/58 %), and since according to Sundt himself radiological osteoarthritis spread over the entire "ovoid" group, there is a predominant likelihood that the subjective symptoms, in the form of pain, also spread over the same area. This is beyond doubt, if *a limp* is included among the subjective symptoms. A limp was found in 67 % of the patients – far into the "ovoid" group. True, a limp is not a sure sign of osteoarthritis, but at least it is a sequel to the primary LCPD, and a sequel which may be a great subjective strain on the patients.

In accordance with these reflections, it is assumed that the subjective symptoms, like the radiological signs of osteoarthritis, were spread over *91 %* of Sundt's series.

Ratliff: In this series information is yielded only about the percentage of all patients in the series who had radiological osteoarthritis and subjective symptoms – 50 % and 20 % respectively. These rates are only slightly lower than the percentages of the groups "fair" + "poor" and "poor" respectively. The spread rates were therefore fixed as the size of these two groups of patients, i.e. 55 % and 23 % respectively. In actual fact, however, they are presumably somewhat higher.

As already mentioned, the spread rates in the other 14 series were determined according to exactly the same principles as those used for the five series with the longest follow-up periods.

COMMENT 5

Ruelle's Figures and Their Use in Predicting the Development of Osteoarthritis in LCPD Series

Hip-deforming diseases – congenital or running their course during childhood – are followed by a certain number of cases of secondary osteoarthritis. The percentage depends largely upon the extent of the joint deformities left by the disease.

A material of such secondary osteoarthritis (271 patients, presumably not selected according to age) following upon various hip-deforming diseases has been analysed by *Ruelle* with a view to the age at which the osteoarthritis (subjective symptoms of osteoarthritis) set in.

He found that

about 1/3 had started before the 40th birthday,
about 1/3 had started between the 40th and 50th birthday,
and 1/3 had started after the 50th birthday.

More detailed findings were that

100 %	had	developed	symptoms	of	osteoarthritis	before	the	80th	birthday
99 %	”	”	”	”	”	”	”	70th	”
93 %	”	”	”	”	”	”	”	60th	”
70 %	”	”	”	”	”	”	”	50th	”
36 %	”	”	”	”	”	”	”	40th	”
10 %	”	”	”	”	”	”	”	30th	”
2 %	”	”	”	”	”	”	”	20th	”

These figures then refer to cases of osteoarthritis developing after the mixture of mild, moderate, and severe deformities present in Ruelle's total series – deformities probably on the average moderate. In series with a larger number of mild deformities a smaller part of the cases of osteoarthritis – e.g. 1/5 – will start before the 40th birthday and a larger part, e.g. 1/2, after the 50th birthday. The reverse will apply to series containing a larger number of severe deformities.

Cf. also the values listed for Ruelle's special groups (Table 12).

As already mentioned, Ruelle's cases of osteoarthritis were the sequelae to several different hip-deforming diseases. However, the picture of the development of osteoarthritis might easily have been exactly the same, if all the cases were sequelae to LCPD – provided that the hip deformities corresponded with respect to arthritogenic effect to those in Ruelle's series.

We shall now follow, from the time of primary healing, an LCPD series in which the development of osteoarthritis occurs in conformity with the figures from Ruelle's *total* series and in which *all* patients are potential osteoarthritics.

If the patients of such a series are examined, say when they *pass their 40th birthday*, the examination will show that: about 1/3 of the total cases of osteoarthritis that will develop in the series have started before the 40th birthday.

It is evident that if no patient died before the 40th birthday, one-third of the examined ("surviving") patients would have symptoms of osteoarthritis.

But of course some patients – though few – die before the 40th birthday. The majority will die without signs of osteoarthritis, and only a minority have had time to develop signs of osteoarthritis before dying – i.e. they die with osteoarthritis.

Since, however, the mortality is the same in patients with and without osteoarthritis, the osteoarthritis rate among the survivors on the 40th birthday will be the same as if none had died.

In other words:

When 1/3 of the final number of cases of osteoarthritis set in before the 40th birthday, this means that 1/3 of the *survivors* have osteoarthritis at that time.

The same rule – only using another fraction – naturally applies also if the examination has been carried out at any other age, e.g. 50, 60, or 70.

(The *potential* osteoarthritic patients who *die before the expected osteoarthritis has developed* of course reduce the final rate of osteoarthritis.

However, this reduction is not more than 4–6 % of the final cases. In practice, this must be said to be immaterial considering the uncertainty of the deformity criteria by which the group of "final osteoarthritis" is selected. In the *traction* series, for instance, there is a question of only 2 patients (cf. Diagram 37)).

"Final osteoarthritis" makes up a varying percentage of the patients in the various LCPD series – hardly ever 100 % as in the above example.

Thus, if the final osteoarthritis rate is 60 % of the original series at primary

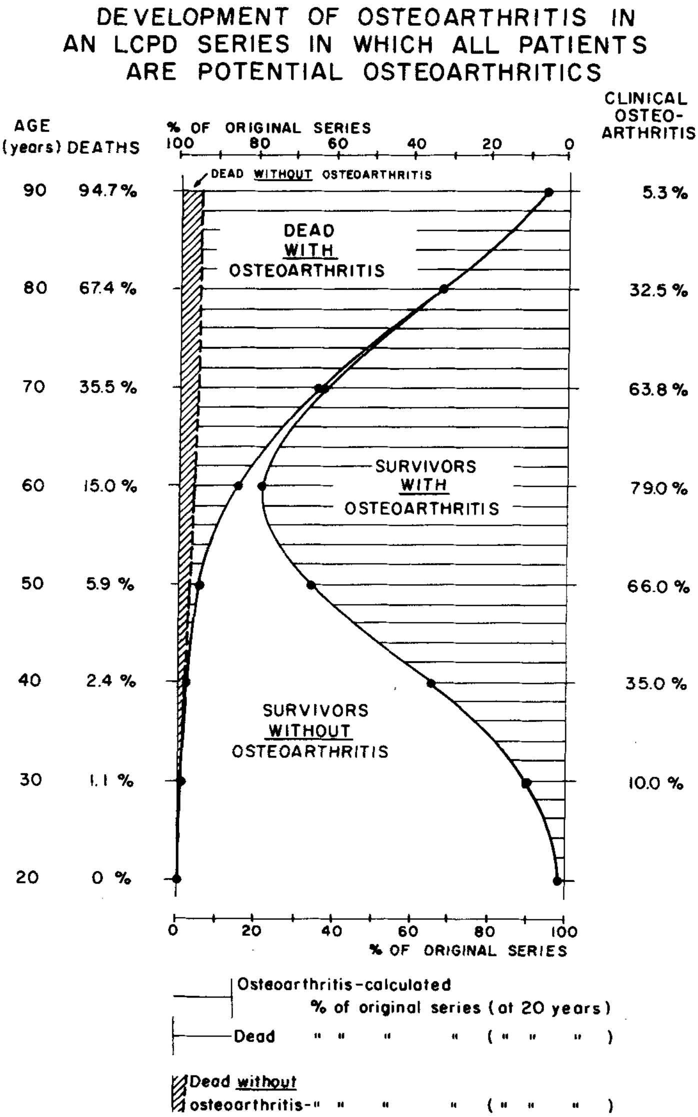


Diagram 37. Development of clinical osteoarthritis presented for treatment in an LCPD series in which all patients must be considered potential osteoarthritics because of the severity of the articular joint deformities.

Calculation based upon Ruelle's total material (I + II).

The calculated osteoarthritis rates signify osteoarthritis in survivors when passing the listed birthday expressed in per cent of the "original" material at the age of 20 years.

Mortality curve in relation to the age of 20 years: Stat. Årbog, Denmark 1968.

From this diagram it is possible to read for each age (birthday):

% survivors without osteoarthritis,
% survivors with osteoarthritis,
% dead with osteoarthritis,
% dead without osteoarthritis – i.e. dead before clinical symptoms of osteoarthritis have appeared.

healing, 20 % have started before the 40th birthday, and among the survivors 20 % have osteoarthritis (still using the figures of Ruelle's *total* materieal). With figures from Ruelle's less deformed groups, the percentage is <20 and with figures from his more deformed groups >20.

It was now attempted to *single* out such a group of "final osteoarthritis" – i.e. potentially osteoarthritic patients – from the *wheelchair, bed rest,* and *traction* series on the basis of the radiological deformity at primary healing: All patients of the deformity groups "NON-sph." and "PATH.sph." were assigned to this group.

If a reasonably reliable estimate regarding the number of potential osteoarthritis at primary healing – and thereby regarding the final maximum osteoarthritis rate to be expected – has been made in an LCPD series, Ruelle's figures ought to be applicable, as described above, for predicting the osteoarthritis rate that will be found among the survivors at a given age.

So far the discussion has concerned only the osteoarthritis rate at *a given age,* 40, 50, and 60, etc.

To ascertain the osteoarthritis rate at a *given time* – e.g. at a possible follow-up examination – regard must be paid to the fact that at a given time the patients will differ in age. Say, for instance, that the age distribution is from 40 to 50 at the time of follow-up, the number of patients with osteoarthritis among these survivors can be calculated with approximation by using the mean of the osteoarthritis rates at 40 and 50 (i.e. 53 % in deformities corresponding to those in Ruelle's total series and 100 % final osteoarthritis).

In extreme age groups, however, the mean cannot be used without correction.

Of course, the same procedure is applicable when the age distribution is over *several* 10-year periods. Only, in that event the calculated number of patients with osteoarthritis in each 10-year period must be added and related to the total number of surviving patients.

This is the procedure used for the majority of the calculations in the clinical section – first to check the method in *series already seen at follow-up* (Helbo, Gower & Johnston, and Danielsson & Hernborg) and thereafter, when the method had proved reasonably applicable, for predicting the osteoarthritis rates at increasing mean ages, in the series already seen at follow-up as well as in those not yet followed up, viz. the *wheelchair, bed rest and traction series.*

Which are the degrees of severity of osteoarthritis to which Ruelle's figures refer?

It is characteristic of Ruelle's patients that all had, sooner or later, *applied for treatment* of osteoarthritis.

Ruelle's series was divided into 10-year age groups according to the onset of osteoarthritis (20–30 years, 30–40 years, etc.).

It seems likely that the *majority* of patients whose symptoms of osteoarthritis have set in within such a 10-year period have also applied for treatment before the expiry of this, relatively long period. Only a *minority* develop their symptoms of osteoarthritis at such a late stage of the period that they have not applied for treatment before its expiry.

If this is true at the expiry of the earliest 10-year period (e.g. 20–30 years), it must be even more true of the osteoarthritis rates calculated at older ages. The fact is that these calculations were based on patients with osteoarthritis from all the preceding 10-year periods – i.e. a number of patients increasing in the course of the years. Since *all* patients from the preceding 10-year periods have gradually applied for treatment, the part – percentage – of patients who have *not* applied for treatment will *decrease in* the course of time – to a very low percentage.

Thus, it appears *likely* that the majority of Ruelle's patients applied for treatment within the 10-year period in which their osteoarthritis set in. However, we do not know this for certain, as Ruelle does not state the time interval between the onset of symptoms and the institution of treatment.

Whether it is true depends upon whether Ruelle counts only the time at onset of

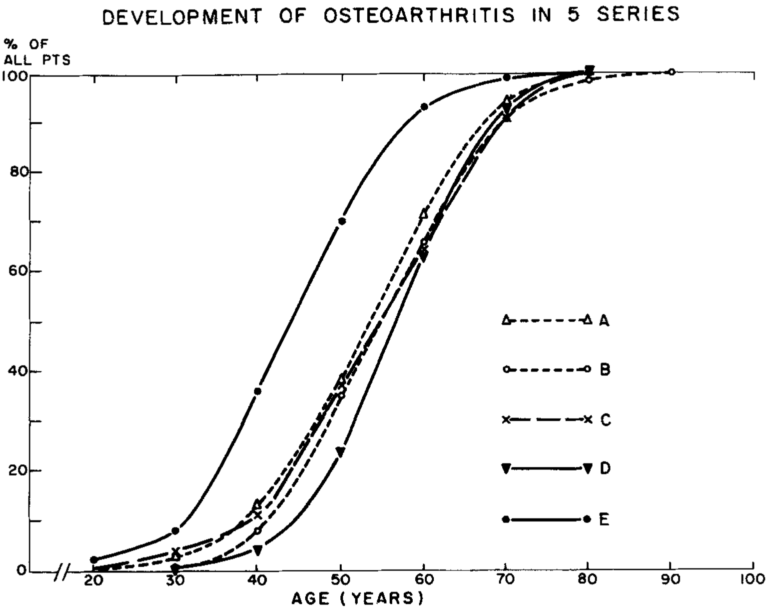


Diagram 38. Development of osteoarthritis in 5 different series of osteoarthritis affecting the hip.
The points on the curves signify the percentage of cases of osteoarthritis causing symptoms before the age stated.

A: Primary + secondary osteoarthritis – Ruelle *(patient groups I, II, III, IV, and V), 924 pts., 1961.*
B: "Osteoarthritis" – presumably primary + secondary A. Graber-Duvernay, *quoted by Francois Francon, 1067 pts., 1956.*
C: Primary + secondary osteoarthritis Danielsson *1964, 115 pts., data from patient list p. 98.*
D: Primary osteoarthritis Ruelle *(patient groups III, IV, and V), 653 pts., 1961.*
E: Secondary osteoarthritis Ruelle *(patient groups I + II), 271 pts., 1961.*

symptoms which really troubled the patient – and therefore rapidly led to treatment – or whether he included also the mildest symptoms – which a patient may have for years without applying for treatment.

Ruelle's study is evidently an analysis *based upon case notes* (through several years) concerning the time at onset of osteoarthritis – and not the result of a follow-up examination. Such an analysis is likely to afford information only about the onset of osteoarthritis symptoms which constitute a real complaint, and therefore have made the patient apply for treatment – and not about milder symptoms which the patient does not remember and to which he had not attached any importance.

It is different with a *follow-up examination* in which even mild symptoms are easier to disclose by an interested and careful examiner.

For instance, in Helbo's follow-up examination in 1950, when the patients' mean age was 42, 62 % had clinical symptoms of osteoarthritis, but only about half of these (34 %) had applied for treatment. Helbo expressly states that the symptoms were very mild and of little significance to the patients, especially among those who had not applied for treatment.

Thus, apart from the long 10-year intervals. Ruelle's type of analysis indicates that his figures refer only to osteoarthritis causing symptoms of such severity that the patients had applied for treatment.

If we calculate, on this presupposition, the expected osteoarthritis rate in Helbo's series at the time of follow-up by means of figures from that of Ruelle's groups of diseases in which the primary deformity corresponds to that in Helbo's series, the result ought to be that the calculated osteoarthritis rate would correspond in all essentials to the percentage of osteoarthritis presented for treatment in Helbo's material (34 %), not to the higher percentage (62 %) of all cases of clinical osteoarthritis found by him.

But which of Ruelle's groups is suited for such a calculation?

Ruelle's *total* material comprises patients with all kinds of primary deformity – mild as well as severe, but presumably predominantly severe – following upon congenital dislocation, subluxation, epiphysiolysis, and (a few) LCPD.

Helbo's series, which consists of "untreated" LCPD cases, is also a predominantly severely deformed material.

A priori it might be assumed, therefore, that the deformities in Ruelle's total series would correspond in arthritogenic effect quite well to those in Helbo's series (like the deformities in the special groups of patients closest to the middle: epiphysiolysis, LCPD, and subluxation).

Using the figures from Ruelle's total material for the calculation the rate, therefore, ought to correspond quite well to Helbo's percentage of osteoarthritis that had been presented for treatment and should preferably be *somewhat higher!*

This proved to be entirely true: The calculated osteoarthritis rate was 41 %, the actual rate 34 %.

Thus, the deformities in Ruelle's total material (RU I–II) seem to correspond well to those in Helbo's – that is if Ruelle's values, as substantiated above, refer to patients who have applied for treatment of their osteoarthritic symptoms.

The correctness of this supposition is also indicated by the following: There is a striking difference in the percentage of clinical osteoarthritis found at follow-up examination of Helbo's series – 62 % – and at follow-up examination of Danielsson & Hernborg's LCPD series – which was only *23 %*. It is striking because the mean age (and the age distribution at onset of the disease) is the same in both series and because the treatment of both series had been of little efficacy – (somewhat better in Danielsson & Hernborg's, viz. 6 months' non-weightbearing against at most 3 months' in Helbo's).

On the other hand, the percentage of *radiological* osteoarthritis was approximately the same in both series: Danielsson & Hernborg's *50 %* and Helbo's *56 %*. This small difference is perhaps explicable by the somewhat more effective treatment of Danielsson & Hernborg's series – but this explanation can by no means account for the enormous difference between the clinical cases of osteoarthritis in the two very similar series.

The only conceivable explanation is that Helbo's "clinical osteoarthritis" did not signify the same as Danielsson & Hernborg's, comprising a far larger number of mild cases than Danielsson & Hernborg's.

Possibly, their criteria of clinical osteoarthritis do not differ much in theory, but in practice they function very differently. Indeed it is (almost) impossible to set up a definite objective criterion of clinical osteoarthritis.

Below, the term criteria refers exclusively to their function in practice.

Thus: Danielsson & Hernborg's criteria of clinical osteoarthritis appear to be far stricter than Helbo's.

But plotting of 3 curves for the development of clinical osteoarthritis in three large series of predominantly *primary* osteoarthritis, reported by Ruelle, Danielsson, and Graber-Duvernay, shows that these curves practically coincide (Ruelle 1961, Danielsson 1964, Graber-Duvernay (quoted by Francon 1956). (Diagram 38)).

This can in fact only be interpreted to the effect that the three authors have had the same criterion of "clinical osteoarthritis" – in particular that in practice Danielsson's and Ruelle's has been the same.

However, the results of the follow-up examination of secondary osteoarthritis showed, as already mentioned, that Danielsson's criterion, also used by Danielsson & Hernborg, must be considerably stricter than *Helbo's.*

This, then, must apply also to Ruelle's criterion – just what had to be expected, if it is correct that Ruelle's rates, unlike Helbo's, refer exclusively to osteoarthritis of a severity so that the patients soon apply for treatment.

The course of the curves confirms that this *is* correct.

The similarity of Danielsson's and Ruelle's criteria of clinical osteoarthritis also explains why the calculated percentage in Danielsson & Hernborg's material corresponds to the percentage of *all* clinical cases of osteoarthritis found – 28 %/23 % – and not, as in Helbo's series, to only *a fraction* of them, viz. those presented for treatment – 41 %/34 %.

The two fractions are equal = 1.2 – which might indicate that Danielsson's criterion of clinical osteoarthritis corresponds quite accurately to what characterizes the cases of osteoarthritis presented for treatment in Helbo's series.

These curves are highly informative and afford further support to the other arguments that the percentage of osteoarthritis calculated on the basis of Ruelle's figures refers in all essentials *only to the percentage of osteoarthritis presented for treatment.*

TABLES AND CHARTS*)

Table 22. Epiphyseal quotients, joint surface quotients, and radius quotients in 114 patients who had ambulatory wheelchair *treatment (Orthopaedic Hospital, Århus 1959–64 incl.).*

	Number	%
Total patients	114	100
Patients with *spherical* femoral heads	97	85
Patients with *non-spherical* femoral heads	17	15

Within the group of patients with spherical heads:

1			2			3		
Epiphyseal quotient	No. of pts.	% of all pts.	Joint surface quotient	No. of pts.	% of all pts.	Radius quotient	No. of pts.	% of all pts.
100–96 incl.	6	5.2	110–106 incl.	2	1.7	90– 94 incl.	1	0.9
100–91 incl.	15	13.1	110–101 incl.	12	10.5	90– 99 incl.	0	0.9
100–86 incl.	24	21.0	110– 96 incl.	29	25.4	90–104 incl.	23	20.2
100–81 incl.	32	27.2	110– 91 incl.	52	45.5	90–109 incl.	49	43.0
100–76 incl.	41	36.0	110– 86 incl.	74	65.0	90–114 incl.	64	56.0
100–71 incl.	52	45.5	110– 81 incl.	85	74.5	90–119 incl.	76	66.7
100–66 incl.	63	55.3	110– 76 incl.	89	78.0	90–124 incl.	83	73.0
100–61 incl.	75	65.7	110– 71 incl.	96	84.0	90–129 incl.	87	76.2
100–56 incl	79	69.3	110– 66 incl.	97	85.0	90–134 incl.	92	80.6
100–51 incl.	86	75.5				90–139 incl.	95	83.3
100–46 incl.	88	77.2				90–144 incl.	95	83.3
100–41 incl.	93	81.5				90–149 incl.	95	83.3
100–36 incl.	96	84.0				90–154 incl.	96	84.0
100–31 incl.	97	85.0				90–159 incl.	97	85.0

"NORM.sph." 54 pts. = 47.3 % "PATH.sph." 43 pts. = 37.7 %

*) CHARTS: p. 114–118.

Table 23. Epiphyseal quotients, joint surface quotients, and radius quotients in 79 patients treated by bed rest without traction *(Refsnæs 1953–57).*

	Number	%
Total patients	79	100
Patients with *spherical* femoral heads	58	73.4
Patients with *non-spherical* femoral heads	21	26.6

Within the group of patients with spherical heads:

1

Epiphyseal quotient	No. of pts.	% of all pts.
100–96 incl	2	2.5
100–91 incl.	8	10.0
100–86 incl.	12	15.2
100–81 incl.	21	26.6
100–76 incl.	26	33.0
100–71 incl.	34	43.0
100–66 incl.	42	53.2
100–61 incl.	47	59.5
100–56 incl.	50	63.3
100–51 incl.	55	70.0
100–46 incl.	57	72.0
100–41 incl.	58	73.4

2

Joint surface quotient	No. of pts.	% of all pts.
110–106 incl.	2	2.5
110–101 incl.	6	7.6
110– 96 incl.	14	17.8
110– 91 incl.	38	48.0
110– 86 incl.	49	62.0
110– 81 incl.	54	68.3
110– 76 incl.	57	72.2
110– 71 incl.	58	73.4

3

Radius quotient	No. of pts.	% of all pts.
100–104 incl.	10	12.7
100–109 incl.	25	31.6
100–114 incl.	40	50.6
100–119 incl.	48	61.0
100–124 incl.	52	66.0
100–129 incl.	54	68.5
100–134 incl.	58	73.4

"NORM.sph." 36 pts. = 45.6 %   "PATH.sph." 22 pts. = 27.9 %

Table 24. Epiphyseal quotients, joint surface quotients, and radius quotients in 113 patients treated by traction in bed *(Refsnæs 1958–63).*

	Number	%
Total patients	113	100
Patients with *spherical* femoral heads	95	84
Patients with *non-spherical* femoral heads	18	16

Within the group of patients with spherical heads:

1

Epiphyseal quotient	No. of pts.	% of all pts.
115–111 incl.	2	1.8
115–106 incl.	2	1.8
115–101 incl.	3	2.6
115– 96 incl.	10	8.9
115– 91 incl.	24	21.2
115– 86 incl.	38	33.6
115– 81 incl.	56	49.5
115– 76 incl.	69	61.0
115– 71 incl.	81	71.6
115– 66 incl.	86	76.0
115– 61 incl.	87	77.0
115– 56 incl.	92	81.3
115– 51 incl.	94	83.0
115– 46 incl.	94	83.0
115– 41 incl.	95	84.0

2

Joint surface quotient	No. of pts.	% of all pts.
110–106 incl.	2	1.8
110–101 incl.	10	8.8
110– 96 incl.	40	35.4
110– 91 incl.	66	58.4
110– 86 incl.	85	75.2
110– 81 incl.	90	79.6
110– 76 incl.	92	81.5
110– 71 incl.	95	84.0

3

Radius quotient	No. of pts.	% of all pts.
95– 99 incl.	3	2.6
95–104 incl.	48	42.5
95–109 incl.	71	62.8
95–114 incl.	79	70.0
95–119 incl.	86	76.0
95–124 incl.	91	80.5
95–129 incl.	94	83.0
95–134 incl.	95	84.0

"NORM.sph." = 75 pts. = 66 % "PATH.sph." = 20 pts. = 18 %

Table 25. Epiphyseal quotients, joint surface quotients, and radius quotients in 98 normal children *(>5 years).*

Total No.: 98 – **all** with spherical femoral heads.

1			2			3		
Epiphyseal quotient	No. of children	% of all children	Joint surface quotient	No. of children	% of all children	Radius quotient	No. of children	% of all children
115–111 incl.	1	1.0	115–106 incl.	4	4.0	90– 94 incl.	3	3.1
115–106 incl.	6	6.0	115–101 incl.	24	24.4	90– 99 incl.	8	8.2
115–101 incl.	32	32.7	115– 96 incl.	75	74.6	90–104 incl.	90	92.0
115– 96 incl.	80	81.5	115– 91 incl.	96	98.0	90–109 incl.	95	97.0
115– 91 incl.	94	96.0	115– 86 incl.	98	100.0	90–114 incl.	98	100.0
115– 86 incl.	98	100.0						

All children: "NORM.sph." = 100 %

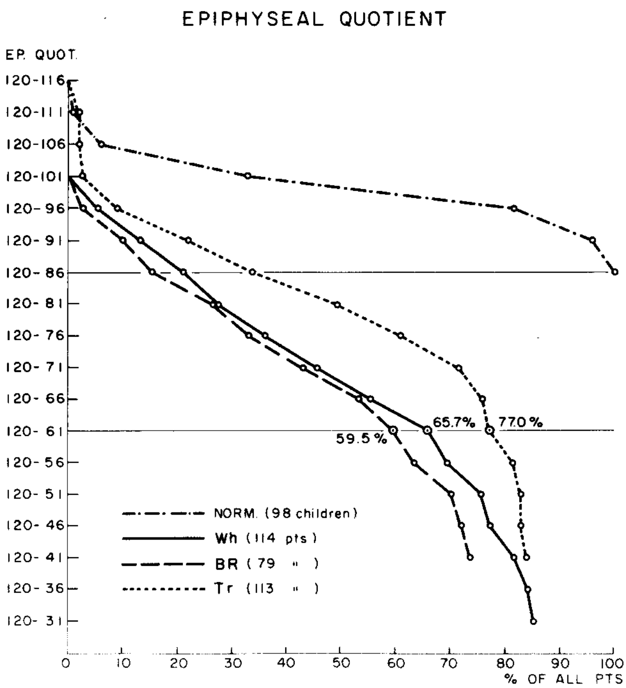


Diagram 39. Epiphyseal quotients in the

Wh series as referred,
BR series as referred,
Tr series as referred,

showing, for comparison, the epiphyseal quotients in a series of 98 normal children aged 5–14 years.

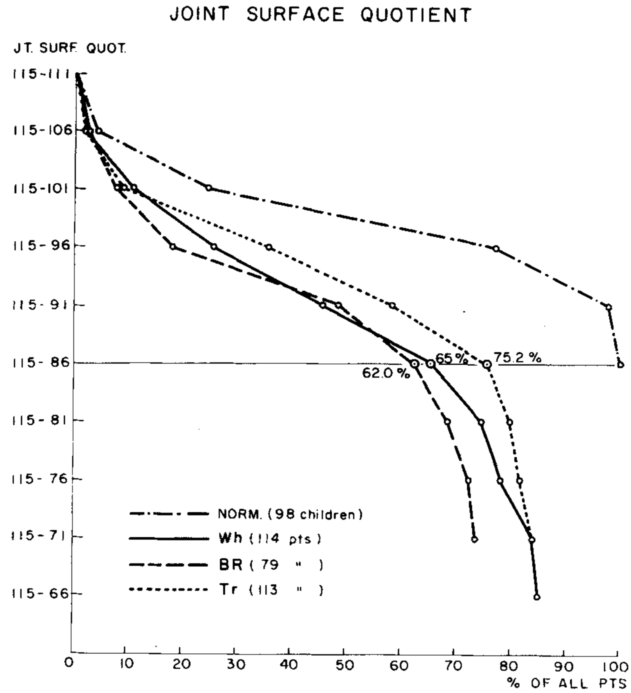


Diagram 40. Joint surface quotients in the

Wh series as referred,
BR series as referred,
Tr series as referred,

showing, for comparison, the joint surface quotients in a series of 98 normal children aged 5–14 years.

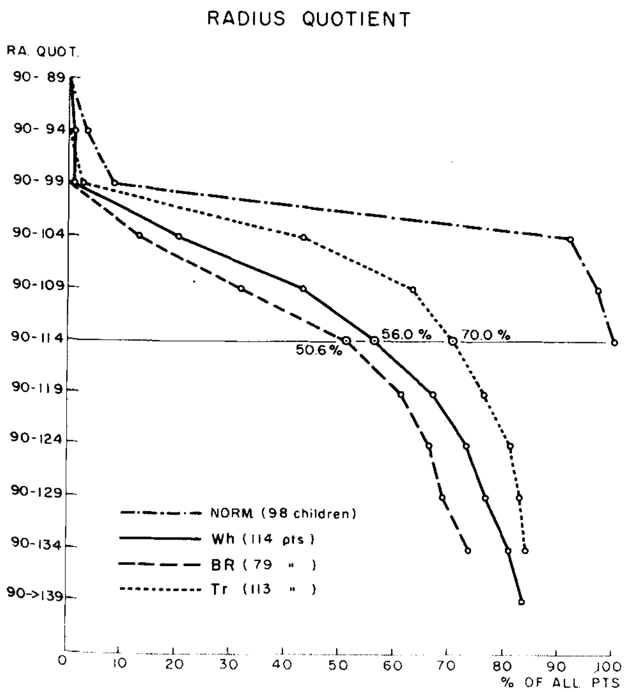


Diagram 41. Radius quotients in the

Wh series as referred,
BR series as referred,
Tr series as referred,

showing, for comparison, the radius quotients in a series of 98 normal children aged 5–14 years.

Table 26. Percentages in Tables 1, 3, 4, 5, 6, 7, 8, and 9 and in Diagrams 4, 5, and 32 expressed in number of patients.

Table 1

Radiological groups	Wh series	BR series	Tr series
"NON-sph."	17/114	21/79	18/113
"PATH.sph."	43/114	22/79	20/113
"NORM.sph."	54/114	36/79	75/113

Table 3

	Age groups		
	I	II	III
Wh series (114 pts.)	37/114	69/114	8/114
BR series (79 pts.)	17/79	48/79	14/79
Tr series (113 pts.)	31/113	62/113	20/113

Table 4

	Stage	
	A	B
Wh series (114 pts.)	68/114	46/114
BR series (79 pts.)	25/79	54/79
Tr series (113 pts.)	45/113	68/113

Table 5

	Sex	
	♂	♀
Wh series (114 pts.)	93/114	21/114
BR series (79 pts.)	60/79	19/79
Tr series (113 pts.)	97/113	16/113

Table 6

♂+♀	A I	A II	A III	B I	B II	B III
Wh series (114 pts.)	24/114	46/114	4/114	13/114	23/114	4/114
BR series (79 pts.)	5/79	24/79	10/79	12/79	24/79	4/79
Tr series (113 pts.)	14/113	33/113	15/113	17/113	29/113	5/113

Table 7

♂+♀	A I	A II	A III	B I	B II	B III
Wh series (114 pts.)	19/24	22/46	0/4	6/13	7/23	0/4
BR series (79 pts.)	4/5	13/24	3/10	7/12	7/24	2/4
Tr series (113 pts.)	14/14	28/33	4/15	13/17	15/29	1/5

Table 8

♂	A I	A II	A III	B I	B II	B III
Wh series (93 pts.)	21/93	40/93	4/93	10/93	16/93	2/93
BR series (60 pts.)	3/60	19/60	8/60	10/60	16/60	4/60
Tr series (97 pts.)	12/97	27/97	14/97	14/97	25/97	5/97

(Table 26 continued).

Table 9

♂	A I	A II	A III	B I	B II	B III
Wh series (93 pts.)	12/21	19/40	0/4	4/10	4/16	0/2
BR series (60 pts.)	2/3	11/19	3/8	7/10	6/16	2/4
Tr series (97 pts.)	12/12	25/27	3/14	10/14	14/25	1/5

Diagram 4. J.M.'s measurements

♂+♀	as referred	A I	A II	B I	B II	A III + B III
Wh series	54/114	19/24	22/46	6/13	7/23	0/8
Tr series	75/113	14/14	28/33	13/17	15/29	5/20

Diagram 32. LAU's measurements

♂+♀	as referred	A I	A II	B I	B II	A III + B III
Wh series	57/114	15/20	26/42	9/17	6/27	1/8
Tr series	71/113	10/10	19/23	15/20	20/40	7/20

Diagram 5

♂+♀	as referred	A I	A I-II	A II	A II B I	A II B I-II	B I-II	A III B I-II	A III B I-II-III	A III B II-III
Wh series	54/114	19/24	41/70	22/46	28/59	35/82	13/36	13/40	13/44	7/31
Tr series	75/113	14/14	42/47	28/33	41/50	56/79	28/46	32/61	33/66	20/49

Table 27. Survey *of radiological results of treatment of all patients – GIRLS + BOYS – in the series as referred and their A II groups and also of BOYS alone in the same series and groups.*

Results of treating GIRLS + BOYS in the			No. of pts.	% "NORM.sph."	% "SPH."
	1	Wh series as referred by Wh	114	47 %	85 %
a	2	BR series as referred by BR	79	46	73
	3	Tr series as referred by Tr	113	66	84
	1	A II group of Wh series by Wh	46	48	80
b	2	A II group of BR series by BR	24	54	79
	3	A II group of Tr series by Tr	33	85	97
	1	Wh series as referred by Wh		47	85
c	2	Wh series as referred by BR	114	54	82 calcul.
	3	Wh series as referred by Tr		76	91 calcul.
	1	BR series as referred by Wh		36	79 calcul.
d	2	BR series as referred by BR	79	46	73
	3	BR series as referred by Tr		64	80 calcul.
	1	Tr series as referred by Wh		38	82 calcul.
e	2	Tr series as referred by BR	113	48	82 calcul.
	3	Tr series as referred by Tr		66	84
Results of treating BOYS in the					
	1	Wh series as referred by Wh	93	47 %	82 %
♂a	2	BR series as referred by BR	60	52	77
	3	Tr series as referred by Tr	97	67	84
	1	A II group of Wh series by Wh	40	47	77
♂b	2	A II group of BR series by BR	19	58	84
	3	A II group of Tr series by Tr	27	92	100
	1	Wh series as referred by Wh		47	82
♂c	2	Wh series as referred by BR	93	57	83 calcul.
	3	Wh series as referred by Tr		81	93 calcul.
	1	BR series as referred by Wh		32	76 calcul.
♂d	2	BR series as referred by BR	60	52	77
	3	BR series as referred by Tr		65	83 calcul.
	1	Tr series as referred by Wh		35	78 calcul.
♂e	2	Tr series as referred by BR	97	53	78 calcul.
	3	Tr series as referred by Tr		67	84

1, 2, and 3 signify Wh, BR, and Tr treatment respectively.
calcul. = the results are calculated.

Table 28. **Statistical calculation.**

Application of the Fisher-Yates test (two-tailed)(Geigy: Wissenschaftliche Tabellen, 7th Ed. p. 109) showed that:

I	The frequency of patients with *"normally spherical"* heads differed significantly in the	
	Tr series and Wh series as referred	$p < 0.01$
	Tr series and BR series as referred	$p < 0.01$
	A II groups of the Tr series and Wh series	$p < 0.01$
	A II groups of the Tr series and BR series	$p < 0.05$
	Boys of the A II groups of the Tr series and of the Wh series	$p < 0.001$
	Boys of the A II groups of the Tr series and of the BR series	$p < 0.02$
	The frequency of patients with *"spherical"* heads differed significantly in the	
	Boys of the A II groups of the Tr series and Wh series	$p < 0.05$
II	The frequency of patients with *"spherical"* heads did *not* differ significantly in the	
	Tr series and Wh series as referred	$p > 0.05$
	Tr series and BR series as referred	$p > 0.05$
	A II groups of the Tr series and of the Wh series	$p > 0.05$
	A II groups of the Tr series and of the BR series	$p > 0.05$
	Boys of the A II groups of the Tr series and BR series	$p > 0.05$

Whether the different groups of patients are statistically comparable is discussed in the text.

Chart 1. 19 LCPD series followed up – analysed in the clinical section.

Age groups: III: mean age about 40–45 years,
II: mean age about 20–25 years,
I: mean age $<$20 years.

Designation of series: Numbers and abbreviations of authors' names (or treatments) used in the present study.
Authors' names and year of publication (further information in the list of references).
Nos. 15, 18, and 19: The three series evaluated in the present study: The bed rest (BR) series, wheelchair (Wh) series, and traction (Tr) series.

Age groups	Designation of series		Author – year
	No.	Abbreviation	
III	1	HE.	Helbo, 1953
	2	SU_{II}	Sundt, 1949 (pts. followed $>$25 years)
	3	GOW.	Gower & Johnston, 1971
	4	DA.	Danielsson & Hernborg, 1965
	5	RAT.	Ratliff, 1967
II	6	SU_{I}	Sundt, 1949 (pts. followed $<$25 years)
	7	EV.	Evans, 1958
	8	STA.	Stamp et al., 1959
	9	M. & S.	Mindell & Sherman, 1951
	10	EA.	Eeton, 1967
	11	EV. & Ll.R.	Evans & Lloyd-Roberts, 1958
	12	WA.	Wansbrough et al., 1959
I	13	EB.	Ebach, 1967
	14	MO.	Mose, 1964 (Thomas' splint)
	15	BR	Mose, 1964; Meyer, 1966
	16	KA.	Katz, 1967
	17	STEI.	Steinhauser, 1967
	18	Wh	Lauritzen, 1975
	19	Tr	Meyer – present paper

Chart 2. 19 LCPD series followed up – analysed in the clinical section.
Number of patients and age. Age range chiefly within the limits stated – possibly a few isolated cases outside.
I = ⩽4 years, II = 5–8 years, III = ⩾9 years at institution of treatment.

Designation of series No.	Abbrev. (cf. Chart 1)	No. of pts. (or hips)	Age at institution of treatment I, II, III (cf. rad. section) % % %	Age at follow-up: Mean age (years)	Age range (years)	Age distribution % = % of pts. in the series
Age group III (40–45 years)						
1	HE.	47	13 – 47 – 40	**42**	32 – 57	0 % <30 yrs. <89 % <50 yrs. <11 %
2	SU_{II}	63 (69 hips)	15 – 57 – 27	**40**	32 – 59	ca. 32 yrs. <87 % <47 yrs. <13 %
3	GOW.	36	5 – 39 – 56	**45**	35 – 60	0 % <30 yrs. <78 % <50 yrs. <22 %
4	DA.	35	15 – 51 – 34	**41**	26 – 61	11 % <30 yrs. <69 % <50 yrs. <20 %
5	RAT.	34	10 – 60 – 30	**38**	29 – 52	30 yrs. <90 % <50 yrs.
Age group II (about 20–25 years – 2 series not measured <20 years)						
6	SU_{I}	74 (85 hips)	15 – 57 – 27	ca. 25	(17 – 32)	
7	EV.	52	16 – 62 – 22	23	15 – 42	
8	STA.	132 (146 hips)	?	ca. 19	(11 – 39)	
9	M. & S.	72	16 – 65 – 16	ca. 20	(9 – 39)	
10	EA.	88 (100 hips)	9 – 37 – 53	ca. 25	(17 – 50)	
11	EV. & Ll.R. (in hosp.)	24	25 – 75 – 0	ca. 13	(10 – 15)	
12	WA.	129	14 – 60 – 26	ca. 20	(15 – 30)	
Age group I (<20 years – all series measured (1 series = 20–21 years))						
13	EB.	52	(62 % <8 yrs. <38 %)	ca. 20–21		
14	MO.	64	39 – 54 – 7	<20		
15	BR	79	21 – 61 – 18	12 (1960)	6 – 18	9 yrs. <87 % <16 yrs.
16	KA.	229	23 – 69 – 8	<20		
17	STEI.	75	30 – 28 – 22	16 – 20		
18	Wh	114	32 – 61 – 7	13 (1968)	5 – 22	9 yrs. <78 % <16 yrs.
19	Tr	113	27 – 55 – 18	13 (1968)	7 – 21	9 yrs. <75 % <16 yrs.

Chart 3. 19 LCPD series followed up – analysed in the clinical section.
Treatment *by non-weightbearing.*

No.	Author etc. (cf. Chart 1)	NON-WEIGHTBEARING % of the pts. in the series	Duration (years)	In hospital/At home	No non-weightbearing % of the pts. in the series
Age group III (40–45 years)					
1	HE.	(60) only symptomatic	<3/12		(40)
2	SU_{II}	(40) only symptomatic	mean 6/12		(60)
3	GOW.	30	mean 8/12	chiefly at home	70
4	DA.	95	mean 6/12	in hosp.	5
5	RAT.	75	mean 18/12	in hosp.	25
Age group II (20–25 years)					
6	SU_{I}	(40) only symptomatic	mean 6/12		(60)
7	EV.	100	25/12	in hosp.	0
8	STA.	68	mean 27/12	in hosp./at home	32
9	M. & S.	82	1–2	in hosp./at home	18
10	EA.	80	>6/12	chiefly in hosp.	20
11	EV. & Ll.R. (in hosp.)	100	25/12	in hosp.	0
12	WA.	100	1–2	chiefly at home	0
Age group I (<20 years – at primary healing)					
13	EB.	100	34/12	chiefly at home	0
14	MO.	100	ca. 22/12	at home	0
15	BR	100	24/12	in hosp. 18/12	0
16	KA.	100	"long-lasting"		0
17	STEI.	100	15/12	at home	0
18	Wh	100	1–2	at home	0
19	Tr	100	24/12	in hosp. 18/12	0

Chart 4. 19 LCPD series followed up – analysed in the clinical section.

Classifications: *Age groups II and III: The various authors' classifications. The classifications are based upon an estimate – mainly according to radiological criteria. In 2 series (5 and 8), however, the criteria were radiological-clinical.*

Age group I: In this age group the classifications were based upon the result of radiological measurements using the nomenclature of the present study (cf. text p. 20).

Age group	Series No.	Classifications of the series	
III	1	spherical 12 % – greatly flattened 61 % – irregular 27 %	
	2	spherical 9 % – ovoid 36 % – cylindrical 52 % – angular 3 %	
	3	round 20 % – flattened 73 % – angular 7 %	
	4	0: 17 % – 1: 23 % – 2: 23 % – 3: 37 %	
	5	good 44 % – fair 32 % – poor 23 % (cf. Appendix, Comment 3)	
II	6	spherical 6 % – ovoid 37 % – cylindrical 48 % – angular 8 %	
	7	good 29 % – fair 40 % – poor 31 %	
	8	satisfactory 38 % – fair 25 % – poor 37 %	
	9	satisfactory 56 % – fair 15 % – poor 29 %	
	10	spherical 7 % – mildly flattened 55 % – moderately flattened 19 % – severely flattened 19 %	
	11	almost normal 62 % – intermediate 21 % – bad 17 %	
	12	excellent 35 % – good 29 % – fair 21 % – poor 15 %	
I	13	"NORM.sph." (E) 47 % – "PATH.sph." (E) 13 % – "NON-sph." 40 %	("SPH." 60 %)
	14	"NORM.sph." (E) 42 % – "PATH.sph." (E) 19 % – "NON-sph." 39 %	("SPH." 61 %)
	15	"NORM.sph." 46 % – "PATH.sph." 27 % – "NON-sph." 27 %	("SPH." 73 %)
	16	"NORM.sph." (E) 68 % – "PATH.sph." (E) 12 % – "NON-sph." 20 %	("SPH." 80 %)
	17	"NORM.sph." (E) 71 % – "PATH.sph." (E) 11 % – "NON-sph." 18 %	("SPH." 82 %)
	18	"NORM.sph." 47 % – "PATH.sph." 38 % – "NON-sph." 15 %	("SPH." 85 %)
	19	"NORM.sph." 66 % – "PATH.sph." 18 % – "NON-sph." 16 %	("SPH." 84 %)

Chart 5. 19 LPCD series followed up.

Age group	Series No.	% "SPH." estimated by J. M. or measured. % of series	Age groups III and II: Pt. groups in the authors' classification comprised by the group "SPH." as estimated by J. M. Age group I: Group "SPH." directly measured.
III	1	12 %	"spherical"
	2	27	"spherical" + ½ "ovoid"
	3	30	"round" + 10 % "flattened"
	4	35	"0" + ¾ "1"
	5	48	"good" + 4 % (cf. Appendix, Comment 3)
II	6	24 %	"spherical" + ½ "ovoid"
	7	49	"good" + ½ "fair"
	8	50	"satisfactory" + ½ "fair"
	9	64	"satisfactory" + ½ "fair"
	10	64	"spherical" + "mildly flattened"
	11	73	"almost normal" + ½ "intermediate"
	12	76	"excellent" + "good" + ½ "fair"
I	13	60 %	direct measurement
	14	61	direct measurement
	15	73	direct measurement
	16	80	direct measurement
	17	82	"NORM.sph." (E) + 11 %
	18	85	direct measurement
	19	84	direct measurement

Table 29. Primary radiological deformity, radiological osteoarthritis, and subjective clinical symptoms in 19 LCPD series.

		Primary radiol. deformity		Radiol. osteoarthritis			Subjective clinical sympt. (Cause: Primary radiol. deformity or radiol. osteoarthritis)		
Age group	Series No.	"NORM.sph." % of all pts.	"SPH." % of all pts.	Spread over % of the series (cf. diagr.)	% of pts. without spread	% of pts. with narrowing of joint space	Spread over % of the series (cf. diagr.)	% of pts. without spread	% of pts. with disabling osteoarthr.
		%	%	%	%	%	%	%	%
III	1		12	88	56		88	62	21
	2		27	91	58		91	68	19
	3		30	86	77	42	86	61	27
	4		35	72	50	28	37	23 (20)	?
	5		48	55	50	25	23	20	10
II	6		24	76	32		57	29	6
	7		49	31	?		80	37	10
	8		50				62	?	
	9		64	29	?		44	?	
	10		64	19	?		63	48	6
	11		73						
	12		76	15	?		36	?	6
I	13		60				53	32	
	14		61				?	?	
	15	46	73				60	22	
	16		80				?	?	
	17		82				29	11	
	18	47	85				?	?	
	19	66	84				40	13	

Table 30. Development of osteoarthritis in Ruelle's total material of secondary osteoarthritis (pt. groups I and II, a total of 271 pts.).

Among 271 pts. with sec. osteoarthr. who applied for treatment in a rheumat. clinic *the symptoms of osteoarthritis started:*							*Total survey:* % of all clin. cases of osteoarthr. developing before the ages stated	
In age group	No. of pts.	Before age	In No. of pts.	% of 271 found	Before age	% of 271 calculated (inter-polation)	Age	% osteo-arthritis
years	No.	years	No.	%	years	%	years	%
		80	271	100			80	100
70 – 80	3				75	99.5	75	99.5
		70	268	99			70	99
60 – 70	17				65	96	65	96
		60	251	93			60	93
50 – 60	61				55	81	55	81
		50	190	70			50	70
40 – 50	93				45	53	45	53
		40	97	36			40	36
30 – 40	69				35	23	35	23
		30	28	10			30	10
20 – 30	(22) (graphic)				25	(3) (graphic)	25	(3) (graphic)
		20	(6) (graphic)	(2) (graphic)			20	(2) (graphic)
10 – 20	(6) (graphic)							
		10	0					

PATIENT LISTS

The patient lists for the traction and bed rest series comprise all patients referred for LCPD to the Seaside Hospital, Refsnæs, during the periods 1958–63 and 1953–57 respectively.

All figures on the lists refer to unilateral cases on which the evaluation was based. The remainder – the majority bilateral – are only marked Excl. (excluded) adding the reason for exclusion.

The patients of the wheelchair series are arranged in the same way – only 17 patients from the study period (1957–64 incl.) are missing, as they were excluded before J. M. got the opportunity to see the series. Nearly all these cases were bilateral.

The number of the patients of the 3 series treated for LCPD is then:

	Number of pts.	% of all treated cases
Unilateral cases:		
Wheelchair series	114	
Bed rest series	79	
Traction series	113	
Bilateral cases:		
Wheelchair series	21	15.6 %
Bed rest series	14	15.1 -
Traction series	24	17.5 -

(As to the justification of excluding bilateral cases in the evaluation of the therapeutic results, cf. Meyer 1966).

Table 31. Number of patients with dysplasia of the capital femoral epiphysis (J.M. 1964) *(this number can only be approximate, as the limit between dysplasia and typical LCPD is not sharp):*

Wheelchair series:	Unilateral dysplasia about 12/144 = 10.5 %.
Bed rest series:	Unilateral dysplasia. The number is not definitely known, as the series was measured before the syndrome dysplasia was describ-ed (Meyer 1964). (No.: >3/79 (3.8 %)).
Traction series:	Unilateral dysplasia about 10/113 = 8.8 %, unilateral + bilateral 19/137 = 13.6 %.

Table 32. Wheelchair series – corresponding numbers.
Transfer table between J.M.'s pt. Nos. in the present study and LAU's pt. Nos. in his thesis from 1975. (Excluded pts. not listed).

J. M. No.	LAU No.	J. M. No.	LAU No.	J. M. No.	LAU No.	J. M. No.	LAU No.	J. M. No.	LAU No.	J. M. No.	LAU No.
3	108	25	82	47	67	69	35	89	3	109	123
4	126	26	88	48	85	70	33	90	2	110	118
5	128	27	94	49	87	71	31	91	100	111	107
6	138	28	102	50	101	72	29	92	30	112	86
7	127	30	110	53	91	73	28	93	20	113	76
8	139	32	113	54	84	74	141	94	90	114	75
10	106	33	115	55	63	75	122	95	16	116	68
11	120	34	116	56	61	76	83	96	7	117	65
12	114	35	119	57	58	77	70	97	9	118	62
13	111	36	117	58	53	78	54	98	36	119	46
14	104	37	124	59	52	79	34	99	66	120	44
15	95	38	125	60	51	80	26	100	56	122	39
16	79	39	130	61	50	81	23	101	78	123	11
17	72	40	129	62	48	82	22	102	27	124	5
18	71	41	132	63	47	83	21	103	92		
19	57	42	133	64	49	84	18	104	17		
21	41	43	134	65	43	85	69	105	10		
22	103	44	137	66	42	86	14	106	6		
23	80	45	136	67	45	87	12	107	4		
24	81	46	64	68	38	88	8	108	1		

Abbreviations and terms used in the patient lists.

Excl.	Excluded (reason stated)
Co.	Stage of condensation
Fragm.	Stage of fragmentation
A	Stage of condensation. Initial quotient >85.
B	Stage of condensation. Initial quotient <85.
Bilat.	Bilateral
I	Age $\leqslant 4$ years
II	Age 5–8 years
III	Age $\geqslant 9$ years
Dy.	Dysplasia of the capital femoral epiphysis
"NORM.sph."	Cases healed with "spherical heads" of normal shape and size.
"PATH.sph."	Cases healed with "spherical heads" of pathological shape and/or size.
"NON-sph."	Cases healed with heads without circular contours.

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief designation	Radiological result: Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
1		Excl. – bilat.						
2		Excl. – quest. path.						
3	♂	Co. – 91	7	A II	82 –	88 –	109	"NORM.sph."
4	♀	Fragm.	4	B I	41 –	74 –	122	"PATH.sph."
5	♂	Co. – 94	7	A II	83 –	105 –	110	"NORM.sph."
6	♂	Co. – 100	5	A II	91 –	100 –	100	"NORM.sph."
7	♂	Co. – 103	6	A II	58 –	93 –	130	"PATH.sph."
8	♂	Dy. – 100	3	A I	94 –	96 –	100	"NORM.sph."
9		Excl. – quest. path.						
10	♂	Co. – 97	2	A I	94 –	100 –	100	"NORM.sph."
11	♂	Co. – 103	5	A II	97 –	104 –	100	"NORM.sph."
12	♂	Co. – 89	6	A II	"NON-sph."			"NON-sph."
13	♂	Fragm.	6	B II	53 –	94 –	122	"PATH.sph."
14	♂	Co. – 91	5	A II	48 –	78 –	136	"PATH.sph."
15	♂	Co. – 72	6	B II	71 –	87 –	116	"PATH.sph."
16	♂	Co. – 79	11	B III	86 –	84 –	107	"PATH.sph."
17	♂	Dy. – 100	5	A II	94 –	103 –	105	"NORM.sph."
18	♂	Co. – 104	6	A II	84 –	81 –	110	"PATH.sph."
19	♂	Co. – 96	5	A II	39 –	91 –	125	"PATH.sph."
20		Excl. – bilat.						
21	♂	Co. – 43	4	B I	55 –	92 –	108	"PATH.sph."
22	♂	Dy. – 93	3	A I	93 –	103 –	105	"NORM.sph."
23	♀	Fragm.	6	B II	46 –	75 –	135	"PATH.sph."
24	♂	Co. – 100	4	A I	39 –	85 –	150	"PATH.sph."
25	♂	Fragm.	4	B I	61 –	78 –	134	"PATH.sph."
26	♂	Fragm.	3	B I	74 –	109 –	100	"NORM.sph."
27	♂	Dy. – 86	4	A I	87 –	96 –	100	"NORM.sph."
28	♂	Co. – 83	4	B I	61 –	85 –	118	"PATH.sph."
29		Excl. – bilat.						
30	♂	Co. – 89	4	A I	68 –	100 –	100	"NORM.sph."
31		Excl. – bilat.						
32	♂	Co. – 94	8	A II	74 –	101 –	109	"NORM.sph."
33	♂	Co. – 75	7	B II	89 –	88 –	109	"NORM.sph."
34	♂	Co. – 88	5	A II	61 –	85 –	111	"PATH.sph."
35	♀	Co. – 91	3	A I	87 –	99 –	106	"NORM.sph."
36	♂	Co. – 80	5	B II	44 –	66 –	155	"PATH.sph."
37	♂	Co. – 87	3	A I	83 –	91 –	100	"NORM.sph."
38	♂	Co. – 76	7	B II	43 –	98 –	118	"PATH.sph."
39	♀	Fragm.	5	B II	79 –	91 –	110	"NORM.sph."
40	♂	Co. – 95	2	A I	55 –	75 –	133	"PATH.sph."
41	♂	Co. – 107	4	A I	100 –	95 –	107	"NORM.sph."
42	♂	Co. – 97	8	A II	"NON-sph."			"NON-sph."
43	♂	Co. – 96	6	A II	64 –	103 –	110	"NORM.sph."
44	♂	Dy. – 100	6	A II	85 –	84 –	110	"PATH.sph."
45	♀	Co. – 84	10	B III	65 –	83 –	125	"PATH.sph."
46	♂	Co. – 93	11	A III	64 –	72 –	115	"PATH.sph."
47	♂	Co. – 86	8	A II	66 –	93 –	108	"NORM.sph."
48	♂	Co. – 75	3	B I	71 –	100 –	100	"NORM.sph."

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig- nation	Radiological result: Ep. quot. – Jt. surf. quot. – Ra. quot.	Group
49	♀	Dy. – 100	5	A II	97 – 96 – 104	"NORM.sph."
50	♂	Co. – 107	6	A II	75 – 98 – 110	"NORM.sph."
51		Excl. – Ep. lysis				
52		Excl. – cong. disloc.				
53	♂	Co. – 100	3	A I	78 – 109 – 100	"NORM.sph."
54	♂	Co. – 91	3	A I	90 – 96 – 100	"NORM.sph."
55	♂	Co. – 100	6	A II	67 – 93 – 108	"NORM.sph."
56	♂	Co. – 93	6	A II	68 – 98 – 113	"NORM.sph."
57	♂	Co. – 103	7	A II	76 – 92 – 109	"NORM.sph."
58	♂	Fragm.	8	B II	70 – 90 – 105	"NORM.sph."
59	♂	Co. – 92	8	A II	88 – 82 – 122	"PATH.sph."
60	♂	Co. – 87	5	A II	"NON-sph."	"NON-sph."
61	♀	Co. – 104	4	A I	76 – 78 – 122	"PATH.sph."
62	♀	Dy. – 67	2	B I	80 – 95 – 106	"NORM.sph."
63	♀	Fragm.	6	B II	41 – 79 – 120	"PATH.sph."
64	♂	Co. – 55	4	B I	"NON-sph."	"NON-sph."
65	♂	Fragm.	6	B II	59 – 96 – 105	"PATH.sph."
66	♂	Co. – 79	6	B II	91 – 95 – 105	"NORM.sph."
67	♀	Co. – 82	6	B II	70 – 87 – 105	"NORM.sph."
68	♂	Fragm.	6	B II	53 – 87 – 116	"PATH.sph."
69	♀	Co. – 91	6	A II	54 – 90 – 117	"PATH.sph."
70	♂	Fragm.	10	B III	68 – 89 – 115	"PATH.sph."
71	♀	Fragm.	9	B III	"NON-sph."	"NON-sph."
72	♂	Co. – 74	6	B II	58 – 91 – 107	"PATH.sph."
73	♂	Dy. – 106	2	A I	79 – 95 – 105	"NORM.sph."
74	♂	Co. – 89	5	A II	"NON-sph."	"NON-sph."
75	♀	Fragm.	8	B II	"NON-sph."	"NON-sph."
76	♂	Co. – 90	3	A I	"NON-sph."	"NON-sph."
77	♂	Co. – 104	4	A I	90 – 100 – 100	"NORM.sph."
78	♂	Co. – 59	4	B I	67 – 87 – 128	"PATH.sph."
79	♀	Fragm.	4	B I	69 – 88 – 100	"NORM.sph."
80	♂	Co. – 100	6	A II	86 – 102 – 92	"NORM.sph."
81	♂	Fragm.	7	B II	40 – 92 – 128	"PATH.sph."
82	♀	Co. – 92	5	A II	74 – 105 – 104	"NORM.sph."
83	♂	Co. – 92	11	A III	"NON-sph."	"NON-sph."
84	♂	Co. – 110	5	A II	93 – 85 – 100	"PATH.sph."
85	♂	Co. – 69	3	B I	77 – 94 – 111	"NORM.sph."
86	♂	Co. – 103	6	A II	"NON-sph."	"NON-sph."
87	♀	Co. – 117	6	A II	67 – 90 – 117	"PATH.sph."
88	♂	Fragm.	8	B II	52 – 88 – 118	"PATH.sph."
89	♂	Co. – 75	1	B I	78 – 90 – 111	"NORM.sph."
90	♂	Co. – 107	9	A III	65 – 88 – 118	"PATH.sph."
91	♂	Co. – 95	5	A II	94 – 92 – 105	"NORM.sph."
92	♂	Co. – 97	7	A II	"NON-sph."	"NON-sph."
93	♂	Co. – 92	6	A II	61 – 91 – 118	"PATH.sph."
94	♂	Co. – 91	3	A I	71 – 90 – 111	"NORM.sph."
95	♀	Dy. – 91	3	A I	62 – 90 – 111	"NORM.sph."
96	♀	Co. – 87	5	A II	81 – 94 – 100	"NORM.sph."

Wheelchair series. – Measurements: J.M.

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig-nation	Radiological result: Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
97	♂	Co. – 81	7	B II	62 –	87 –	124	"PATH.sph."
98	♂	Co. – 86	7	A II	91 –	97 –	100	"NORM.sph."
99	♂	Co. – 95	3	A I		"NON-sph."		"NON-sph."
100	♂	Co. – 103	7	A II	84 –	93 –	108	"NORM.sph."
101	♀	Fragm.	7	B II	65 –	75 –	133	"PATH.sph."
102	♂	Co. – 105	10	A III		"NON-sph."		"NON-sph."
103	♂	Co. – 80	6	B II	31 –	75 –	132	"PATH.sph."
104	♂	Co. – 90	4	A I	90 –	87 –	100	"NORM.sph."
105	♂	Co. – 81	7	B II		"NON-sph."		"NON-sph."
106	♂	Co. – 103	6	A II	75 –	82 –	113	"PATH.sph."
107	♂	Co. – 56	3	B I	53 –	90 –	120	"PATH.sph."
108	♂	Co. – 87	4	A I	69 –	92 –	109	"NORM.sph."
109	♂	Co. – 99	8	A II		"NON-sph."		"NON-sph."
110	♂	Co. – 92	8	A II	75 –	83 –	110	"PATH.sph."
111	♂	Co. – >85	6	A II	85 –	89 –	112	"NORM.sph."
112	♂	Co. – 103	8	A II		"NON-sph."		"NON-sph."
113	♂	Co. – 105	6	A II	58 –	90 –	116	"PATH.sph."
114	♂	Co. – 119	7	A II	72 –	102 –	107	"NORM.sph."
115		Excl. – not tr. here						
116	♀	Co. – 100	6	A II	100 –	103 –	100	"NORM.sph."
117	♂	Co. – 89	7	A II		"NON-sph."		"NON-sph."
118	♂	Fragm.	5	B II	73 –	93 –	107	"NORM.sph."
119	♀	Fragm.	7	B II	63 –	95 –	109	"NORM.sph."
120	♂	Co. – 94	5	A II	43 –	74 –	138	"PATH.sph."
121		Excl. – bilat.						
122	♂	Dy. – 86	2	A I	96 –	96 –	104	"NORM.sph."
123	♂	Co. – 95	3	A I	77 –	90 –	108	"NORM.sph."
124	♂	Dy. – 105	3	A I	100 –	96 –	100	"NORM.sph."

(17 excluded patients not listed here)

Bed rest series. – Measurements: J.M.

No.	Sex	Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig-nation	Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
1		Excl. – bilat.						
2	♂	Fragm.	7	B II	82 –	95 –	109	"NORM.sph."
3	♀	Co. – 92	9	A III		"NON-sph."		"NON-sph."
4	♂	Co. – 78	3	B I	95 –	94 –	100	"NORM.sph."
5		Excl. – not tr. here						
6		Excl. – bilat.						
7	♂	Co. – 78	6	B II		"NON-sph."		"NON-sph."
8	♀	Co. – 72	6	B II	46 –	78 –	127	"PATH.sph."
9	♀	Co. – 78	6	B II	55 –	91 –	117	"PATH.sph."
10	♂	Co. – 89	6	A II	78 –	103 –	108	"NORM.sph."
11	♀	Fragm.	6	B II	58 –	92 –	109	"PATH.sph."
12	♂	Dy. – 78	7	B II	83 –	96 –	109	"NORM.sph."
13		Excl. – bilat.						
14	♂	Co. – 102	7	A II	70 –	95 –	108	"NORM.sph."
15	♂	Fragm.	4	B I	83 –	93 –	100	"NORM.sph."

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig- nation	Radiological result: Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
16	♂	Fragm.	6	B II		"NON-sph."		"NON-sph."
17	♀	Co. – 78	6	B II	71	94	110	"NORM.sph."
18		Excl. – bilat.						
19	♂	Co. – 103	8	A II	68	92	109	"NORM.sph."
20	♂	Co. – 98	5	A II	45	78	133	"PATH.sph."
21	♂	Co. – 84	5	B II		"NON-sph."		"NON-sph."
22	♂	Co. – 89	10	A III		"NON-sph."		"NON-sph."
23	♀	Co. – 92	7	A II		"NON-sph."		"NON-sph."
24	♂	Co. – 72	6	B II	66	93	105	"NORM.sph."
25		Excl. – bilat.						
26	♂	Co. – 91	7	A II	78	92	109	"NORM.sph."
27	♀	Co. – 90	8	A II		"NON-sph."		"NON-sph."
28	♂	Co. – 100	5	A II	92	107	100	"NORM.sph."
29	♂	Co. – 96	11	A III	67	82	116	"PATH.sph."
30	♂	Co. – 79	4	B I	73	90	111	"NORM.sph."
31		Excl. – not. tr. here						
32	♂	Co. – 80	3	B I	65	105	100	"NORM.sph."
33	♂	Fragm.	8	B II	63	90	114	"NORM.sph."
34	♂	Dy. – 70	3	B I	88	87	100	"NORM.sph."
35	♀	Fragm.	8	B II		"NON-sph."		"NON-sph."
36	♂	Co. – 107	7	A II	100	100	100	"NORM.sph."
37	♂	Co. – 94	3	A I	71	87	110	"NORM.sph."
38	♂	Co. – 104	4	A I	89	105	100	"NORM.sph."
39	♀	Fragm.	7	B II		"NON-sph."		"NON-sph."
40	♀	Co. – 90	4	A I	84	92	108	"NORM.sph."
41	♂	Co. – 99	9	A III	98	97	100	"NORM.sph."
42	♂	Co. – 108	7	A II	93	95	110	"NORM.sph."
43	♂	Co. – 82	6	B II		"NON-sph."		"NON-sph."
44		Excl. – bilat.						
45	♂	Co. – 87	9	A III		"NON-sph."		"NON-sph."
46		Excl. – not tr. here						
47		Excl. – bilat.						
48		Excl. – bilat.						
49	♂	Co. – 107	11	A III		"NON-sph."		"NON-sph."
50	♀	Co. – 92	8	A II	62	91	117	"PATH.sph."
51	♂	Co. – 100	7	A II	59	87	133	"PATH.sph."
52	♂	Fragm.	7	B II		"NON-sph."		"NON-sph."
53		Excl. – bilat.						
54	♂	Co. – 100	6	A II	68	92	109	"NORM.sph."
55	♂	Co. – 89	6	A II	81	93	122	"PATH.sph."
56	♂	Fragm.	4	B I	78	86	111	"NORM.sph."
57	♂	Fragm.	6	B II	86	92	109	"NORM.sph."
58	♂	Co. – 98	10	A III	68	96	104	"NORM.sph."
59		Excl. – bilat.						
60	♂	Co. – 98	10	A III	61	96	111	"NORM.sph."
61		Excl. – bilat.						
62	♂	Co. – 103	6	A II		"NON-sph."		"NON-sph."
63	♂	Co. – 98	7	A II		"NON-sph."		"NON-sph."

Bed rest series. – Measurements: J.M.

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig- nation	Radiological result: Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
64	♂	Fragm.	3	B I	84 –	95 –	110	"NORM.sph."
65	♂	Co. – 75	8	B II		"NON-sph."		"NON-sph."
66	♂	Co. – 106	8	A II	93 –	102 –	108	"NORM.sph."
67	♀	Fragm.	8	B II		"NON-sph."		"NON-sph."
68	♀	Co. – 93	9	A III		"NON-sph."		"NON-sph."
69	♂	Co. – 86	7	A II		"NON-sph."		"NON-sph."
70		Excl. – bilat.						
71	♀	Co. – 83	4	B I	48 –	78 –	118	"PATH.sph."
72	♂	Co. – 88	5	A II	77 –	92 –	108	"NORM.sph."
73	♂	Fragm.	7	B II	71 –	86 –	108	"NORM.sph."
74		Excl. – bilat.						
75	♂	Fragm.	9	B III	83 –	100 –	104	"NORM.sph."
76	♂	Co. – 83	4	B I	72 –	87 –	120	"PATH.sph."
77	♂	Fragm.	7	B II	71 –	83 –	133	"PATH.sph."
78	♀	Fragm.	5	B II	52 –	87 –	130	"PATH.sph."
79	♂	Fragm.	14	B III		"NON-sph."		"NON-sph."
80	♀	Co. – >85	5	A II	67 –	94 –	110	"NORM.sph."
81	♂	Co. – 62	6	B II	51 –	72 –	127	"PATH.sph."
82	♂	Co. – 91	4	A I	71 –	81 –	111	"PATH.sph."
83	♂	Co. – 100	7	A II	83 –	85 –	114	"PATH.sph."
84	♂	Co. – 69	5	B II		"NON-sph."		"NON-sph."
85	♂	Co. – 87	4	A I	72 –	89 –	112	"NORM.sph."
86	♂	Co. – 97	6	A II	84 –	106 –	116	"PATH.sph."
87	♂	Co. – 93	9	A III	87 –	91 –	118	"PATH.sph."
88	♂	Fragm.	3	B I	58 –	97 –	120	"PATH.sph."
89	♂	Co. – 94	8	A II	79 –	98 –	110	"NORM.sph."
90		Excl. – bilat.						
91	♂	Fragm.	13	B III	64 –	84 –	115	"PATH.sph."
92	♂	Fragm.	10	B III	93 –	94 –	107	"NORM.sph."
93	♀	Fragm.	4	B I	54 –	87 –	110	"PATH.sph."
94	♂	Co. – 92	6	A II	95 –	93 –	111	"NORM.sph."
95	♂	Co. – 84	8	B II	70 –	92 –	117	"PATH.sph."
96	♂	Fragm.	4	B I	53 –	92 –	122	"PATH.sph."

Traction series. – Measurements: J.M.

1	♂	Co. – 100	8	A II	82 –	91 –	103	"NORM.sph."
2	♂	Co. – 75	6	B II	85 –	92 –	109	"NORM.sph."
3	♀	Co. – 88	11	A III	96 –	94 –	104	"NORM.sph."
4	♂	Co. – 103	9	A III	66 –	86 –	120	"PATH.sph."
5		Excl. – bilat.						
6	♂	Co. – 100	5	A II	88 –	100 –	100	"NORM.sph."
7	♂	Co. – 83	5	B II	72 –	100 –	100	"NORM.sph."
8	♂	Fragm.	9	B III	79 –	96 –	104	"NORM.sph."
9	♂	Co. – 88	8	A II	84 –	99 –	104	"NORM.sph."
10	♂	Co. – 81	9	B III		"NON-sph."		"NON-sph."
11	♂	Co. – 91	4	A I	83 –	93 –	96	"NORM.sph."
12	♂	Co. – 100	6	A II	84 –	93 –	104	"NORM.sph."

Traction series. – Measurements: J.M.

No.	Sex	Condition at institution of treatment			Radiological result	
		Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig- nation	Ep. quot. – Jt. surf. quot. – Ra. quot.	Group
13	♂	Co. – 87	5	A II	86 – 94 – 103	"NORM.sph."
14	♂	Co. – 74	6	B II	68 – 82 – 122	"PATH.sph."
15	♂	Co. – 97	6	A II	86 – 96 – 108	"NORM.sph."
16	♂	Fragm.	7	B II	55 – 86 – 117	"PATH.sph."
17		Excl. – bilat.				
18	♂	Fragm.	4	B I	59 – 90 – 108	"PATH.sph."
19		Excl. – not tr. here				
20	♀	Co. –	6	B II	"NON-sph."	"NON-sph."
21	♂	Co. –	10	A III	78 – 90 – 115	"PATH.sph."
22	♂	Co. – 85	5	B II	59 – 96 – 104	"PATH.sph."
23		Excl. – bilat.				
24		Excl. – other diagn.				
25	♀	Co. – 88	8	A II	70 – 71 – 119	"PATH.sph."
26	♂	Co. – 93	7	A II	82 – 91 – 103	"NORM.sph."
27	♂	Co. – 92	4	A I	97 – 100 – 100	"NORM.sph."
28	♂	Co. – 87	11	A III	84 – 95 – 103	"NORM.sph."
29	♂	Co. – 87	9	A III	58 – 74 – 125	"PATH.sph."
30	♂	Dy. – 71	5	B II	95 – 100 – 100	"NORM.sph."
31		Excl. – not tr. here				
32		Excl. – doublet				
33		Excl. – bilat.				
34	♂	Co. – 96	5	A II	94 – 100 – 100	"NORM.sph."
35	♂	Co. – 93	7	A II	87 – 97 – 107	"NORM.sph."
36		Excl. – not tr. here				
37	♀	Co. – 96	4	A I	100 – 100 – 100	"NORM.sph."
38		Excl. – treatm. interrupt.				
39	♂	Dy. – 84	4	B I	113 – 107 – 100	"NORM.sph."
40	♂	Co. – 95	12	A III	"NON-sph."	"NON-sph."
41	♂	Co. – 76	6	B II	77 – 96 – 104	"NORM.sph."
42	♀	Co. – 104	4	A I	85 – 96 – 100	"NORM.sph."
43	♀	Co. – 60	4	B I	91 – 96 – 104	"NORM.sph."
44	♀	Fragm.	3	B I	78 – 107 – 100	"NORM.sph."
45	♂	Co. – 87	5	A II	91 – 92 – 104	"NORM.sph."
46	♂	Co. – 98	12	A III	"NON-sph."	"NON-sph."
47	♀	Co. – 60	6	B II	"NON-sph."	"NON-sph."
48	♂	Co. – 100	9	A III	86 – 94 – 100	"NORM.sph."
49	♂	Co. – 72	7	B II	"NON-sph."	"NON-sph."
50	♂	Co. – 89	5	A II	88 – 93 – 100	"NORM.sph."
51	♂	Co. – 89	8	A II	91 – 88 – 104	"NORM.sph."
52	♂	Co. – 81	6	B II	84 – 100 – 100	"NORM.sph."
53	♂	Fragm.	5	B II	75 – 100 – 104	"NORM.sph."
54		Excl. – bilat.				
55		Excl. – bilat.				
56	♂	Co. – 71	4	B I	79 – 88 – 100	"NORM.sph."
57	♂	Co. – 83	4	B I	71 – 89 – 104	"NORM.sph."
58		Excl. – bilat.				
59	♂	Fragm.	6	B II	51 – 88 – 119	"PATH.sph."
60	♂	Co. – 50	7	B II	"NON-sph."	"NON-sph."

Traction series. – Measurements: J.M.

No.	Sex	Condition at institution of treatment			Radiological result			
		Stage/ initial quotient	Age at inst. of treatment (years)	Brief designation	Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
61	♂	Co. – 93	4	A I	86 –	92 –	100	"NORM.sph."
62		Excl. – bilat.						
63	♂	Co. – 90	5	A II	79 –	92 –	105	"NORM.sph."
64	♂	Dy. – 69	3	B I	84 –	100 –	100	"NORM.sph."
65	♂	Co. – 101	6	A II	82 –	99 –	105	"NORM.sph."
66	♂	Co. – 89	9	A III		"NON-sph."		"NON-sph."
67	♂	Co. – 100	3	A I	88 –	101 –	96	"NORM.sph."
68	♂	Fragm.	6	B I	82 –	85 –	105	"PATH.sph."
69	♂	Co. – 73	3	B I	79 –	104 –	105	"NORM.sph."
70		Excl. – not tr. here						
71		Excl. – bilat.						
72	♂	Dy. – 58	2	B I	76 –	75 –	128	"PATH.sph."
73	♂	Co. – 78	6	B II	88 –	95 –	105	"NORM.sph."
74	♂	Co. – 92	6	A II	75 –	89 –	117	"PATH.sph."
75	♂	Dy. – 96	3	A I	100 –	95 –	105	"NORM.sph."
76	♂	Co. – 93	9	A III		"NON-sph."		"NON-sph."
77	♂	Co. – 100	10	A III		"NON-sph."		"NON-sph."
78	♂	Dy. – 88	3	A I	94 –	100 –	100	"NORM.sph."
79	♂	Co. – 95	4	A I	94 –	101 –	96	"NORM.sph."
80	♂	Co. – 110	7	A II	41 –	82 –	125	"PATH.sph."
81	♂	Fragm.	7	B II	58 –	88 –	118	"PATH.sph."
82	♂	Co. – 89	4	A I	83 –	86 –	113	"NORM.sph."
83	♂	Dy. – 75	3	B I	92 –	91 –	106	"NORM.sph."
84	♂	Co. – 78	8	B II	66 –	84 –	130	"PATH.sph."
85		Excl. – bilat.						
86		Excl. – bilat.						
87	♂	Fragm.	3	B I	74 –	94 –	107	"NORM.sph."
88		Excl. – not tr. here						
89	♀	Co. – 100	7	A II	93 –	78 –	116	"PATH.sph."
90	♂	Co. – 100	10	A III		"NON-sph."		"NON-sph."
91		Excl. – Coxitis						
92	♂	Co. – 91	9	A III		"NON-sph."		"NON-sph."
93	♂	Co. – 90	6	A II	87 –	103 –	104	"NORM.sph."
94	♂	Co. – 78	5	B II	67 –	85 –	114	"PATH.sph."
95	♂	Fragm.	11	B III		"NON-sph."		"NON-sph."
96	♂	Dy. – >85	2	A I	75 –	90 –	106	"NORM.sph."
97	♀	Co. – 86	8	A II	80 –	91 –	104	"NORM.sph."
98	♀	Co. – 85	6	B II	86 –	96 –	104	"NORM.sph."
99	♂	Fragm.	5	B II	88 –	99 –	105	"NORM.sph."
100		Excl. – bilat.						
101	♂	Co. – 96	4	A I	94 –	96 –	100	"NORM.sph."
102	♂	Co. – 67	3	B I	79 –	87 –	110	"NORM.sph."
103		Excl. – bilat.						
104	♂	Co. – >85	6	A II	84 –	96 –	104	"NORM.sph."
105		Excl. – bilat.						
106		Excl. – bilat.						
107		Excl. – not tr. here						
108	♂	Fragm.	13	B III		"NON-sph."		"NON-sph."

No.	Sex	Condition at institution of treatment: Stage/ initial quotient	Age at inst. of treatment (years)	Brief desig- nation	Radiological result: Ep. quot.	Jt. surf. quot.	Ra. quot.	Group
109	♂	Co. – 103	5	A II	85 –	82 –	109	"NORM.sph."
110		Excl. – bilat.						
111	♂	Co. – 101	4	A I	97 –	99 –	104	"NORM.sph."
112	♂	Fragm.	9	B III		"NON-sph."		"NON-sph."
113		Excl. – not tr. here						
114	♂	Co. – 92	5	A II	91 –	88 –	109	"NORM.sph."
115		Excl. – not tr. here						
116	♂	Co. – 80	4	B I	75 –	92 –	109	"NORM.sph."
117	♀	Co. – 83	3	B I	103 –	104 –	100	"NORM.sph."
118	♂	Co. – 98	9	A III	91 –	88 –	107	"NORM.sph."
119	♂	Fragm	8	B II	75 –	88 –	114	"NORM.sph."
120	♂	Co. – 99	6	A II	111 –	96 –	104	"NORM.sph."
121	♂	Co. – 94	9	A III		"NON-sph."		"NON-sph."
122		Excl. – bilat.						
123	♂	Co. – 67	8	B II	74 –	103 –	111	"NORM.sph."
124		Excl. – bilat.						
125	♀	Co. – 88	8	A II	83 –	89 –	108	"NORM.sph."
126		Excl. – bilat.						
127	♂	Fragm.	6	B II		"NON-sph."		"NON-sph."
128	♂	Fragm.	7	B II	64 –	92 –	127	"PATH.sph."
129		Excl. – bilat.						
130		Excl. – cong. disloc.						
131		Excl. – bilat.						
132		Excl. – not tr. here						
133		Excl. – bilat.						
134	♂	Co. – 94	7	A II	84 –	92 –	109	"NORM.sph."
135		Excl. – not tr. here						
136	♂	Co. – 97	6	A II	100 –	97 –	100	"NORM.sph."
137		Excl. – Erron. diagn. (normal)						
138	♀	Co. – 97	8	A II		"NON-sph."		"NON-sph."
139	♂	Fragm.	4	B II	76 –	86 –	122	"PATH.sph."
140		Excl. – bilat.						
141	♂	Co. – 100	4	A I	79 –	99 –	111	"NORM.sph."
142	♂	Dy. – 83	2	B I	88 –	100 –	105	"NORM.sph."
143		Excl. – cong. disloc.						
144	♂	Co. – 100	5	A II	98 –	100 –	100	"NORM.sph."
145		Excl. – bilat.						
146	♂	Fragm.	8	B II	73 –	92 –	109	"NORM.sph."
147	♀	Co. – 98	5	A II	91 –	94 –	111	"NORM.sph."
148	♂	Co. – 86	6	A II	80 –	92 –	104	"NORM.sph."
149	♂	Fragm.	5	B II	75 –	104 –	109	"NORM.sph."
150	♀	Fragm.	5	B II	59 –	79 –	122	"PATH.sph."
151		Excl. – cong. disloc.						
152	♂	Fragm.	5	B II	81 –	92 –	104	"NORM.sph."
153	♂	Co. – 91	5	A II	92 –	100 –	100	"NORM.sph."
154	♂	Fragm.	8	B II	90 –	103 –	104	"NORM.sph."
155		Excl. – bilat.						
156	♂	Co. – 92	5	A II	75 –	90 –	111	"NORM.sph."

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