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THE KNEE IN PATIENTS WITH HIP JOINT ANKYLOSIS

Clinical Survey and Bio-mechanical Aspects

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In patients with hip joint ankylosis, the ipsilateral knee has a typical clinical appearance (Hauge 1963). The condition has no special name or designation. The term "coxitis knee" (c.k.) has previously been used in coastal hospitals for patients confined to bed for a long time, due to tuberculous coxitis. The condition has nothing to do with hip infection, but for practical purposes the abbreviation *c.k.* will be used in the present paper.

When patients, as well as doctors, reflect on the drawbacks of an ankylosed hip joint, they are primarily preoccupied by the suspected increased stress and strain on the spine. Very few consider the consequent pathophysiology of the knee. It has been mentioned briefly in some publications (Agerholm-Christensen 1942, Karlén 1944, Ducroquet 1951) but the author's work from 1963 appears to be the first publication of clinical material. The present is a continuation of this study based on a larger number of patients and a more detailed analysis of the material.

MATERIAL AND METHODS

The series comprises 200 patients with unilateral operatively arthrodesed hips. The primary cause of the hip lesion is of no significance in the development of c.k., and will thus not be further commented upon.

In accordance with criteria used in the selection of the patients, two prerequisites were essential:

1. There had to be *bony* union of the hip in all cases, with trabeculae crossing the resection space and transformation of bone architecture corresponding to the new stresses (Figure 1).

2. No pathological changes of the knee in question should be found *before* the hip operation.

The observation period ranged from 8 to 32 years, mean 22 years, counted from the time when the hip joint was found to be ankylosed clinically and radiographi-

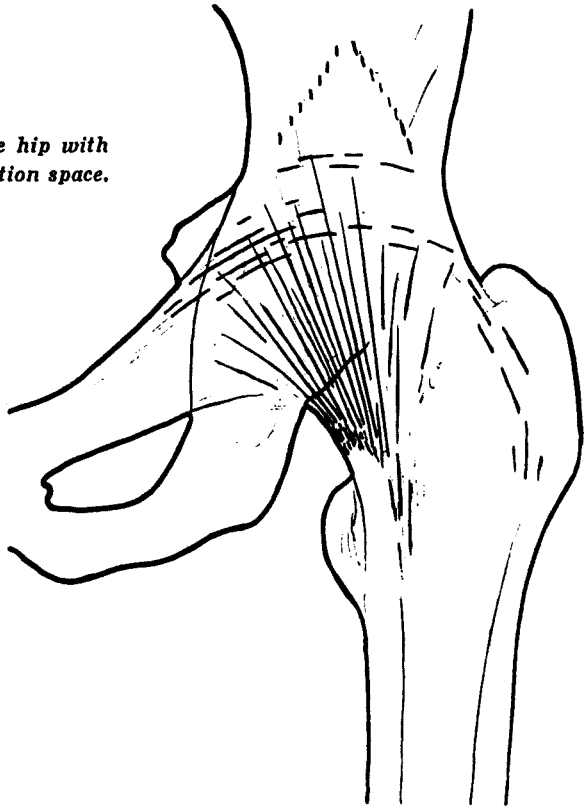

Figure 1. Bony union of the hip with trabeculae crossing the resection space.

Drawing from a radiograph.

Table 1. The series—age and sex distribution.

Age (years)	Number		
	Men	Women	Total
<30	4	3	7
30 – 49	23	18	41
40 – 49	29	26	55
50 – 59	33	30	63
60 – 69	12	13	25
>70	4	5	9
Total	105	95	200

cally (usually 4–5 months after the operation) up to the time of the follow-up examination. This took place during the years 1970–1972.

The age of the patients at the time of follow-up ranged from 22 to 73 years, mean 52 years (Table 1).

The clinical examination has proceeded exactly along the same lines as detailed in the previous publication (Hauge 1963). This also applies to the radiological criteria. Particular attention has been paid to factors that may lead to erroneous evaluation of the radiographs. All the reported findings are based on comparative examination with the other sound knee.

RESULTS

Signs – Table 2

Table 2. Clinical features of the knee in patients with ipsilateral hip joint ankylosis.

	No.	per cent
Change of contour	190	95
Genu valgum	102	51
Genu varum	36	18
Backward subluxation	44	22
Outward rotated position	78	39
Increased rotation ability	130	65
Instability—sagittal plane	98	49
Instability—frontal plane	192	96

1. *Change of contour* (Figure 2)—190 patients. The knee appeared to be narrower, the bone contours were more marked, and the whole joint impressed as being smaller than the opposite knee. To a certain extent this may have been an optical illusion, as the changed contour of the knee was partly caused by atrophy of m. vastus lateralis and, even to a greater extent of m. vastus medialis in the lower part of the thigh (the atrophy being estimated by measuring the thigh girth 15 cm above the knee joint).

In 20 patients, the affected knee appeared more bulky than the sound one. Sometimes the swelling was caused by accumulation of fluid in the joint, probably as a result of synovitis following repeated minor traumas or abnormal strain of the knee. In some of these patients, there was a tendency to oedema of the entire limb due to impaired circulation.

2. *Genu valgum*, i.e. an increased physiological valgus—present in 102 patients—ranged from a few degrees up to 15, mean 8°. The investigation showed *no* significant correlation between the valgus position of the knee and the degree of abduction of the ankylosed hip (see Comments and Discussion).

Figure 2. Typical appearance of a "coxitis knee" on the right side.

3. *Genu varum* (36 patients) ranged from 2–3° to 12°, mean 7° It was not possible in these patients to find any relation between the varus-position of the knee and that of the ankylosed hip in the frontal plane.

4. *Backward subluxation* of the leg in relation to the thigh was found in 44 patients.

5. *Outward rotated position and/or lateral displacement of the leg,* in relation to the thigh, was present in 78 patients (estimated with knee fully extended).

6. *Increased ability to passive rotation of the joint* is connected with the outward rotated position of the leg. This sign was present in 130 patients.

The examination is carried out with the patient lying prone, the knee flexed 90°, and the ankle joint fixed by maximal dorsiflexion of the foot. The extent of rota-

tion is judged by projection of the inner margin of the foot on to the bed, where an angle measurer has been placed.

The investigation shows that the *lateral* tibial condyle slides over the lateral femoral condyle. On the medial side there is rotation movement only, the axis of rotation thus being on the medial side of the knee.

7. *Instability—sagittal plane* (anterior and/or posterior glide) was found in 98 cases. The anterior cruciate ligament is lax when the knee is flexed at about 60°, the posture in which this sign is usually tested. Thus a *moderate* anterior glide is not necessarily pathological. However, in 98 of the patients there was an *increase* of the glide, compared to the healthy knee.

In this series, a posterior glide was a more frequent finding than an anterior, the ratio being 5 to 3.

8. *Instability—frontal plane* (with the knee in neutral position) was observed in 192 cases. This is one of the most characteristic and constant findings in c.k., but in 8 cases even the most scrupulous examination failed to reveal any sideward instability. A meticulous mode of procedure, preferably with the femur fixed in a special frame (Hauge 1963), is required. Normally, medial and/or lateral movements cannot be brought about in a fully extended (hyperextended) knee.

There was a tendency to correlation between this finding and prolonged preoperative immobilization, but this parallelism was not significant. There was no connection between degrees of side to side mobility and time elapsed since bony union. On the other hand, there was a definite preponderance of sideward instability in patients who had their hip ankylosis before growing up. A preponderance of lateral as opposed to medial mobility was regularly found, i.e. it was more often possible to press the leg (passively) into a varus (adducted) than into a valgus (abducted) position.

Other signs such as reduced lateral mobility of the patella, reduced active and passive flexion and/or extension of the knee were likewise observed. These findings were not constant, however, and are not due to the hip ankylosis as such.

Symptoms

Very few patients complain about knee trouble and many hardly give their knee a thought until lateral instability develops. 40 patients had noticed some degree of instability in the knee *when walking*, and 32 had mild knee-ache. Another 6 patients had more regular and, in

part, quite severe knee pains. In these, radiographs revealed considerable osteoarthritis (see below). A fairly large number of patients—48 in all—complained that the knee had become distorted, by which they mostly meant a displacement to valgus position. However, their troubles were of a cosmetic rather than functional nature.

A few patients occasionally experienced slip in the knee, others complained of ache after sitting with the knee maximally flexed for longer periods (a finding that may be more normal than pathological). 25 patients stated that the actual knee was weaker than the other, and tired more easily, but just as many claimed that the opposite was the case; that ever since the operation increased strain was put on the contralateral knee which more easily tired.

Radiographic findings—Table 3.

Radiographs revealed *osteoporosis* in all patients. It might be slight or pronounced but was always present, even in patients in good physical form as illustrated by the following example:

The radiograph (Figure 3) was taken 2 years after an 18-year-old boy developed ankylosis of the hip by arthrodesis. He was confined to bed for two weeks preoperatively, and full weight-bearing was not allowed for 4 months after the operation. He had always been a keen athlete and had tried to restitute the limb maximally after the operation. The osteoporosis was, however, unmistakable.

Table 3. Radiological findings of the knee in patients with ipsilateral hip joint ankylosis.

	No.	per cent
Osteoporosis	200	100
Osteoarthritis	128	64
Genu valgum	110	55
Genu varum	34	17

Radiographs taken at regular intervals following ankylosis of the hip show that in c.k. the osteoporosis progresses to some extent during the first 2–3 years, but after that time there is no demonstrable progression. A patient with ankylosis of the hip of 20 years' standing will not, ordinarily, show more osteoporosis than someone with an ankylosis of 5 years' standing.

The present investigation confirms also the author's previous find-

Figure 3. Radiograph of the knees—same patient as in Figure 2.

ings (Hauge 1963) that protracted bed confinement prior to the hip joint ankylosis usually leads to a high-degree of osteoporosis.

Osteoarthritis is a more frequent finding in the c.k. than in the contralateral knee. A total of 128 patients had osteoarthritis either in the actual knee alone, or in both knees, but preponderantly on the ankylosed side. There was no definite relation between duration of the hip joint ankylosis and degree of osteoarthritis, although a *tendency* to more marked osteoarthritis in patients with hip joint ankylosis of long standing was traceable. However, the series includes some patients with hip joint ankylosis of more than 30 years' standing, presenting

no demonstrable signs of degenerative changes of the knee. 42 patients had developed osteoarthritis in the contralateral knee.

Genu valgum and *genu varum* were demonstrated radiographically to approximately the same extent as in the clinical examination.

COMMENTS AND DISCUSSION

C.k. is characterized by its marked objective signs but rather moderate symptoms. The condition is due to the ankylosed hip joint, with the following altered muscle function of the lower limb, and altered mechanics of the knee in standing and walking, i.e. there must be a non-physiological strain on the knee joint.

Firstly, a pathological rotation in the knee joint occurs during gait. Normally, with two mobile hips, rotation of the pelvis in the transversal plane takes place to a variable degree during the stance phase. In patients with an ankylosed hip, this causes a rotational strain on the knee in that part of the stance phase when the foot is locked to the ground. Previous clinical studies have shown that the pelvic rotation during gait has no provable effect on the ankle and foot joints (Hauge 1963). It is possible that pelvic tilt (in the frontal plane) during gait, varying from one individual to another, adds to this abnormal effect by producing sideward bending movements of the knee.

Secondly, the strain on the knee due to the body weight will be altered in unilateral hip joint ankylosis.

> In standing position, with two mobile hips, the body weight is shared equally by both limbs, and as the mechanical axis passes through the middle part of the knee joint, the force acting on the knee will have no tendency to varus or valgus bending.
>
> Standing on one leg, the plumb line will pass medially to the knee joint and thus have a varus-bending effect. (Exceptions are when the trunk is tilted more sideways, thus making the plumb line pass through the hip and knee joint, or even outside the joints.) But this effect is counterbalanced by the muscle force and ligaments on the lateral side.
>
> During gait the line of action will pass medially to the knee joint, but the varus-bending effect will vary throughout the whole stance phase in correspondence to the changing length of the lever arm.

In unilateral hip ankylosis, part of the head—sometimes also the neck—of the femur is damaged, either primarily or due to the operation, causing the mechanical axis to fall on the lateral side of the knee joint.

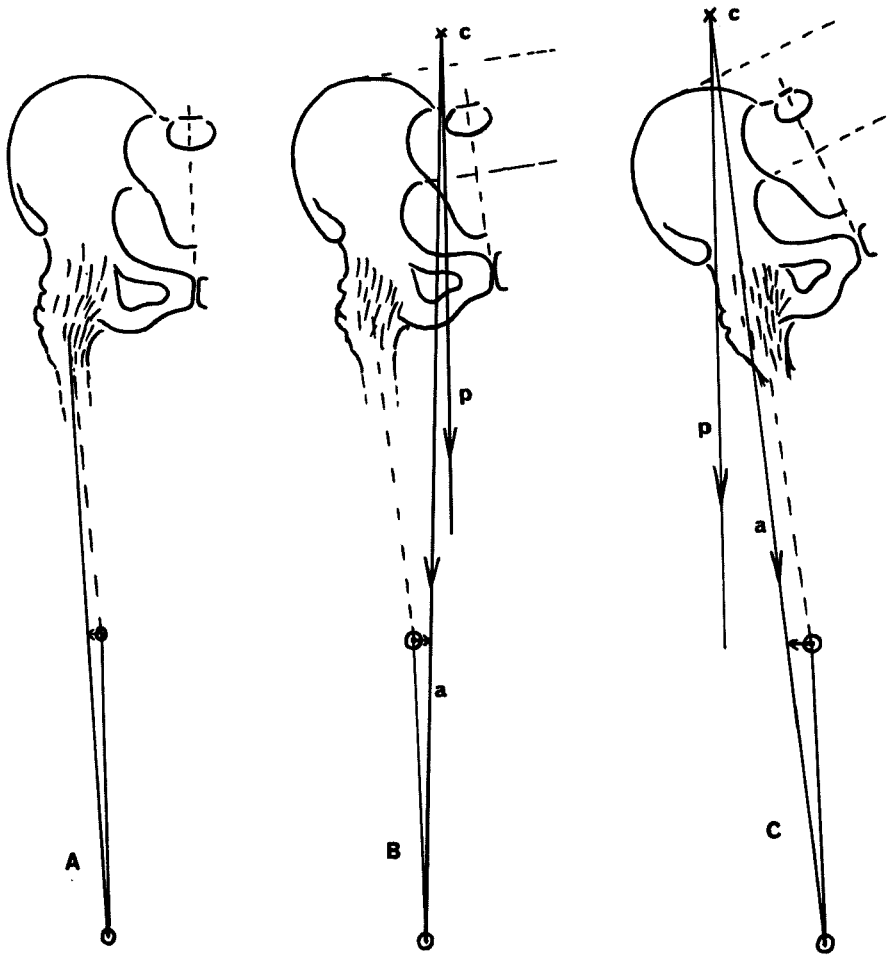

Figure 4—see text.
a = line of action p = plumb line c = centre of gravity.

Standing on both legs, the body weight will now tend to cause a valgus angulation of the knee (Figure 4 A).

Standing on one leg, and during the stance phase (single support) the force acting on the knee depends on the position of the ankylosed limb. In *moderate* abduction, the lever arm from the plumb line and from *the line of action* is reduced (Figure 4 B), and thus the varus-bending effect on the knee joint should diminish. On the other hand, the effect of the valgus-promoting muscles such as m. tensor fasciae latae is also reduced (Hauge 1963). When the abducted position of the

hip is more marked (Figure 4 C), the line of action will probably pass laterally to the knee while walking, thus causing a valgus strain on the knee.

If the limb is ankylosed in a moderately adducted position, up to 4 or 5°, the weight of the body will have the same effect on the knee joint, but greater adduction will theoretically represent a varus-bending influence on the knee.

A high frequency of pathological valgus of the knee joint would therefore be expected. Indeed the investigation showed a preponderance of valgus as compared to varus positions, but no convincing relationship to the different positions of the ankylosed hip in the frontal plane. What factors are decisive in this respect is impossible to state. Nor do we have any exact knowledge regarding the centre of body gravity in the different hip positions, the flexibility of the spinal column, and hence its capacity to compensate the static scoliosis, or the consequences of the reduced pull from the hip muscles. This problem can only be solved through biomechanical analysis with adequate measuring instruments.

Lastly, substitutional movements of the affected lower limb undoubtedly contribute to the instability of the knee joint. Patients with an ankylosed hip expose the knee joint to an extreme stress in certain situations, as a substitute for a movable hip, for instance when putting on shoes and stockings, or when sitting with the foot and leg in forced outward rotation or valgus position. Forcing the leg passively into valgus position and abnormal outward rotation increases the instability in the transversal and frontal planes.

SUMMARY

An account is given of the typical clinical changes of the knee joint in patients with unilateral ankylosed hip joint, on the basis of 200 examined patients.

The objective findings in the knee were: change of contour (95 per cent), genu valgum (51 per cent), genu varum (18 per cent), posterior subluxation of the leg (22 per cent), increased outward rotated position of the leg (39 per cent), increased rotatory ability (65 per cent), instability in sagittal plane (49 per cent), instability in frontal plane (96 per cent).

Radiographic findings: Osteoporosis (100 per cent) and osteoarthritis (65 per cent).

The symptoms were surprisingly inconspicuous.

The aetiology and pathogenesis of the above findings are discussed.

The three main reasons for the pathological changes are:

1. Abnormal rotation of the knee joint during ordinary walking.
2. Abnormal distribution of the body weight on the condyles of the knee joint and reduced effect of the knee-stabilizing muscles.
3. Forced passive movements of the knee (during daily activity), increasing the instability primarily caused by 1 and 2.

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