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IMMEDIATE EFFECT OF OSTEOTOMY ON THE INTRAMEDULLARY PRESSURE OF THE FEMORAL HEAD AND NECK IN PATIENTS WITH DEGENERATIVE OSTEOARTHRITIS

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Recently, Arnoldi, Linderholm & Müssbichler (1971, and to be published) demonstrated a considerable hypertension in the cancellous bone marrow of the proximal part of the femur in patients with advanced stages of coxarthrosis. Simultaneous examinations by means of intraosseous phlebography indicated that the high pressure was accompanied by impaired venous drainage from the femoral head and neck.

There are indications that intramedullary hypertension may be a causative factor for the aching rest pains typical of these patients. Therefore we have thought it of interest to investigate the effect upon intramedullary pressure of two operative procedures routinely performed for painful conditions in osteoarthritis of the hip. In both procedures the medullary space is opened and drained, in osteotomy, in the subtrochanteric region, in Smith Petersen cup arthroplasty by removal of bone and cartilage from the femoral head.

In the present study the immediate effect of both procedures upon the intramedullary pressure was tested.

MATERIAL

Two groups of patients with degenerative osteoarthritis of the hip joint were examined.

The first group consisted of seven patients treated by means of intertrochanteric osteotomy. In the second group, containing eight patients, Smith Petersen cup

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Table 1. Age and sex distribution in the two groups of patients with coxarthrosis examined in the present study and in a control group of patients in whom the intramedullary pressure of the femoral neck was measured (Arnoldi, Linderholm & Müssbichler, to be published), cf. Table 2. The osteotomy group contains patients with coxarthrosis on whom subtotal osteotomy was performed; the fenestration group patients with coxarthrosis treated with Smith Petersen cup arthroplasty.

Groups	n	Men	Women	Age, years Mean (range)
Controls	11	4	7	61 (40–74)
Coxarthrosis				
Osteotomy group	7	2	5	60 (36–72)
Fenestration group	8	1	7	64 (52–71)
Total	26	7	19	61 (36–74)

n = number of patients.

arthroplasty was performed. Severe rest pains, i.e. aching pains felt at rest and when lying in bed and not relieved by changes of position, were the dominant symptoms in six of the patients treated by osteotomy and in five of the patients treated by arthroplasty. Severe pains on joint movement and loading and restriction of joint movements were the reasons for operation in the remaining four cases.

Age and sex distribution in the two groups with coxarthrosis are shown in Table 1. This table includes data from pressure measurements on non-affected hip joints (controls) examined by Arnoldi, Linderholm & Müssbichler (to be published).

Neither the controls nor the patients examined in the present study showed signs or symptoms of heart failure.

METHODS

General procedure. Two metal needles (made by AB Stille-Werner, Stockholm) with an external diameter at the tip of 2.00 mm and a lumen measuring 1.40 mm, were inserted into the proximal part of the femur from the lateral aspect of the trochanter at the beginning of the operation. One was placed with the tip in the femoral head, the other with the tip in the neck (Figure 1). The needles were flushed with a few ml of a 0.9 per cent solution of saline containing 50 mg heparine/100 ml to obtain free flow. A continuous drip of saline was then introduced through each needle and continued—interrupted by periods of pressure measurements—until the end of the examination.

The intraosseous pressures of the femoral head and neck were recorded before and after subtotal intertrochanteric osteotomy, which left the medial cortex intact (Figure 1). In three patients of this group intraosseous pressures were measured before and after incision of subcutaneous tissue and fascia and cutting or retraction of muscles. In the patients on whom arthroplasty was performed, the pressures were

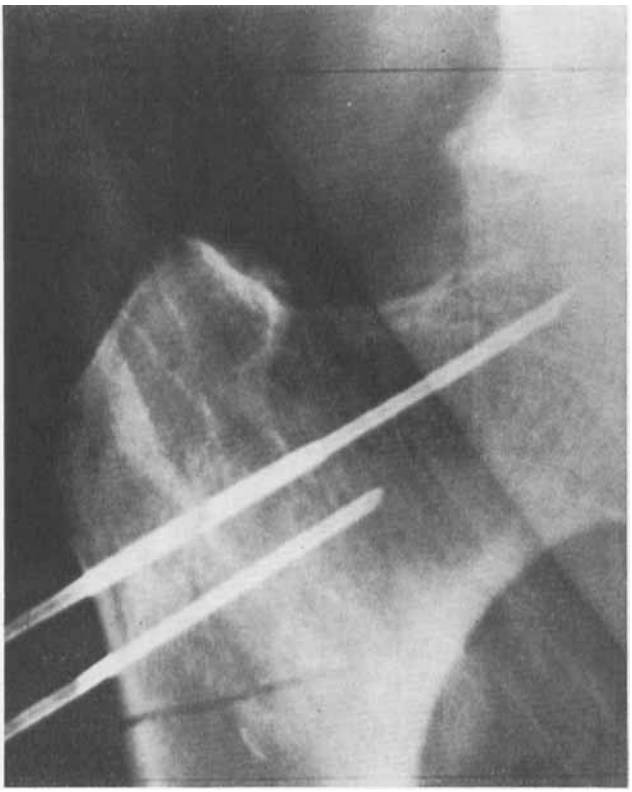

Figure 1. The two needles for measurement of intraosseous pressure in situ *in the femoral head and neck. In this patient a subtotal intertrochanteric osteotomy has been performed leaving the medial cortex intact.*

first measured before and after incision of the anterior part of the joint capsule, care being taken to leave the superior and inferior retinacular vessels intact. Following this, the medullary space of the femoral head was laid bare by removal of cartilage and subchondral bone from the anterior aspect of the caput. A window measuring four by four cm was performed and the pressure measurements were repeated.

Controls: In this group a specially constructed conical needle (made by AB Stille-Werner, Stockholm), 15 cm long with an external diameter at the tip measuring 4.55 mm and a lumen of 2.60 mm, was introduced through the lateral aspect of the trochanteric region through a skin puncture. The tip of the needle was placed in the femoral neck. The needle was connected to a drip of saline in the same manner as the needles used for measurements in patients with coxarthrosis.

Pressure measurements. The same technique was used in the two groups of patients and in the controls. Polyethylene catheters (PE 90) were fitted to the needles and these tubes were connected to a pressure recording system for simul-

Table 2. Intramedullary pressure in the femoral neck from hip joints without roentgenological or clinical signs and symptoms of osteoarthritis (Arnoldi, Linderholm & Müssbichler, to be published) and from the two groups of patients with coxarthrosis examined in the present study.

Group	n	Collum pressure Mean (range)		S. E.
Controls	11	18.7	(12.9–23.5)	1.27
Coxarthrosis				
Osteotomy group	7	43.4	(23.0–66.7)	6.47
Fenestration group	8	42.8	(29.9–64.6)	4.14

Mean difference in collum pressure between controls and the combined coxarthrosis groups = 24.4 mm Hg. $P < 0.001$.

n = Number of cases.

S. E. = Standard error of the mean.

P is the probability that the difference is caused by chance.

taneous recording of the pressure curves by means of a Mingograph (Elema). For experimental details, see Arnoldi & Linderholm (1969).

Patients and controls were examined lying supine on the operating table in a nearly horizontal position. General anaesthesia with intermittent positive pressure breathing was used. Where two needles were used the tips of both needles were very nearly at the same horizontal level and almost at the same and usually short vertical distance from the heart level.

The mid-axillary plane at the level of the fourth costal insertion at the sternum was chosen as a convenient level of reference, approximately corresponding to the heart level. All pressures are referred to this level.

RESULTS

As seen from Table 1 the intramedullary collum pressures of the patients with coxarthrosis examined in the present study were high compared with pressures obtained from clinically and roentgenologically normal hip joints (controls).

Table 3 shows intraosseous pressures in the femoral head and neck before and after subtotal osteotomy and before and after "fenestration" of the femoral head.

In both series the pressure was higher in the femoral head than in the neck. Both operative procedures caused a significant fall of pressure at both points of measurement. In both series the fall of pressure was greater in the femoral head than in the neck (Figure 2).

Incision or retraction of soft tissues and of the anterior part of the joint capsule did not influence the pressure at either point of measurement.

Table 3. Intramedullary pressures of the femoral head and neck in patients with coxarthrosis before and within one minute after intertrochanteric osteotomy and before and after fenestration of the femoral head. The mean and S.E. of intra-individual differences between pressures before and after osteotomy or fenestration are also given.

Site of pressure measurement	n	Pressures, mm Hg		
		Before operation mean S.E. (range)	After operation mean S.E. (range)	Difference Before − After mean S.E. (range)
Osteotomy group				
Caput	7	54.8 8.23 (30.9–88.7)	37.3 7.41 (17.9–61.7)	+17.6* 2.06 (+11.2–+27.0)
Collum	7	43.4 6.47 (23.0–66.7)	29.9 5.29 (17.9–61.7)	+13.5* 2.05 (+6.0–+23.8)
Fenestration group				
Caput	8	53.2 4.19 (37.7–76.5)	31.7 3.03 (17.5–41.6)	+21.5* 3.68 (+8.8–+37.7)
Collum	8	42.8 4.14 (29.9–64.6)	26.9 3.77 (15.5–43.4)	+15.9* 1.32 (+12.5–+21.2)

* $P < 0.001$.
Other symbols as in Table 2.

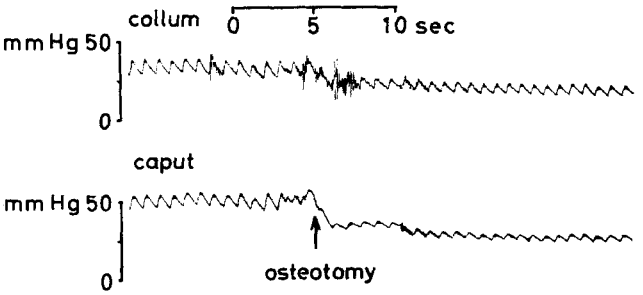

Figure 2. Pressure tracings from the femoral neck and head, before and after subtotal intertrochanteric osteotomy.

DISCUSSION

Immediate Effect of Osteotomy and Cortical Fenestration

Rest pain is often the dominant symptom of severe osteoarthritis of the hip joint. That high femoral osteotomy has a favourable effect on these pains has been noted by many authors (Osborne & Fahrni 1950, Pearson & Riddell 1962, Nissen 1963, Phillips, Bulmer, Hoyle & Davies 1967, and others). In ten of the eleven patients in the present study who complained of rest pains before the operation, these pains had disappeared within 24 hours after the operation.

Recently, Renard (1969) obtained equally satisfactory immediate relief of pain in patients with gonarthrosis by resection of altered subchondral tissue through a metaphyseal cortical window in the tibia and femur.

Although the effect of osteotomy and cortical fenestration is well known, the reason for the relief of pain is still a subject of discussion.

Intraosseous phlebography in patients with coxarthrosis has shown changes in the pattern of venous drainage from the proximal part of the femur. Normally, the femoral head is drained through extraosseous veins in the joint capsule. As the osteoarthritic changes progress, these peri-capsular extraosseous veins disappear from the phlebogram and the drainage takes place through dilated and tortuous intramedullary vessels into the femoral shaft (Mériel, Ruffié & Fournié 1955, Phillips 1966, Arnoldi, Linderholm & Müssbichler, to be published). Further, in osteoarthritis the venous outflow from the medullary space is greatly retarded (Arnoldi, Linderholm & Müssbichler, to be published).

Examination of the intraosseous pressure of the femoral neck showed that the changes in venous drainage were accompanied by an increase of pressure. There seemed to be a close correlation between rest pain and intramedullary pressure. Thus, rest pains were never observed in patients with pressures below 35 mm Hg (intraosseous pressures from controls are given in Table 2), but were a constant symptom with intramedullary pressures above 40 mm Hg. In contrast, pain released by joint movements or loading seemed to be more or less independent of the pressure level (Arnoldi, Linderholm & Müssbichler, to be published).

Considered together, these observations seem to indicate that venous engorgement with stasis and intramedullary hypertension may be a probable cause of rest pain.

The results of the present investigation show that intertrochanteric

osteotomy of cortical fenestration of the femoral head result in an immediate and significant fall of the pathologically high pressure in the proximal part of the femur.

The immediate decrease of pressure to normal or nearly normal levels would give a reasonable explanation of the often immediate disappearance of rest pains after these operations. It also gives further support to the hypothesis that intraosseous hypertension may be the factor responsible for the rest pain in degenerative osteoarthritis.

The intraosseous pressures obtained in the present study from patients operated upon for severe coxarthrosis are of the same order as those obtained from the femoral neck in hip joints with osteoarthritis by Arnoldi, Linderholm & Müssbichler (to be published). In a series of patients with unilateral coxarthrosis they determined the pressures on the arthrotic and normal side simultaneously. The collum pressures of controls in Table 2 are from the unaffected hip joints of that study. The fact that these pressures were obtained with the patients in general anaesthesia, lying supine on the operating table with the tip of the needle placed in the femoral neck, probably permits a direct comparison with the pressures obtained from the patients of the present study. In the controls the needles were introduced through skin punctures, whereas a larger incision was used in the patients examined prior to operation. However, experiments have shown that intraosseous pressures are not influenced by surgical interventions in the surrounding soft tissue (as long as arterial supply and venous drainage to and from the bone are left intact). The slightly larger needles used for pressure measurements in controls, according to our experience of pressure determinations, give comparable results.

The relief of symptoms obtained after intertrochanteric osteotomy has also been explained as the result of mechanical changes, such as a medial shift of weight transmission (McMurray 1935, Pauwels 1959), correction of deformity (Malkin 1936), relaxation of the contracted capsule (Lloyd-Roberts 1953) or elimination of tension in the psoas muscle (McFarland 1962). The main objection to these theories is the fact that osteotomy without displacement may give as good results as the displacement osteotomies performed by the spokesmen for the mechanical viewpoints (Nissen 1963).

Harrison, Schajowicz & Trueta (1953), by means of injection studies on cadavers, observed a hyperplasia of the intraosseous arteries of the femoral head in patients with coxarthrosis. On the basis of these findings they assumed that the arterial inflow to the femoral head was in-

creased. They concluded that the onset of pain was in some way dependent upon the degree of hyperemia. This conception was supported by Nissen (1963), who saw the effect of intertrochanteric osteotomy as a result of division of large medullary arteries. This would, in his opinion, cause a sharp and immediate reduction of the level of arterial hyperemia in the femoral head and neck.

The main objection to this hypothesis—which has not been supported by experimental evidence—is the fact that the femoral head receives most of its blood supply via the retinacular and intraosseous arteries deriving from the medial and lateral circumflex arteries. These vessels are situated proximal to the level of the intertrochanteric osteotomy. Interruption of arteries distal to these vessels can therefore only have a marginal effect upon an assumed arterial hyperemia of the femoral head.

Long Term Effects of Osteotomy

The present investigation clearly showed that one effect of osteotomy is an immediate fall of intramedullary pressure in the proximal part of the femur. If it is true, as our observations indicate (see above) that the presence of rest pains is dependent upon the level of intraosseous hypertension, the often observed immediate relief of pain after osteotomy is easily understood. However, the osteotomy usually heals within a few months, whereas the effect of the operation may last for years. This lasting relief cannot be the result of drainage of fluids or a simple "safety-valve" effect.

Phillips, Bulmer, Hoyle & Davies (1967), by means of intraosseous phlebography before and 12–20 months after displacement osteotomy observed that in most patients in whom osteotomy had brought relief from pain, the venous drainage from the femoral head and neck had changed back to normal or nearly normal. Thus, it seems that osteotomy may have an effect beyond the simple primary reduction of intramedullary pressure. How this is brought about is unknown at present, just as we do not know the mechanism responsible for the initial failure of the drainage system from the femoral head.

SUMMARY

The intraosseous pressures of the femoral head and neck in patients with severe degenerative osteoarthritis were measured before and after incision or removal of cortical bone in the proximal part of the femur.

Subtotal intertrochanteric osteotomy was performed in seven patients. In eight patients in whom Smith Petersen cup arthroplasty was intended, cartilage and subchondral bone was removed from the femoral head over an area measuring four by four cm.

Prior to osteotomy or fenestration the intraosseous pressures of the femoral head and neck were high. Both types of operation caused an immediate fall of pressure at both points of measurement.

Intraosseous hypertension is a characteristic feature of degenerative osteoarthritis. The immediate fall of pressure may be the factor causing the fairly constant and immediate relief of rest pains after osteotomy and Smith Petersen arthroplasty.

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