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INTRAOSSEOUS PRESSURE IN THE FEMORAL HEAD AND GREATER TROCHANTER BEFORE AND 1–3 YEARS AFTER OSTEOTOMY FOR OSTEOARTHRITIS OF THE HIP JOINT

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To elucidate the long-term effect of osteotomy upon the intraosseous pressure in osteoarthritis of the hip, pressure measurements in the femoral head and greater trochanter were performed in 22 patients before intertrochanteric osteotomy and 11.5–33.5 months later, on the occasion of removing the osteosynthesis material after the osteotomy had healed. Preoperatively the mean pressure in the femoral head was higher (35.0 mmHg) than in the greater trochanter (23.4 mmHg). At follow-up the mean pressure in the femoral head had fallen, but not significantly ($0.10 < P < 0.20$). A significant reduction in pressure ($0.001 < P < 0.005$) was found in 10 patients in whom the primary pressure was high (exceeding 35 mmHg) and in 16 patients seen at follow-up less than two years after the osteotomy ($0.01 < P < 0.02$), whereas with a longer observation period there was a tendency towards an increasing pressure. The trochanteric pressures accompanied the pressures in the femoral head, but without significant changes. No close correlation was found between intraosseous pressure and pain at rest. The operation had a good clinical effect, especially upon the pain at rest. A reduction in intraosseous hypertension may be a contributory cause, but the tendency to another increase in pressure after a long observation period indicates the possibility of a subsequent recurrence.

Key words: osteoarthritis; hip joint; intraosseous pressure; femoral head

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It has been demonstrated that in osteoarthritis of the hip the intraosseous pressure in the femoral head and neck is increased and that presumably there is a correlation between pain at rest in this condition and the intraosseous pressure (Arnoldi et al. 1972). Intertrochanteric osteotomy entails an immediate fall of intraosseous pressure (Arnoldi et al. 1971), and frequently an immediate disappearance of the pain at rest. It is a general surgical experience that as a rule intertrochanteric osteotomy has a favourable effect, also a long time after the osteotomy has healed. The long-term effect cannot be explained by the drainage of the medullary cavity during operation.

The present study was designed to

compare the pressure findings in the greater trochanter and femoral head in patients with osteoarthritis of the hip immediately before intertrochanteric osteotomy and a long time (1–3 years) after healing had taken place.

METHOD

The pressure measurements were carried out immediately before the osteotomy and again prior to removal of the osteosynthesis material after healing of the osteotomy, an average of 18.3 (11.5–33.5) months later. During the pressure measurements the patient was under general anaesthesia, lying flat on his back on the operating table. After exposure of the trochanteric region a needle (length 20 cm, lumen 1.20 mm, outer diameter 1.75 mm) was passed, under fluoroscopic control, so that its tip lay centrally in the femoral head, and a sternal needle (lumen 1.50 mm, outer diameter 2.05 mm) was placed in the greater trochanter. The needles were coupled to pressure transducers (Elema-Schönander, EMT 35) by polyethylene catheters (length 180 cm, lumen 1.20 mm, outer diameter 2.3 mm), and pressure curves were traced using an electromagnetic writer (Elema-Schönander, mingograph 81). The level of reference was the central axillary plane. Prior to the pressure measurements the catheters and needles were filled with heparin saline solution. The pressures in the femoral head and in the trochanter were recorded simultaneously, and at the same time the patients' systolic and diastolic blood pressures were measured. All the measurements were performed by the authors.

MATERIAL

Primarily the pressure was measured in 24 patients, and after healing in 22, as one patient was excluded because of infection and another because of a suspicion of infection. The operative indication was our usual one; we employ intertrochanteric osteotomy mainly for patients having symptoms interfering with their working capacity, but without the most severe degrees of restricted movement or radiological changes. In the most severe cases the treatment is total hip replacement. The patients were included in the material in random sequence, depending only upon the authors' presence in the Department.

Table 1 gives the sex ratio and age distribution. All the patients had pain on weightbearing, but of extremely varying duration (1–17 years), and 14 had pain at rest. Movements were moderately restricted in all patients, especially flexion and rotation, and all had moderate to severe radiological changes. No patient had decompensated heart disease. A few had hypertension at admission, but during the pressure measurements the mean blood pressure exceeded 110 mmHg in only four cases in each of the two measuring series.

Table 1. Sex ratio and age distribution.

Number of patients	Men	Women	Age, years Mean, range
22	14	8	56.5 (41–69)

RESULTS

In Figure 1 the result of the pressure measurements in the femoral head is plotted against the observation period. The values are assessed statistically in Table 2. The mean preoperative pressure in the femoral head was 35.0 mmHg, but with a considerable variation of the individual values. At pressure measurement an average of 18.3 (11.5–33.5) months later, the pressures were lower, again with a considerable variation, but without any significant decrease in the mean value.

Table 3 shows the corresponding trochanteric pressures. The preoperative mean value was considerably lower than

Table 2. Mean intramedullary pressure in the femoral head in mmHg before, t_1, and after, t_2, intertrochanteric osteotomy, and mean individual differences in pressures, t_1–t_2. Number of patients: 22.

	Mean	S.E.	Range
t_1	35.0	3.56	9.2 – 61.0
t_2	28.3	2.65	4.3 – 52.0
$t_1 - t_2$	6.7 *	4.36	– 38.6 – 55.5

* $0.10 < P < 0.20$ (paired 't' test).
S.E. = Standard error of the mean.

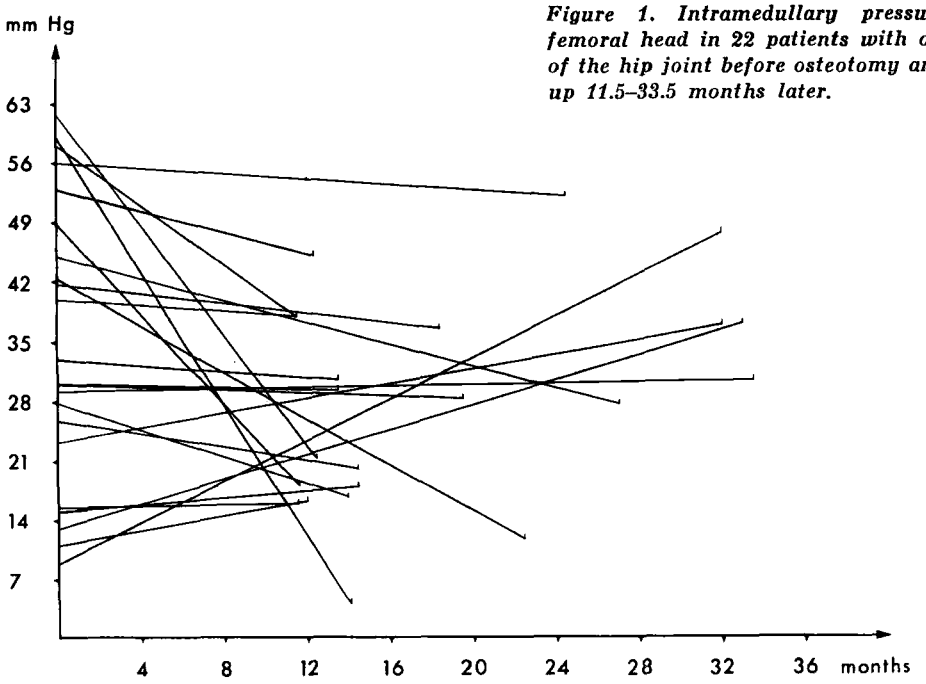

Figure 1. Intramedullary pressures in the femoral head in 22 patients with osteoarthritis of the hip joint before osteotomy and at follow-up 11.5–33.5 months later.

in the head of the femur. There was no significant fall from the former to the latter measurement. (This series includes only 21 patients, as the primary pressure measurement in the trochanter was a failure in one case).

Two factors appear to influence the pressure changes demonstrated in the femoral head, viz. the preoperative pressure in the femoral head and the observation period. Ten patients with a *high preoperative pressure in the femoral head* (> 35 mmHg) exhibited a significant fall after an average observation period of 16.2 (11.5–24.5) months, whereas 12 patients with a *low preoperative pressure* (< 35 mmHg) showed a non-significant increase in the pressure an average of 20.0 (11.5–33.5) months after the osteotomy (Table 4). In 16 patients followed for less than 2 years, average 13.7 (11.5–22.5) months, the mean pressure in the femoral head fell significantly, whereas a non-significant increase occurred in the remaining 6 patients in whom the observation period exceeded 2 years, average 30.7 (24.5–33.5) months (Table 5). However, the comparison is rendered difficult by the latter group being small and including a couple of patients having very low primary pressures.

Table 3. Mean intramedullary pressure in the greater trochanter in mmHg before, t_1, and after, t_2, intertrochanteric osteotomy, and mean individual differences in pressures, $t_1 - t_2$. Number of patients: 21.

	Mean	S.E.	Range
t_1	23.4	2.08	6.8 – 41.0
t_2	21.0	2.62	1.6 – 48.0
$t_1 - t_2$	2.4 *	3.61	– 31.6 – 27.5

* $0.50 < P < 0.60$ (paired 't' test).
S.E. = Standard error of the mean.

Both when classified according to preoperative pressure in the femoral head and by observation period, the trochanteric pressures accompanied the pressures in the femoral heads, showing non-significant changes.

The average mean blood pressure of

Table 4. Mean intramedullary pressure in the femoral head in mmHg before, t_1, and after, t_2, intertrochanteric osteotomy, and mean individual differences of pressures, $t_1 - t_2$.

A) Preoperative pressure in the femoral head: > 35 mmHg.
Number of patients: 10.

	Mean	S.E.	Range
t_1	50.5	2.54	40.0 – 61.0
t_2	29.4	4.81	4.3 – 52.0
$t_1 - t_2$	21.2 *	5.59	1.6 – 55.5

* $0.001 < P < 0.005$ (paired 't' test).
S.E. = Standard error of the mean.

B) Preoperative pressure in the femoral head: < 35 mmHg.
Number of patients: 12.

	Mean	S.E.	Range
t_1	22.0	2.51	9.2 – 33.0
t_2	27.4	2.95	15.9 – 47.8
$t_1 - t_2$	– 5.3 *	4.03	– 38.6 – 11.2

* $0.20 < P < 0.30$ (paired 't' test).
S.E. = Standard error of the mean.

the 22 patients was somewhat higher (97 mmHg) at the former than at the latter operation (90 mmHg), but the difference was not significant, and there was no correlation between the mean blood pressures and the intraosseous pressures.

The clinical effect of the operation was good with regard to the most annoying symptom of osteoarthritis, the pain. Fourteen of the 22 patients had pain at rest before the osteotomy, but only one at follow-up. Preoperatively all patients complained of pain on joint movement and on weightbearing. At follow-up this pain had disappeared in 8, decreased in 12, while in 2 it was unchanged. However, we found no close correlation between the intraosseous pressure and pain in the individual patient, the mean intraosseous pressure being at the same level whether pain at rest was present or not. Mobility in the hip was unchanged in the group with a short observation period, slightly worse in that with a long observation period. Radiologically the osteoarthritis had decreased a bit (increased width of the joint space) in 6 patients, was unchanged in 15, and slightly worse in 1.

DISCUSSION

The cause of the favourable effect of intertrochanteric osteotomy upon osteoarthritis of the hip has not been finally elucidated, but changes in the vascular conditions around the arthritic joint seem to play a role. Hawk & Shim (1970) emphasized the dependence of the intraosseous pressure upon blood flow, an increased arterial flow and an inhibited venous drainage entailing an increase in the pressure, while reduced arterial flow and improved venous drainage lowered the pressure. Phlebographic studies have demonstrated that the venous drainage

Table 5. Mean intramedullary pressure in the femoral head in mmHg before, t_1, and after, t_2, intertrochanteric osteotomy, and mean individual differences of pressures, $t_1 - t_2$.

A) Observation period: less than 2 years.
Number of patients: 16.

	Mean	S.E.	Range
t_1	37.1	4.04	10.9 – 61.0
t_2	24.4	2.80	4.3 – 45.0
$t_1 - t_2$	12.7 *	4.38	– 5.7 – 55.5

* $0.01 < P < 0.02$ (paired 't' test).
S.E. = Standard error of the mean.

B) Observation period: more than 2 years.
Number of patients: 6.

	Mean	S.E.	Range
t_1	29.4	7.43	9.2 – 56.0
t_2	38.8	3.91	27.7 – 52.0
$t_1 - t_2$	– 9.4 *	8.29	– 38.6 – 17.3

* $0.30 < P < 0.40$ (paired 't' test).
S.E. = Standard error of the mean.

is altered and impaired in the arthritic hip (Mériel et al. 1955, Phillips 1966, Arnoldi et al. 1972), and this agrees with isotope studies (Hernborg 1969). Similar findings were made by Brookes & Helal (1968) in a study of patients with unilateral primary osteoarthritis of the elbow, hip, and knee.

Arnoldi et al. (1972) also found, in patients with unilateral osteoarthritis of the hip, a higher intraosseous pressure in the affected than in the normal hip and a close correlation between pain at rest and intraosseous pressure. By intraosseous injection of contrast medium without anaesthesia, both Phillips (1966) and Arnoldi et al. (1972) were able to induce pain of the same nature as the pain at rest in patients with osteoarthritis. At intertrochanteric osteotomy the sinusoids of the cancellous bone are drained, and this results in an immediate fall of pressure (Arnoldi et al. 1971). As a rule, the pain at rest disappears at the same time.

Our investigations did not show any close correlation between intraosseous hypertension and pain at rest, the mean preoperative pressure being the same in patients with and without pain at rest. However, we found a significant reduction of the pressure in the femoral head as late as 2 years after the osteotomy, especially in patients with a high primary pressure. This decrease in pressure cannot be explained by a difference in arterial pressure in the two series, and it is of a magnitude which cannot be due to differences in central venous pressure. Providing an unchanged arterial flow, the fall in pressure must be explained by reduced resistance in the vascular path from the head of the femur to the central veins. At phlebography before and about one year after intertrochanteric osteotomy on patients with osteoarthritis of the hip, Phillips et al. (1967) did indeed find a normalization of the venous drainage from the femoral head in the majority of those who responded favourably to the osteotomy. Similar findings were made by Brookes & Helal (1968) after osteotomy in cases with osteoarthritis of the hip and knee.

After a considerable period of time the fall in pressure is possibly again replaced with an increase, and this agrees with the most recent reports on a decreasing subjective effect of osteotomy after a long observation period (Appel & Friberg 1973).

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