PRIMARY PROTRUSION OF THE ACETABULUM

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Protrusion of the acetabulum is the term applied to the pelvic deformity in which the medial wall of the acetabulum bulges into the pelvic cavity, with medial displacement of the femoral head. The condition is classified into primary and secondary groups. The primary group is not associated with any obvious cause. The secondary group is the end-result of a recognised disease process, which may be metabolic (Paget’s disease, osteomalacia), infective (gonococcal, tuberculous, acute pyogenic), traumatic or non-specific (rheumatoid arthritis). This paper deals only with primary protrusion of the acetabulum.

We have reviewed the patients with primary protrusion of the acetabulum who came to the Nuffield Orthopaedic Centre during the last ten years with symptoms of pain and stiffness of the hips.

PREVIOUS REPORTS

Otto (1824) first described the condition, which he found at necropsy. White (1883) described the first English case, and Schertlin (1911) was the first to diagnose the condition radiologically. The condition is commonly called Otto pelvis. An alternative name is arthrokatadysis, which literally means subsidence of a joint.

Golding (1934) and Overgaard (1935) were the first to distinguish the primary and secondary groups. Alexander (1965) classified the possible causes of primary protrusion of the acetabulum, and recognised that it might arise either in adult life or in childhood. He did not think generalised bone softening was an acceptable cause, because there were no other stigmata of bone softening such as trifoliate pelvis, bowing of the long bones and platybasia. He favoured the theories incriminating an abnormality of ossification of the Y-cartilage as suggested by Eppinger (1903), Golding (1934) and Gilmore (1939) but did not put forward any radiographic or other evidence to support these concepts. He formed the hypothesis that primary protrusion of the acetabulum is unrelated to any pathological process in the joint, the adjacent bone or the Y-cartilage. On the basis of clinical and experimental evidence he reached the following conclusion: “Protrusion of the acetabulum is normally present in childhood. It is the direct consequence of normal stress on the normal Y-cartilage. It is normally reversible, diminishing stresses after the age of eight permitting corrections in the majority of children. Adult protrusion of the acetabulum is the result of failure of this normal correction. The failure can result from any factor impeding correction or increasing the degree of normal protrusion. The factors so far known to operate are female sex, premature fusion and coxa vara.” He stated that protrusion may be predicted in young children from beaking of the Y-cartilage before it is fused.

Somerville (1969) considered that the cause may be purely mechanical. It was his impression that patients with protrusion of the acetabulum more commonly tended to have a varus neck of the femur, with a decreased neck-shaft angle, than did normal patients.

RADIOLOGICAL CRITERIA FOR DIAGNOSIS

The symptoms of primary protrusion of the acetabulum are non-specific, and the diagnosis depends entirely on radiological criteria. Radiologically there is a gradation from obvious medial protrusion of the femoral head to a normal configuration, and hence the dividing line between normal and abnormal must necessarily be arbitrary.

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The "pear-drop" or "tear-drop", seen on antero-posterior radiographs of the pelvis, is formed by the acetabular floor laterally and the pelvic wall medially. Distortion of this pattern usually involves narrowing of this figure or actual crossing of the medial and lateral components. The crossing of these lines has been taken arbitrarily as the criterion in the diagnosis of protrusion of the acetabulum.

Another method of assessing an abnormally deeply situated acetabulum has been the C/E angle of Wiberg (1939). This is the angle between the perpendicular through the mid-point of the femoral head and the upper and outer margin of the acetabulum. This angle has been widely used in the assessment of abnormally shallow, or deep, acetabuli. In his series Wiberg recorded a range from 20 to 40 degrees in normal individuals, with an average of 36 degrees. Severin (1941), assessing children, found a range from 15 to 40 degrees, with an average of 30 degrees.

HYPOTHESIS

Our hypothesis is that the condition is caused by a force acting on an abnormally soft and malleable acetabulum. In a group of the younger patients a biochemical survey was undertaken to see if any metabolic abnormality could be elicited to account for this peculiar softening of bone.

THE PRESENT STUDY

Material—In the study the notes and radiographs of fifty-nine patients with primary protrusion of the acetabulum who attended the Nuffield Orthopaedic Centre in the last ten years were reviewed. Eleven patients whose symptoms first occurred before the age of twenty-five were recalled for clinical and biochemical investigations and assessment of the family history. Two families were reviewed clinically, radiologically and biochemically.

Physical examination—The general appearance was noted, the involvement of other joints looked for and the spine examined for scoliosis. The height was measured and compared with the crown-to-pubis and pubis-to-heel measurement. The span was measured. The hands were inspected for evidence of ligamentous laxity and arachnodactyly. The palate was examined. The eyes were examined to exclude lens dislocation. The skin turgor was assessed. Secondary sex characteristics were noted, and in females the menarche recorded.

Biochemical examination—Plasma electrolytes and urea were estimated in the routine manner. Plasma calcium (atomic absorption spectrophotometry) and phosphate (Gomorri) and alkaline phosphatase were measured in freshly separated plasma. Plasma proteins were estimated and protein electrophoresis was performed. A twenty-four-hour specimen of urine was collected, and the specific gravity, the total calcium (atomic absorption spectrophotometry) and urinary total hydroxyproline measured. Amino-acid two-way-paper chromatography was done on a random specimen of urine. In the event of abnormal results the tests were repeated. If urinary hydroxyproline was elevated, the test was repeated with the patient on a gelatin-free diet for twenty-four hours preceding and during the collection period (Prockop and Udenfriend 1960). The results of surgical treatment were assessed.

Radiological examination—Films were centred at the level of the anterior superior iliac spine. The films' focal distance was 90 centimetres. In a group of cases the angulation of the central beam was altered to assess the effect on the shape of the tear-drop. Radiographs were assessed for the degree of protrusion of the acetabulum, the presence of beaking of the Y-cartilage in the younger patients, the amount of new bone formation, and the presence of osteoarthritis. The C/E angle of Wiberg and the femoral neck shaft angle were measured.

RESULTS

Fifty-nine cases were reviewed, presenting between the ages of ten and eighty-five. These fell into three age groups: 1) those presenting in their teens; 2) those presenting between thirty-five and fifty; and 3) those presenting between fifty-one and eighty-five (Fig. 1).
The sex ratio was three females to one male, forty-five females being affected and fourteen males. In Group I the sex incidence was equal. The disease was bilateral in forty-eight patients and unilateral in eleven patients. The commonest presenting symptom was pain related to the affected hip.

**Radiological assessment**—In unilateral protrusion of the acetabulum a deep acetabulum was commonly found on the other side, as measured by the C/E angle. This was found to be so in both males and females. The neck-shaft angle in all three groups was within the normal range, averaging 123–127 degrees.

**Biochemical assessment**—Two patients (aged forty and sixty-nine) had repeatedly elevated plasma calcium and are being further investigated. All other biochemical estimations on the blood and urine were within normal limits for the patient’s age and sex.

![Histogram showing the age distribution of patients presenting with primary protrusion of acetabulum. Note the equal age distribution in those presenting in their teens.](image)

![A family of nine siblings, of whom four had acetabular protrusion radiologically. The 27-year-old and the 14-year-old had symptoms and the latter had a femoral osteotomy with a poor result.](image)

**Familial survey**—There was a family history of symptoms of acetabular protrusion in four out of eleven families. One family of nine siblings included two members who were affected clinically and four with radiological protrusion. No biochemical abnormality was detected in this family. In another family the father and the two daughters were affected radiologically. Again no biochemical abnormality was found (Fig. 2).

**Results of surgical treatment**—The results of surgical treatment are shown in Table I.

**DISCUSSION**

Primary protrusion of the acetabulum is recognised to be more common in women than in men (Francis 1959, Alexander 1965). However, in the younger age group (Group I) in this study there were equal numbers of males and females. We believe that the condition is more common than previously recognised, especially in older persons. There is a gradation of this
condition ranging from the very early symptomless cases found incidentally during radiography, to the patient who has two ankylosed hips. These early cases will need to be followed over the years to see if they progress, and to assess the rate of progression. We believe that there are several separate entities grouped together under the name protrusion of the acetabulum, and propose a classification into the following groups.

**Group 1: juvenile group**—In this group the symptoms occur commonly in the teens, and in this study males and females were affected equally. The symptoms may progress rapidly and become incapacitating. Lumbar scoliosis was found to be a commonly associated feature. Some patients were more worried by stiffness than by pain, and limitation of abduction was a common complaint. In this group there was a familial tendency; in two families studied, protrusion was demonstrated in relatives who were free from symptoms. These families will be followed up to discover whether these patients develop symptoms.

**Group 2: middle-aged group**—The symptoms are similar to those in Group 1, but radiologically this group can be subdivided into osteoarthritic and the osteoarthritic types (Overgaard 1935) (Figs. 3 and 4). In the osteoarthritic group there was little new bone formation and the joint space remained unaffected. Clinically the patient may have a good range of flexion, but abduction is always limited. The major feature radiographically is protrusion of the acetabulum and femoral head medially. In the osteoarthritic group there is much new bone formation, together with cysts in the acetabulum and femoral head, in addition to the protrusion. It is not clear whether the difference in these two sub-groups is in the response of the individual to the changes occurring about the acetabulum or whether the underlying defect is more basic and they are just separate entities. We believe that patients whose symptoms start in middle age may well be representatives of patients with asymptomatic protrusion from Group 1.

**Group 3: the elderly**—In this group protrusion of the acetabulum is invariably associated with osteoarthritis (Fig. 5). This is in contrast to Groups 1 and 2 in which serial radiography shows the protrusion of the acetabulum to develop first, and to be followed later by osteoarthritis. That the condition can occur de novo at the age of fifty to sixty in hips previously normal radiologically has been noted (Scott 1969), and would suggest some generalised bone disorder that is manifest at the joints that bear, over a small area, virtually the whole body weight with each step.

**TABLE I**

**The Results of Surgical Treatment**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Dates</th>
<th>Number</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral osteotomy</td>
<td>1964 to 1969</td>
<td>9</td>
<td>Good 1, Fair 4, Poor 3, Unknown 1</td>
</tr>
<tr>
<td>Total hip replacement</td>
<td>1968 to 1969</td>
<td>5</td>
<td>Good 5</td>
</tr>
<tr>
<td>Fusion</td>
<td>1967</td>
<td>1</td>
<td>Good 1</td>
</tr>
<tr>
<td>Thomson arthroplasty</td>
<td>1969</td>
<td>1</td>
<td>Good 1</td>
</tr>
<tr>
<td>Acrylic arthroplasty</td>
<td>1953</td>
<td>1</td>
<td>Poor 1</td>
</tr>
<tr>
<td>Girdlestone arthroplasty</td>
<td>1957 to 1965</td>
<td>3</td>
<td>Good 2, Fair 1</td>
</tr>
<tr>
<td>Drilling right hip</td>
<td>1967</td>
<td>1</td>
<td>Fair 1</td>
</tr>
<tr>
<td>Acetabuloplasty</td>
<td>1965</td>
<td>2</td>
<td>Good 1, Fair 1</td>
</tr>
</tbody>
</table>
One of the interesting features is that in most patients the deformity seems to arise during a period of rapid hormone flux: namely at puberty, when in this series the males and females affected were equal in number; and at about fifty to sixty years, following the menopause, when most cases were in women. In the younger patients none of the females had an early menarche, and they did not show early fusion of the femoral epiphyses, as was the case in two patients studied by Friedenberg (1953). We found no evidence that the condition was primarily metabolic, but the biochemical tests that we used were crude. We were able to confirm the work of Francis (1959) on the familial incidence of the deformity. Relatives were affected both clinically and sub-clinically as shown radiographically. It is our intention to follow up these families over the years. Whether genetic or environmental factors are involved is hard to assess, but in one family the disorder was present in two generations.

Radiologically we have taken the crossing of the tear-drop to be our criterion of diagnosis. The C/E angle of Wiberg did not contribute any further accuracy or consistency in diagnosis. Alteration in the incident beam can cause crossing of the tear-drop only if the tear-drop is
narrow. This only occurs significantly when the beam is in excess of 10 degrees of the central ray. Degrees of pelvic flexion principally caused by lumbar scoliosis may also affect the shape of the tear-drop. This can be assessed on the radiograph by assessing the shape of the obturator foramina, and from the relation of the coccyx to the symphysis pubis.

Beaking of the Y-cartilage as commented on by Alexander (1965) can be shown in most individuals to return to normal as the epiphyses close, and we consider the bulging of the inner wall of the pelvis without actual displacement medially of the femoral head to be a variation of this phenomenon (Fig. 6). It was our impression that lumbar scoliosis was more common in these groups of patients than in comparable unaffected groups. However, this was unable to be confirmed from adequate numbers because not all the patients had lumbar radiographs, and in several of these patients the scoliosis was almost certainly caused by unequal hip involvement. Nevertheless it remains possible that the scoliosis could be a reflection of a subtle metabolic factor causing protrusion of the acetabulum, but not detected by the biochemical methods used.
Regarding treatment, many of the elderly patients require nothing more than physiotherapy and perhaps a cane. In those coming to operation for stiffness or pain, total hip arthroplasty is the treatment of choice. In younger patients the problem is more difficult: osteotomy was not found to be successful and cup arthroplasty was often technically unfavourable. The younger patients should be advised to protect their hips from excessive physical stresses and strains.

There has been no long-term study of a group of patients with this condition, and we hope to be able to keep the symptom-free patients with acetabular protrusion under observation over the years to come.

Brailsford (1953) stated: "In the early years although the clinical manifestations may attract attention, roentgen characteristics are apt to be overlooked because the outlines of bones are regular and clearly defined. Early recognition and successful treatment would check the life-long development." Only a long-term study will tell.

SUMMARY

1. A study of fifty-nine patients with protrusion of the acetabulum showed that they fell into three age groups: those in their teens, those aged thirty-five to fifty years, and those presenting from fifty-one years onwards.
2. The juvenile age group was investigated clinically and biochemically but no causative metabolic factor was found.
3. The familial incidence was confirmed by radiological and biochemical surveys of several families.
4. The results of treatment show that when conservative treatment is insufficient a total hip replacement gives the best result from operation.

We wish to thank the consultant staff at the Nuffield Orthopaedic Centre for access to their patients; Dr Roger Smith for helpful criticism and help with the metabolic studies; Dr Sheila P. Davies for the biochemistry; and Mr R. Emanuel for the photography.

REFERENCES