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Retroversion of the acetabulum

A CAUSE OF HIP PAIN

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We describe a little-known variety of hip dysplasia, termed 'acetabular retroversion', in which the alignment of the mouth of the acetabulum does not face the normal anterolateral direction, but inclines more posterolaterally.

The condition may be part of a complex dysplasia or a single entity. Other than its retroversion, the acetabulum is sited normally on the side wall of the pelvis, and its articular surface is of normal extent and configuration. The retroverted orientation may give rise to problems of impingement between the femoral neck and anterior acetabular edge.

We define the clinical and radiological parameters and discuss pathological changes which may occur in the untreated condition. A technique of management is proposed.

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The clinical and pathological problems produced by gross forms of acetabular dysplasia are well recognised. The significance of lesser varieties is less appreciated, although several studies have reported that these apparently minor anomalies are associated with a predisposition to premature degenerative change.[1-3] The recognition of early symptoms may allow appropriate management of the condition.[4]

A specific variant of dysplasia is referred to as retroversion of the acetabulum.[5] In the normal hip the acetabular opening is anteverted from the sagittal plane (Fig. 1). In the retroverted condition the opening, and in particular its proximal rim (the roof edge), lies at an angle of retroversion from this plane (Fig. 2). In both normal and retroverted conditions the mouth opening spirals gradually into increasing anteversion distal to the roof edge. In the retroverted acetabulum, despite this progress distally into anteversion, the anterior edge of the mouth remains in a more lateral position than is normal, and the posterior edge is more medial (see Fig. 4). This indicates that in retroversion the orientation of the whole socket is altered, not just its superior edge. In a complex dysplasia, retroversion may be one of a combination of anomalous features, but we now describe the condition as a solitary anomaly.

Hitherto, retroversion of the acetabulum has not been identifiable on standard radiographs of the hip and therefore the clinical significance has not been properly appreciated.

Patients and Methods

We studied clinically and radiologically 310 adult patients (620 hips), referred with symptoms arising from the hip. Of this highly selected series, most had severe dysplasia of at least one hip, but many had been referred solely for the investigation of symptoms believed to originate from a hip, but for which clinical assessment alone could demonstrate no definite cause. There were 288 women and 57 men with a mean age of 32 years, the youngest being 13 years. Each patient was examined clinically and by radiography with a carefully-centred anteroposterior (AP) film of the pelvis and axial CT at 2 mm intervals, beginning just proximal to the articular surface and progressing to the distal extremity of the socket. The CT images were then enlarged to full size (Figs 1, 2). From these enlargements, the alignment of the acetabular opening at every level was defined by a line drawn between the anterior and posterior edges. We termed a line which defined the orientation of the opening proximally, as the roof edge (RE) line. It is derived from a contour map constructed from tracings of the outlines of consecutive 2 mm CT cuts, laid one on another (Fig. 3). The resulting image reflects the overall acetabular alignment. The proximal edge is defined in the manner shown.

A second line drawn from a single CT cut at the maximum diameter of the femoral head was termed the equatorial edge (EE) line (Fig. 4). This defines acetabular orientation at a level distal to the roof. The angles which these lines subtend with the sagittal plane are the RE and the EE angles, respectively. The angle is 'positive' when inclined medially to the sagittal plane (anteversion) and 'negative' when inclined laterally (retroversion). The con-

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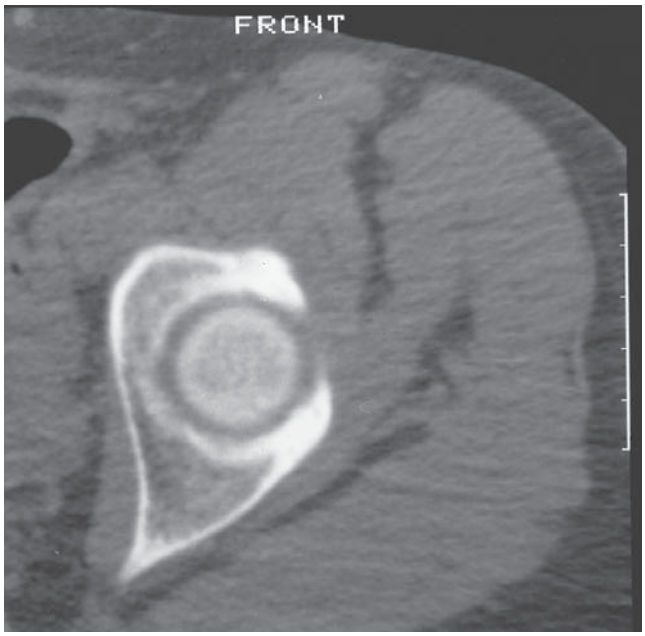

Fig. 1

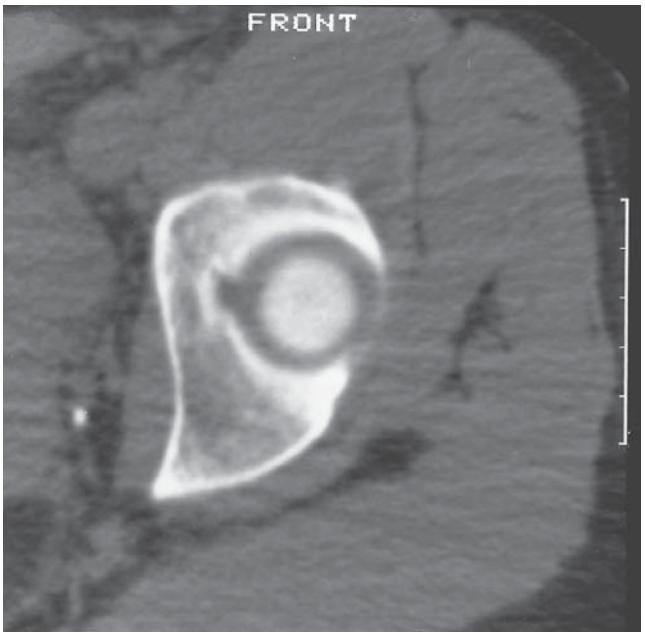

Fig. 2

Figure 1 – CT of the acetabulum in the normal anteverted alignment. The image is 75% of full size. Figure 2 – Case 12. CT of the acetabulum in retroverted alignment.

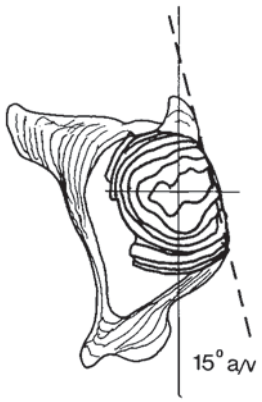

Fig. 3a

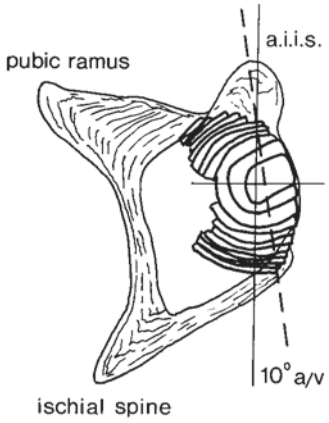

Fig. 3b

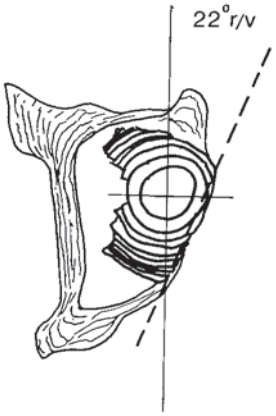

Fig. 3c

Contour maps of superimposed CT cuts of acetabulae and surrounds showing anteverted (a,b) and retroverted (c) alignment. The RE line is indicated for each (broken line). Its reference points are the prominences on the posterior and anterior halves of the acetabular edge. In a retroverted acetabulum each is always clearly identifiable. In an anteverted or lateral-facing acetabulum the anterior prominence may not always be distinct, in which case it is the mid-point anteriorly which is taken as reference (b). The axes shown are centred over the apices of the underlying femoral heads which, for clarity, are not included in the diagrams.

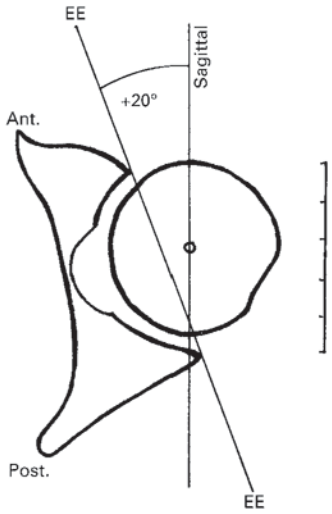

Fig. 4

Tracings of the CT image of the hip, at a maximum diameter of femoral head, to show the derivation of the equatorial edge (EE) line and angle.

struction of both the RE line and angle and the EE line and angle were tested for both interobserver and intraobserver repeatability.[6] These data showed a normal distribution, allowing the use of the unpaired *t*-test for verification.

Results

Of the 620 hips, 174 were free from symptoms and when assessed against previously described radiological parameters,[7] were of normal configuration (Table I) with no differences between the sexes. For this group, on the AP radiograph, the centre-edge (CE) angle of Wiberg had a median value of 30°. On CT, the median value of the RE angle was +5° (i.e. anteversion) and of the EE angle, +20°. The theoretical weakness of using as controls apparently normal hips from a series of patients referred for the investigation of hip dysplasia is appreciated and will be discussed below.

Of the remaining 446 hips, 383 showed features of dysplasia sufficient to account for symptoms. In 20 sympto-

Table I. Values for the angles in 174 normal hips and 43 in the study group

	Normal			Study				
Angle	**Mean**	**Median**	**95% CI**	**Mean**	**Median**	**95% CI**	**p value**	**95% CI**
CE (Wiberg)	30	30	29 to 31	35	35	33 to 37	<0.01*	-6 to -2
RE	4	5	2 to 5	-15	-17	-17 to -13	<0.01†	16 to 22
EE	21	20	20 to 22	14	13	12 to 15	<0.01†	6 to 9
EE-RE: arc	17	16	16 to 19	29	29	27 to 31	<0.01†	14 to 9

* significant
† highly significant

matic hips no abnormality could be demonstrated either clinically or radiologically. In the remaining 43 hips a single other anomaly became recognisable, namely acetabular retroversion.

In these latter hips, the only abnormal observation recognised initially was the CE angle, which was increased, with a median value of 35° compared to the normal of 30°. On the CT images however, there were other differences. The RE angle showed a median value of -17° (retroversion) compared with +5° (anteversion). The EE angle had a median of +13° as opposed to +20° in the normal. The opening of the mouth was more retroverted than usual distally, not just at the roof edge. Finally, in the retroverted hips the extent of the arc between the RE line and the EE line was greater, with a median value of 29° compared with 16° (Table I).

These findings indicate that in the 43 hips the alignment of the acetabulum on the side wall of the pelvis is retroverted in comparison with the normal. The larger-than-normal arc between the RE and EE lines shows that the most marked degree of retroversion is in the proximal part of the acetabulum. The abnormality is not simply a relative deficiency between the anterior and posterior segments. Measurements of the area of the articular surface is the same in both retroverted and normal groups. When occurring as a single feature retroversion represents an abnormality of acetabular orientation, predominantly of the proximal edge, of an otherwise normal structure.

Clinical presentation. The clinical details of the patients with retroversion are given in Table II. Each complained of symptoms which seemed to arise from one or both hips, 28 of the 43 joints being symptomatic.

No source other than the hip was shown to be responsible for any of the symptoms. Presentation may be 'early', in the teens or early twenties, or 'late', usually in mid or late thirties. In our series there are 16 examples of early presentation and 12 of late (Table II). The diagnosis was made on the history, by determining certain physical signs, and on the appearance of the AP radiograph.

Early presentation

Symptoms. There is often a history of recent adoption of a particular physical or sporting activity, or a physically-demanding occupation. The progress from school to adult life-style is a vulnerable period. The presenting symptoms tend to be gradual in onset and may include aching pain in the groin, sometimes radiating to the thigh or knee and aggravated by activity, trochanteric pain, low back pain radiating into the buttock, or a clicking hip.

Physical signs. Acetabular retroversion is not necessarily associated with any change in the range of movement of the hip. When the retroversion is marked, however, there is a demonstrable alteration in the pattern of hip flexion in the neutral line. This may be limited to as little as 90°, progressing to a full range only when allowed to move simultaneously into external rotation and abduction. It is possible that, at 90°, movement is blocked in the neutral plane by a prominent anterior edge of the acetabulum. This block can be overcome only by continuing the movement of flexion in the retroverted plane of the acetabular mouth.

In these individuals the limb tends to lie at rest in a position externally rotated at the hip. The range of external rotation, especially in the flexed position, is more generous than usual, often exceeding 60°. The range of internal rotation may be limited proportionally. Asked to sit on the floor, such patients are comfortable only with hips flexed, abducted, and externally rotated. Some describe a dislike of sitting in a chair with legs crossed, especially with the symptomatic leg crossed over the other.

Signs of impingement. Regardless of the range of movement in the hip, once symptoms begin there will be detectable signs of impingement. Movement of the hip passively into simultaneous flexion, adduction, and internal rotation, particularly in the mid-range of flexion, will produce distinct and repeatable discomfort.[8]

Radiography. The appearance of a retroverted acetabulum on the AP radiograph is distinctive, with two specific features (see Fig. 6).

1) In Figure 5 an example is given of a normal anteverted hip. From the lateral edge of the roof, a line representing the anterior rim of the mouth runs medially and distally, diverging from the posterior rim which runs much more vertically. In the retroverted condition (Fig. 6) the lateral limit of the anterior line will be lateral to the similar point for the posterior rim at the most proximal part of the mouth of the acetabulum. As these lines progress medially and distally, the anterior line crosses the posterior line. We have called this the 'cross-over' sign.

2) The visible outline of the edge of the posterior wall of a normal acetabulum descends through the centre point of the femoral head or lateral to it. In the retroverted situation the descent of this line is medial to the centre point (Fig. 6). In other respects the AP radiograph is normal. The CE angle is never less than generous. The acetabular index is normal.

Table II. Details of the 22 patients in the study group

Case	Sex	Age (yr)	Occupation	Hip No	Symptom side	Symptom No	Presenting		Symptoms				Edge fragmentation	Management			
							Early	Late	None	Effort pain	Rim syndrome	LBP*		None	Excise frag†	PAO‡	THR§
1	F	29	Manageress	1	R	1		x		x	x		x		x		
				2					x								
2	M	34	Labourer	3	R	2		x		x				x			
				4	L	3		x		x	x			x			
3	M	25	Footballer	5	R	4		x		x			x		x		
				6	L	5		x		x			x				
4	F	28	Physiotherapist	7					x								
				8	L	6	x			x		x				x	
5	F	17	Horses	9	R	7	x			x	x					x	
				10					x								
6	F	23	Nurse	11					x								
				12	L	8	x			x				x			
7	F	26	Nurse	13	R	9	x			x	x					x	
				14					x								
8	M	26	Sport	15					x								
				16	L	10		x		x	x	x	x	x			
9	F	50	Housewife	17	R	11	x			x				x			
				18	L	12	x			x				x			
10	F	20	Physiotherapist	19	R	13	x			x						x	
				20					x								
11	F	15	Student	21	R	14	x			x	x					x	
				22					x								
12	F	23	Photographer	23	R	15	x			x	x					x	
				24					x								
13	F	16	Student	25	R	16	x			x						x	
				26					x								
14	M	36	Carpenter	27	R	17		x		x			x		x		
				28					x								
15	M	28	Footballer	29	R	18		x		x			x	x			
				30	L	19		x		x			x	x			
16	F	29	Publican	31	R	20	x			x						x	
				32	L	21	x			x						x	
17	M	46	Squash	33	R	22		x		x	x			x			
				34					x								
18	F	17	Swimmer	35	R	23	x			x	x					x	
				36					x								
19	F	21	Swimmer	37	R	24	x			x						x	
				38	L	25	x			x				x			
20	F	17	Student	39					x								
				40	L	26	x			x						x	
21	M	44	Cricketer	41	R	27		x		x							x
				42					x								
22	M	38	Footballer	43	R	28		x		x				x			
				¶ -	-	-	-	-	-	-	-	-	-	-	-	-	-

* low back pain
† excise fragment
‡ periacetabular osteotomy
§ total hip replacement
¶ Left hip, the site of more complex dysplasia, excluded from review

Late presentation

Symptoms. These patients who present in the age range of 30 to 50 years will remember few or no troublesome symptoms from their younger years, but direct questioning may reveal otherwise. Nearly all are male, with a tendency towards joint stiffness. They often have, or have had, a keen interest in contact sport, or have an occupation in which some discomfort is accepted as a part of the activity (Table II).

Early symptoms in youth have been dismissed merely as an everyday consequence of the lifestyle adopted. Later symptoms suggest progress towards degenerative change. As with early presentation, the principal symptom is that of pain on effort, often associated with postural aching. There may be similar symptoms of clicking or clunking, but in addition the patient complains of increasing stiffness.

Physical signs. The physical signs are similar to those of the 'early' presentation, but it is not unusual to find an asymmetrical diminution of range, with a degree of fixed flexion deformity.

Radiology. In addition to the cross-over and posterior wall signs, there may be evidence of damage from impingement and even fragmentation of the bony margin of the prominent anterior acetabular edge.

If located proximally, this will be visible on the AP radiograph, often as a separated fragment (Fig. 7), as well as on CT (Fig. 8). Fragmentation located more distally on the anterior edge will be seen only on CT (Fig. 9). Degenerative

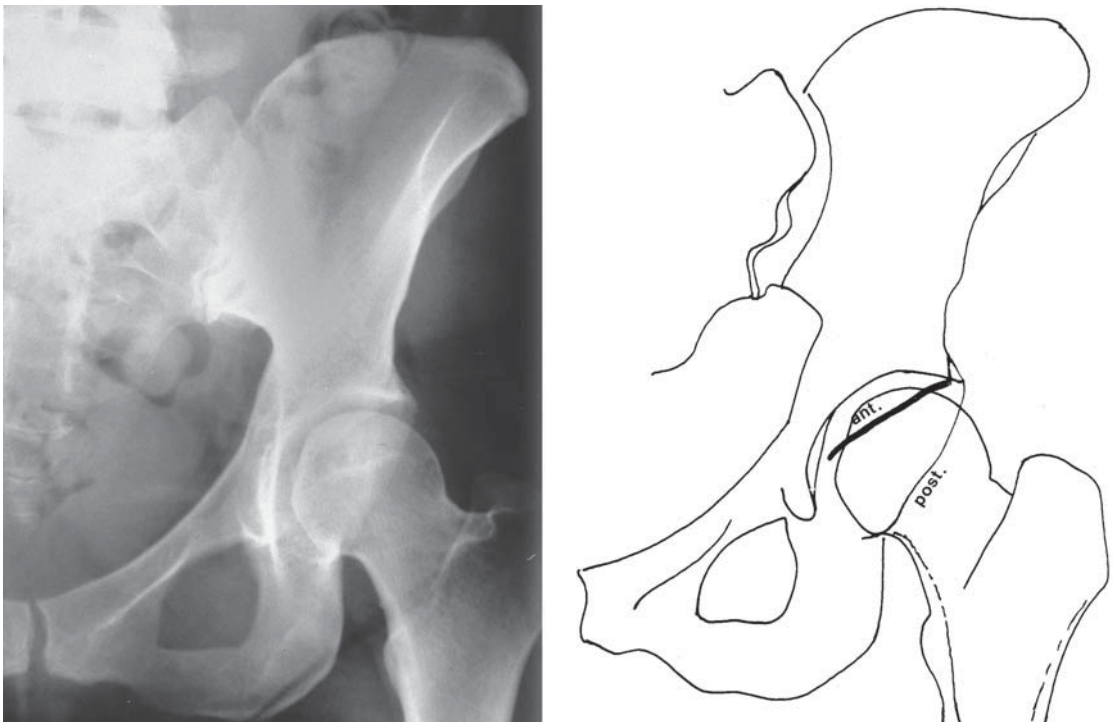

Fig. 5

Radiographs and outline diagram of the normal (anteverted) acetabulum. The posture of this pelvis is flexed more at the lumbosacral junction than in the case described in Figure 6. The outline of the obturator foramen is more circular and the ischial spine is obscured. In such a flexed pelvis the anteverted attitude of the acetabulum is seen at a maximum. When an acetabulum is retroverted adoption of a similar posture will minimise the appearance of retroversion. The line of the edge of the posterior wall is located at or even lateral to the centre of the femoral head.

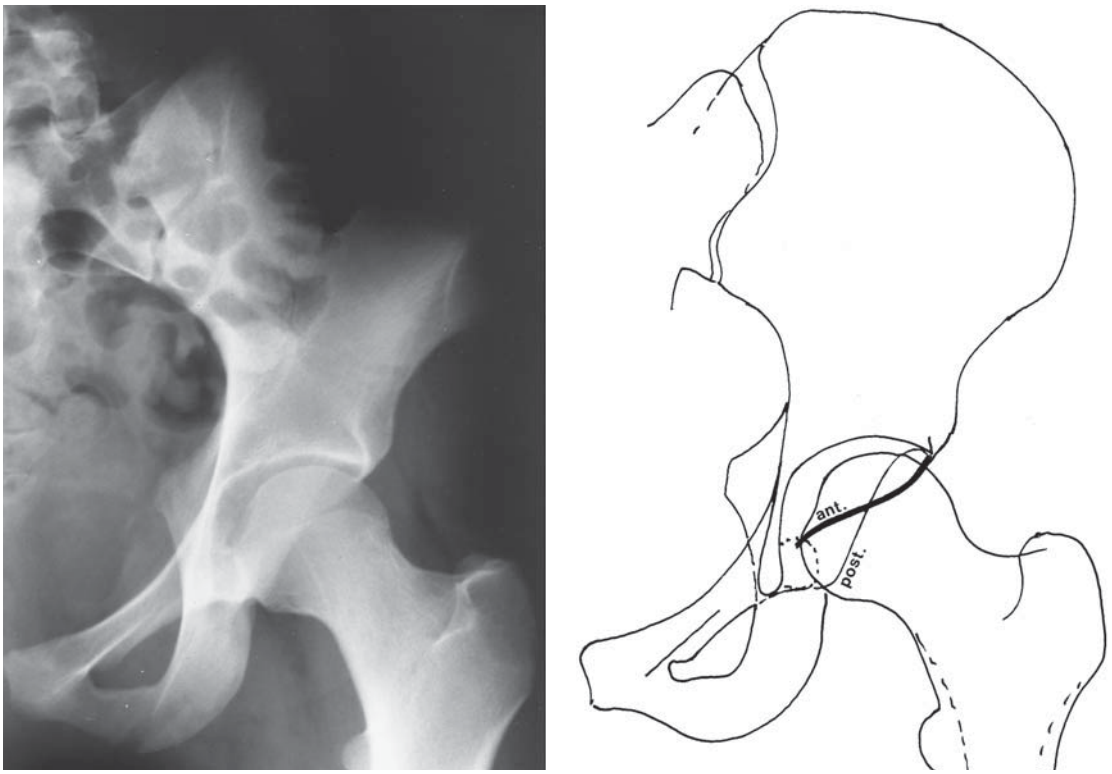

Fig. 6

Diagram showing acetabular retroversion and the 'cross-over' sign. Compare with Figure 5. The line of the posterior wall is shown thin, that of the anterior wall thick. The line of the edge of the posterior wall is located well medial to the centre of the femoral head.

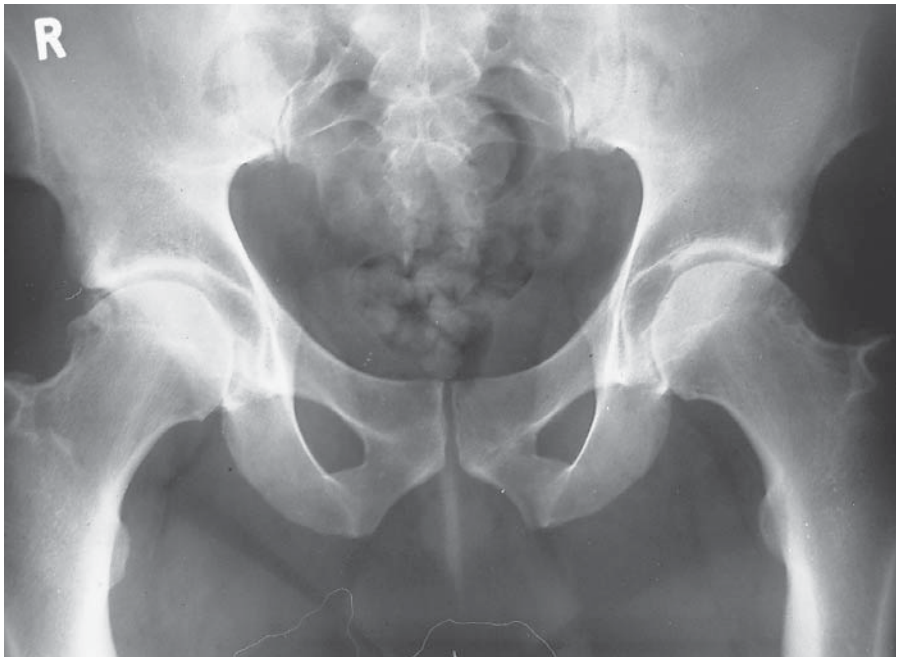

Fig. 7

Case 14. Radiograph showing fragmentation at the superior edges of the retroverted acetabula, most notable in the right hip. Compare with Figure 8.

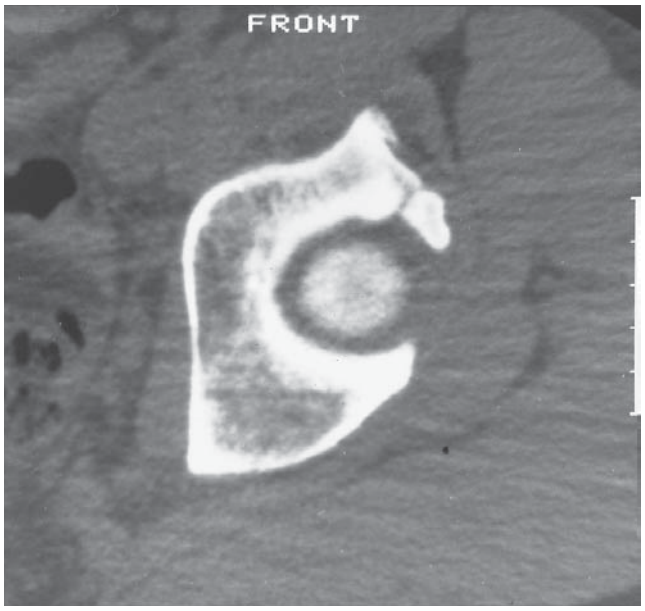

Fig. 8

Case 3. Proximal CT cut of the retroverted acetabulum showing fragmentation of the anterosuperior margin. Compare with Figure 7.

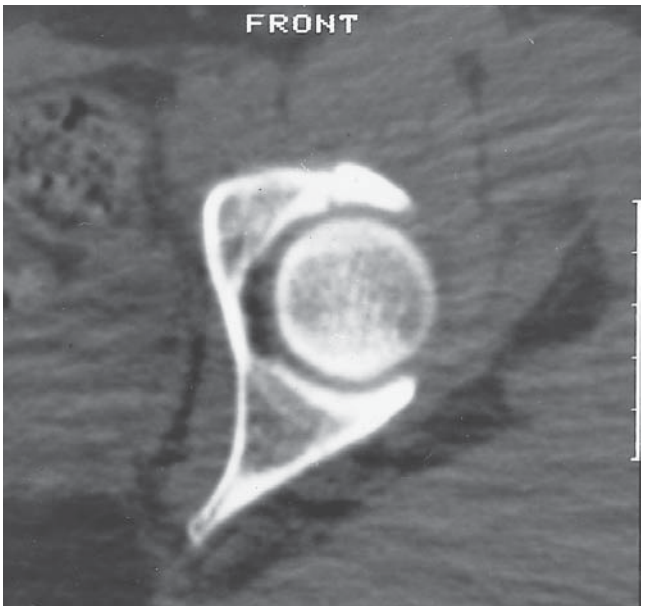

Fig. 9

Equatorial cut CT image of the retroverted acetabulum showing fragmentation of the distal anterior edge, not visible on plain radiography.

change, with or without fragmentation, may show on the plain film, but when this is restricted to the vulnerable anterior surface, it may be revealed only by CT (Fig. 10).

Discussion

The findings which we have reported have emerged as an incidental consequence of using a refined system of close-cut CT scanning for the investigation of hip dysplasia. The radiation received by the patient is not excessive. It is, however, great enough for us to have felt that scanning of normal patients of childbearing age, solely to obtain a comparable normal series, is not justified. Comparing previously reported radiological parameters[7] the data from the 'normals' in our series fell within the observed ranges of normal. Therefore we felt it reasonable to consider the values for the RE and EE parameters in these same cases as representative of the normal.

Clinical and pathological significance. Monitoring of these 22 patients with retroversion of the acetabulum reveals the

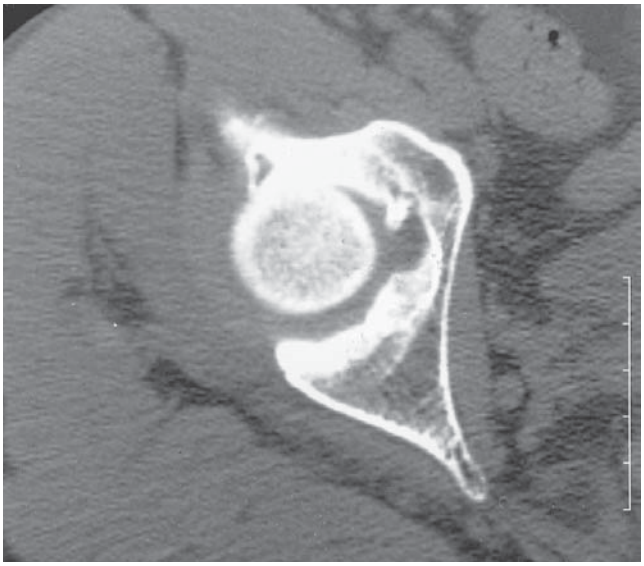

Fig. 10

Case 21. CT image showing anterior impact wear in the retroverted acetabulum, not visible on plain radiography.

symptoms that can develop. The clinical picture described, particularly, the symptoms of groin pain, clicking or clunking. Progress of the condition between early and late presentation in which fragmentation can occur at the acetabular edge, appears to be as a result of impingement between the anterosuperior edge of the acetabulum and the anterior surface of the femoral head and neck.[8] As a result of retroversion, anterolateral cover for the femoral head is more extensive than normal. This is reflected in the observed increase in CE angle and composite CT scans show that in the retroverted state, cover for this quadrant averages 65% compared with 49% in the normal series ($p < 0.001$).

It is possible that during flexion of the hip the edge of the anterior wall and the anterosuperior roof of a retroverted acetabulum are vulnerable to impingement since they tend to lie directly in the path of the femoral neck.

The most likely provocative movement of the hip is into flexion and adduction simultaneously. The phenomenon of impingement can be demonstrated from the handling of specimens of dry bone. It is most readily shown when either the acetabulum or femoral neck are held in a retroverted orientation. CT scans of our patients show no variations from normal in alignment of the femoral neck, whereas retroversion of the acetabulum is measurable.

The differences between the radiological features of early and late presentation include the appearance of fragmentation at the bony acetabular edge and signs of degenerative change of varying but significant degree. Progressive degenerative change may be the result of more prolonged and perhaps more violent impingement resulting from sporting activity.

In all 22 patients retroversion was bilateral and usually symmetrical. In one hip there were additional minor anomalies; this hip has been excluded from our assessment. In 28 instances a retroverted hip was the source of symptoms; in 15 it was not, a disparity which might have reflected the degree of retroversion, but this was not always the case.

Alternatively, the explanation may lie in individual dynamics. Whether anteverted or retroverted, the orientation of the acetabulum on the pelvis is always at an angle to the sagittal plane. Thus, if the pelvis is more extended at the lumbosacral junction, as occurs with increase in lumbar lordosis, the functional retroversion of acetabular is greater (Figs 5 and 6), and vice versa. The attitude or 'pitch' of the pelvis in a particular posture, or during a particular activity, may then have an influence on the production of symptoms.

Bodily habit also may play a part. While a particular degree of retroversion may be associated with symptoms in a physically active individual, in the less active a similar degree of retroversion may produce none. When each of a pair of hips is retroverted, yet only one is troublesome, the mode of use of each leg is significant.

Whatever the particular case, our data suggest that symptoms are unlikely to be experienced from a hip with less than 15° of retroversion.

Management. The appropriate management of symptoms depends upon the circumstances of the individual case. The simple process of achieving the diagnosis may allow the patient to modify various activities and postures to minimise symptoms to the point at which they are no longer a practical problem.

In a later case in which fragmentation has occurred, the damaged superior or anterior edge of the acetabulum will have been removed from weight-bearing, and the fragments alone may be the source of symptoms. It may be sufficient simply to remove them. This was done for three patients (cases 1, 3 and 14, Table II). All have experienced relief, maintained for between three and seven years. In those cases in which degenerative changes have become irreversible, the only solution may have to be total hip replacement (case 21, Table II).

The most difficult problem comes with the case which presents early without visible rim damage, in which symptoms persist and seriously interfere with an ordinary, reasonable lifestyle, or the patient's chosen profession. With the circumstantial evidence available of what may be the outcome if no action is taken, we have felt a more radical approach to be justified. To this end, we do not consider it to be appropriate to remove the impinging section of what is otherwise a healthy acetabular edge and labrum. Experience of having done so in other forms of dysplasia has not been encouraging. Nor is it logical to consider compensatory rotation osteotomy of the femur, whch is likely only to add to the complexity of the situation by deforming an otherwise normal structure. This is also unlikely to overcome impingement at the acetabular edge which is independent of the set of the femoral neck.

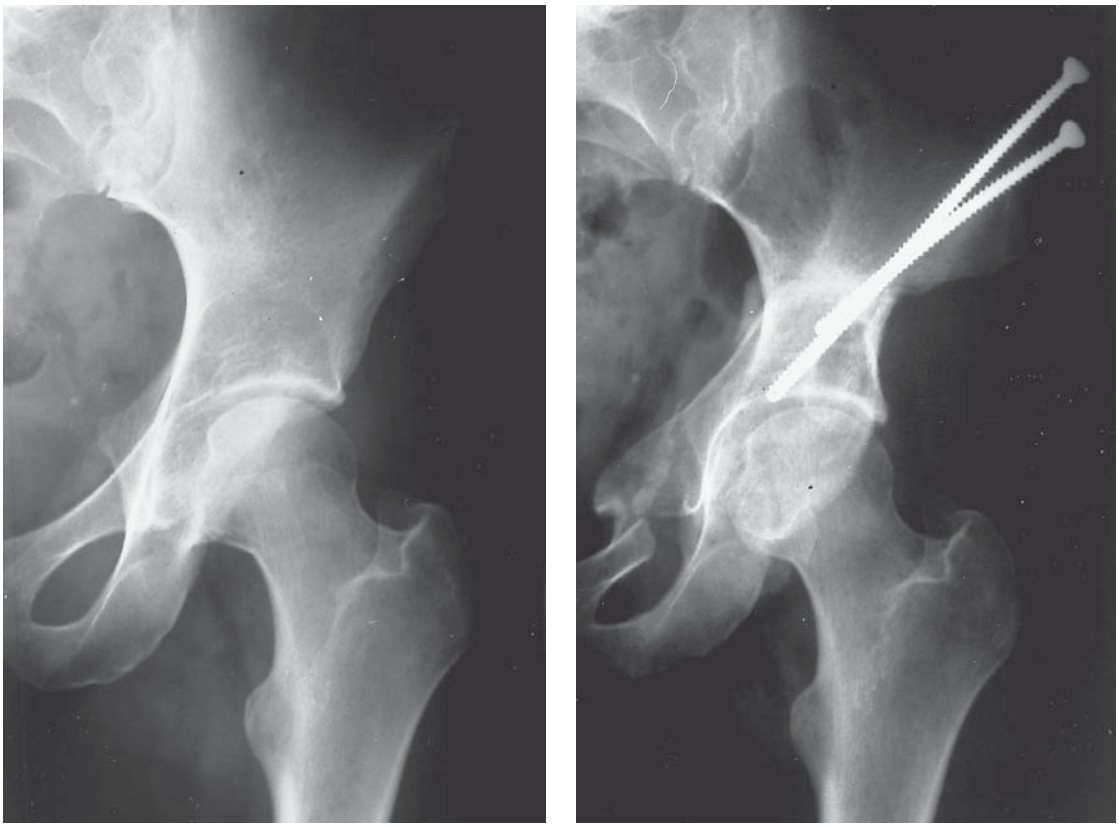

Fig. 11

Case 16. Preoperative (a) and postoperative (b) radiographs of the retroverted acetabulum and after periacetabular correction. In the postoperative film the line of the posterior wall is superimposed on the centre of the femoral head. Compare with Figures 5 and 6.

The alternative is to alter the alignment of the acetabulum into a more anteverted posture in order to reduce the negative RE angle This may seem an excessive surgical intervention as a solution for a 'minor' anomaly, but the problems which the latter can cause are not. Apart from affecting the patient's career or life-style, it may lead to irreversible rim damage and degenerative change.

We propose a technique of realignment by periacetabular reorientation osteotomy.[9,10] The correction must place the edge of the socket at least into a neutral position, preferably into some anteversion. Since it is our observation that significant symptoms are associated only with retroversion greater than 15°, the anteversion correction has to be a minimum of 20°. We have undertaken this procedure in 12 patients, with encouraging early results (Fig. 11).

When a condition is newly defined, its true incidence in the general population cannot be determined. The complaint of hip pain for which no cause can easily be identified is not uncommon in young patients. The diagnosis of acetabular retroversion should be considered when symptoms are referred from a hip of apparently normal structure.

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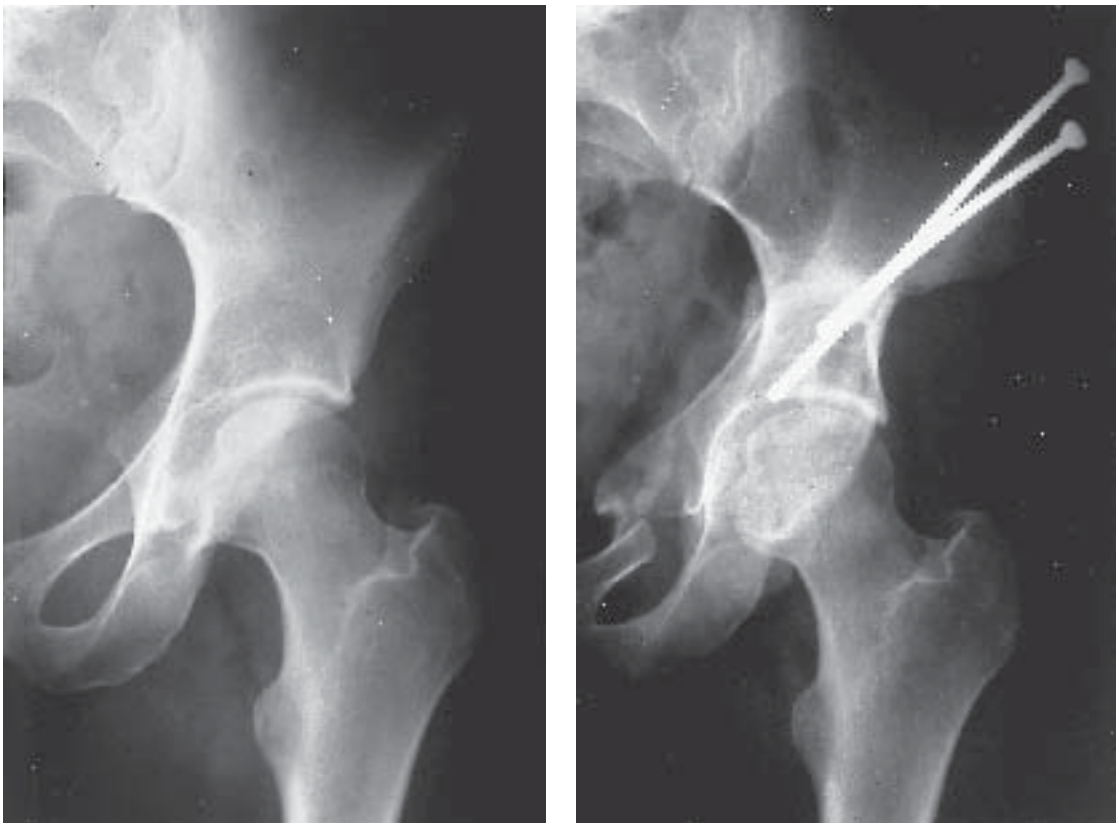

Fig. 11

Case 16. Preoperative (a) and postoperative (b) radiographs of the retroverted acetabulum and after periacetabular correction. In the postoperative film the line of the posterior wall is superimposed on the centre of the femoral head. Compare with Figures 5 and 6.

The alternative is to alter the alignment of the acetabulum into a more anteverted posture in order to reduce the negative RE angle This may seem an excessive surgical intervention as a solution for a 'minor' anomaly, but the problems which the latter can cause are not. Apart from affecting the patient's career or life-style, it may lead to irreversible rim damage and degenerative change.

We propose a technique of realignment by periacetabular reorientation osteotomy.[9,10] The correction must place the edge of the socket at least into a neutral position, preferably into some anteversion. Since it is our observation that significant symptoms are associated only with retroversion greater than 15°, the anteversion correction has to be a minimum of 20°. We have undertaken this procedure in 12 patients, with encouraging early results (Fig. 11).

When a condition is newly defined, its true incidence in the general population cannot be determined. The complaint of hip pain for which no cause can easily be identified is not uncommon in young patients. The diagnosis of acetabular retroversion should be considered when symptoms are referred from a hip of apparently normal structure.

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