BIOLOGICAL FACTORS PREDISPOSING TO TRAUMATIC POSTERIOR DISLOCATION OF THE HIP

A SELECTION PROCESS IN THE MECHANISM OF INJURY

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The factors involved in the mechanism leading to traumatic posterior dislocation of the hip are examined. In 47 adult patients who had previously suffered such a dislocation, ultrasound scans were used to measure femoral anteversion on both the affected and the uninjured side. In 36 normal adult volunteers, used as controls, similar measurements were made. Femoral anteversion on both the injured and uninjured side was significantly reduced in the patients compared with the volunteers.

These findings are discussed in the light of previous work which indicates that medial rotation is a factor in the mechanism of posterior dislocation of the hip. It is suggested that reduced anteversion acts like medial rotation to make the hip more susceptible to posterior dislocation, and that the less the anteversion the more likely is the injury to be a dislocation rather than a fracture-dislocation. It is concluded that patients who suffer such dislocated hips belong at one extreme of the normal population, having either reduced femoral anteversion or even retroversion, and that this anatomical feature selects towards hip dislocation rather than to injury of the femoral shaft, knee or tibia during the appropriate type of accident.

Traumatic posterior dislocation of the hip is generally considered to be produced by an axial force of sufficient magnitude in a certain direction applied when the hip is flexed and adducted.

This view has been supported by several writers including Watson-Jones who stated that a normal hip was vulnerable to traumatic dislocation if the femur was driven back while the hip was flexed and adducted; in this position of the hip a powerful thrust in the long axis of the limb forces the femoral head through the joint capsule on to the dorsum of the ilium (Wilson 1982). Funsten, Kinser and Frankel (1938) describe dashboard injuries producing posterior dislocation at the hip; the passenger in the front seat of a vehicle was thought to be particularly involved rather than the driver, because he may sit cross-legged with one hip flexed and adducted. In contrast, Stewart and Milford (1954) thought that the driver was likely to be more severely affected because his foot on the brake transmitted the force of impact along the limb to the hip. This is also mentioned by Epstein (1974).

Letournel and Judet (1981) have more recently given a detailed theoretical analysis of the mechanism of dislocation. They stated that the position and magnitude of the forces at the hip were determined, first, by the position of the femur in relation to the acetabulum and, secondly, by the point on the limb at which the force was applied. They suggested that the degree of both flexion and adduction at the hip before impact was the principal factor which determined the site of any acetabular fracture, the direction of displacement of the fragments and the type of dislocation. In their analysis, the forces were considered as applied either to a flexed knee along the femoral shaft, or to the foot with the knee extended. In posterior dislocation of the hip caused by a blow on the back whilst stooping, as in some mining accidents, flexion at the hip, and not adduction, is generally considered to be the predisposing factor.

Most authors writing on the mechanism of traumatic posterior dislocation of the hip assume that the limb was in neutral rotation at the time of impact. Some earlier workers did, however, suggest that rotation of the femur at the hip contributes to the type of dislocation (Bigelow 1900; Pringle and Edwards 1943). Epstein (1974) suggested that, in car accidents, posterior dislocation occurs when the hip is medially rotated and flexed at the time of impact.

Numerous car accidents involve head-on collisions, yet posterior dislocation of the hip is an uncommon injury. The femoral shaft, the tibia and the knee are more usually injured. The question is, why do so few people suffer hip dislocation when many sit in vehicles in similar positions but sustain other lower limb injuries?

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This paper reports the measurement of femoral anteversion in patients who had previously sustained a traumatic posterior dislocation of the hip and compares the results with those obtained from a group of healthy adult volunteers. We conclude that reduced femoral anteversion predisposes an individual to traumatic posterior dislocation of the hip.

MATERIALS AND METHODS

Patients. Fifty-eight patients who had previously been the subjects of papers on the late results of traumatic dislocation of the hip (Upadhyay and Moulton 1981; Upadhyay, Moulton and Srikrishnamurthy 1983) were examined clinically and by ultrasound scanning by one of us (SSU). Eleven patients were excluded from the study because they had undergone operations for arthritic hips. The remaining 47 patients included 43 men and four women with an average age of 40.6 ± 14.1 years (mean and standard deviation), range 22 to 65 years.

Classification of injuries. The patients were followed up at a mean of 13.7 years after injury, and their injuries (all posterior dislocations) were grouped using the criteria of Epstein (1974). *Simple dislocations (Grade I)* included those without a fracture or with only a minor chip fracture of the posterior acetabulum. *Fracture-dislocations (Grades II and III)* included those with either a large single fragment or with a comminuted fracture of the posterior acetabulum. No patient with a central dislocation or with anterior dislocation of the hip was included. The relationship between the cause, the grade and the side of injury are shown in Table I.

The normal volunteers. Thirty-six adult volunteers from the hospital staff, all with clinically normal hip and knee joints, had ultrasound scanning to determine femoral anteversion. There were 11 men and 25 women, from 19 to 50 years of age, with a mean age of 27.0 ± 7.5 years.

Table I. The relation of the cause of the accident to the severity of injury at the hip in 47 cases

Cause of injury	Grade I dislocation		Grade II and III fracture-dislocation		Total
	Right hip	Left hip	Right hip	Left hip	
Car accident	3	7	7	7	24
Motorcycle accident	5	6	4	2	17
Colliery accident or falling object	1	2	2	1	6
All	9	15	13	10	47

Ultrasound scanning. At the hip and knee of each patient and normal volunteer, ultrasound scans were obtained as previously reported by Moulton and Upadhyay (1982). The hip scans were at the level of the greater trochanter and the knee scans about 2 cm proximal to the medial joint line.

New criteria were used to determine the lines at hip and knee from which to measure anteversion (Fig. 1). On

Fig. 1

Diagram of ultrasonic scans to show, on the left, the "femoral head-neck line" at the hip and, on the right, the "transcondylar line" at the knee (see text). The corners of each scan are shown as these are used to superimpose the two scans and the angle of anteversion is then measured between the two lines.

the hip scan, a line joining the most anterior parts of the trochanter and of the femoral head was taken as the "femoral head-neck" line. On the knee scan, two mid-points were marked, one halfway between the most anterior projections of the femoral condyles, the other between the widest flare of each femoral condyle. The "transcondylar line" was then drawn at right angles to an anteroposterior line connecting the two midpoints. This method was modified from that of Weiner *et al.* (1978) who, using computed tomograms of the knee, drew a "diacondylar" line connecting two points at the widest flare of the condyles. Our modification overcomes error caused by rotation of the limb and by anatomical variation of femoral condylar flare by using in addition the anterior midpoint between the femoral condyles.

Finally, the hip scan is superimposed on the knee scan, and the femoral anteversion measured as the angle between the femoral head-neck line and the transcondylar line.

The statistical methods used in this study were the two-way analysis of variance, the variance ratio test, Student's *t*-test, regression analysis and the correlation coefficient.

Observer error. Ultrasound scans at the hips and knees of 20 normal volunteers were obtained three times by one observer (SSU). Analysis of the results showed that the error of measuring femoral anteversion was $\pm 2^\circ$ (95% confidence limits, two-way analysis of variance).

Table II. Femoral anteversion in normal volunteers and in patients with previously dislocated hips as mean and standard deviation in degrees (see Fig. 5)

Subjects examined	Number	Femoral anteversion (degrees)			
		Right hip		Left hip	
Group		Mean	SD	Mean	SD
Normal	36	15.4	6.1	16.3	4.4
Grade I dislocation	Right	1.1	5.9	10.4	8.2
	Left	4.4	12.1	-3.2	8.3
Grade II and III fracture-dislocation	Right	3.2	9.4	5.5	6.9
	Left	5.0	9.4	6.1	10.0

RESULTS

Normal volunteers. Femoral anteversion in normal subjects (Table II and Fig. 2) was: left hip, $16.3^\circ \pm 4.4^\circ$; right hip $15.4^\circ \pm 6.1^\circ$ (mean and standard deviation). There was no statistically significant relation between femoral anteversion and either age or sex. Most subjects showed little or no asymmetry of femoral anteversion between left and right hip ($r=0.795$, $P<0.001$).

Patients with previous simple dislocation (Grade I). The femoral anteversion of the injured hips was significantly less than either that of the contralateral uninjured hips, implying pre-existing asymmetry, or that of the hips of the normal volunteers (Figs 2, 3 and 4). There was no significant difference between anteversion of the *injured* left hips and the *injured* right hips, nor between the anteversion of the *uninjured* left hips and the *uninjured* right hips.

The angle of femoral anteversion of injured and uninjured hips in this group of patients showed a significantly wider scatter, using the variance ratio test, than did the hips of the normal volunteers (Table II and Fig. 5).

Patients with previous fracture-dislocation (Grades II and III). Femoral anteversion at the injured hips was significantly less than of the normal hips but not less than that of the uninjured contralateral hips (Figs 6, 7 and 8). Femoral anteversion of the uninjured hips was also significantly less than that of the normal hips.

Cause of injury. There was no relation between femoral anteversion and the causes of injury, which were grouped as resulting from motorcar, motorcycle or mining accident (Table I).

Fig. 2

Scatter diagram showing angles of femoral anteversion of both hips of normal volunteers and of patients who had simple (Grade I) dislocation of either left or right hip. The symbol for each subject gives the anteversion of the left hip on the horizontal axis, and of the right hip on the vertical axis. Minus figures represent retroversion. Best-fit straight lines are drawn for each group. Most subjects with dislocated left hips (circles) have angles of anteversion of both dislocated and uninjured hips which are lower than those for normal volunteers. Similarly most subjects with dislocated right hips have angles of anteversion which are lower than those of normal volunteers.

DISCUSSION

The angle of anteversion has been measured on dried femora by many workers. Parsons (1914) reported a mean angle of anteversion for both sides of 15.5° ; Pearson and Bell (1917) reported a figure of 15.3° . These findings are very similar to ours for normal volunteers, with a mean of 15.4° for the right hip and 16.3° for the left hip. The larger figure for the left compared with the right hip is not statistically significant; but it does confirm an observation made by de Jong (1968).

In the patients with previous traumatic dislocations or fracture-dislocations we found reduced anteversion, or even retroversion, compared with the angle found in normal volunteers. This raises three questions. Is this finding coincidental? Could it be in some way secondary to the injury? Does diminished anteversion make a person more susceptible to traumatic posterior dislocation of the hip?

The finding that anteversion of the contralateral *uninjured* femora of the patients was significantly less than in normal volunteers helps to answer these questions. This reduced anteversion cannot be due to a previous injury, nor can it be coincidental. It is a feature of the group of patients who have been selected out of

Fig. 3

Fig. 4

Figure 3—Diagram to show angles of femoral anteversion of both hips in subjects with simple (Grade I) dislocation of the *right* hip compared with those of normal volunteers. Comparisons were made between arrowed hips using Student's *t*-test. Statistical significance is shown by stars: *** very highly significant; ** highly significant; * significant $P<0.05$; NS, not significant. The hips of patients who have had simple dislocation have significantly less anteversion than (a) either hip of normal volunteers, and (b) the uninjured contralateral hip—which itself is less anteverted than either hip of normal volunteers, but at a lower level of significance. Figure 4—A similar diagram, showing comparison of angles of femoral anteversion in patients who have had a simple (Grade I) dislocation of the *left* hip. Angles of anteversion of both dislocated and uninjured hips are lower than in normal volunteers.

Fig. 5

Angles of femoral anteversion expressed as the mean ± 2 standard errors for the right and left hip plotted separately for normal volunteers, simple (Grade I) dislocation of the right hip, and of the left hip; and fracture-dislocation (Grades II and III) of the right hip, and of the left hip. Normal volunteers have similar angles for right and left hips; the scatter of observations is much less than for any of the groups of dislocated and uninjured hips. In patients who had simple dislocation femoral anteversion is significantly less in the dislocated than in the uninjured hip; both are lower than in normal volunteers. In patients who had fracture-dislocation, anteversion is significantly less in both hips than in normal volunteers.

the general population solely because they have sustained a certain type of injury. This finding supports the hypothesis that patients who have previously had traumatic posterior dislocation of the hip represent one extreme of the normal population in having diminished femoral anteversion or even retroversion. This was particularly so in those who had had a simple (Grade I) dislocation.

How can diminished anteversion make a person susceptible to a dislocated hip in an accident? Moreover, why do some suffer simple dislocation and others fracture-dislocation of the hip?

Fig. 6

Scatter diagram on the same plan as Figure 2 showing angles of femoral anteversion for both hips of normal volunteers and for patients who have had a fracture-dislocation (Grades II and III) of either left or right hip. The plotted point for each subject records the angles of anteversion of left and right hip on horizontal and vertical scales. Most subjects who have had Grade II or III dislocations have angles of anteversion which are lower or are retroverted compared with those of normal volunteers.

Our hypothesis provides another interpretation for the view expressed by Bigelow in 1900. Experimental and clinical experience led him to conclude that, in all dislocations, the head of the femur first left the acetabulum at its inferior part and then dislocated backwards or forwards—depending on whether the femur was rotated medially or laterally. Testing this theory, Pringle and Edwards (1943) produced posterior hip dislocations in over 50 cadavers by flexing the hip to 90° and then medially rotating the femur forcibly using a knee-clamp and a long lever on the flexed knee. They also produced dislocation with the hip extended. Like Bigelow they concluded that extreme rotation of the femur medially or laterally produced respectively posterior or anterior dislocation. Experimental work by Brookes and Wardle (1962) on decalcified bones showed that an unbalanced pull in the direction of the iliopsoas tendon produced not only valgus deformity of the femoral neck but also femoral retroversion which tended to sublunate the head of the femur posteriorly into the gluteal fossa. We conclude from these results that rotation or torsion within the femur in the direction of retroversion acts like medial rotation in making a hip more susceptible to posterior dislocation. This has some medico-legal implications. We cannot comment on acetabular position (valgus or anteverted) in the subjects we examined.

Fig. 7

Fig. 8

Figure 7—Diagram as in Figure 3 to show comparison of angles of anteversion in both hips of patients who have had a fracture-dislocation (Grade II and III) of the right hip, with those of normal volunteers. Diminished femoral anteversion is shown in both dislocated and uninjured hips compared with normal volunteers. Figure 8—Similar diagram to show anteversion angles in both hips of patients after fracture-dislocation of the left hip compared statistically with those of normal volunteers. Again, diminished anteversion is shown in both dislocated and uninjured hips compared with normal volunteers.

Discussing the relative incidence of dislocation as against fracture-dislocation, Watson-Jones suggested that the more the hip is adducted the greater is the probability of simple dislocation without fracture of the posterior acetabulum (Wilson 1982). Grattan and Hobbs (1967) were unable to demonstrate such a relationship, but pointed out that greater hip flexion could be associated with simple dislocation rather than fracture-dislocation, because knee contact with the fascia in car accidents appeared to have been higher when the lesser injury had been produced. Stewart and Milford (1954) have similar views, stating that a front-seat passenger is more likely to sustain the less severe simple dislocation than the driver because of greater hip flexion at the time of impact. In our view, diminished torsion within the femur is an important factor predisposing to simple dislocation rather than fracture-dislocation.

Posterior dislocation of the hip in children has been reported to occur after relatively trivial accidents, such as slipping, doing the splits, tripping or falling (Glass and Powell 1961; Ferguson *et al.* 1960; Schlonsky and Miller 1973). These reports offer no explanation for the ease of dislocation though it applied in over two-thirds of the children reported. In such children, flexion and adduc-

tion at the hip may not be necessary or even common prerequisites for traumatic dislocation of the hip and it would seem that the direction and magnitude of forces causing dislocation in children are not constant features. We suggest that biological factors, as yet undetermined, are involved.

In conclusion, our findings are consistent with the view that patients who have had traumatic posterior dislocation of the hip represent an extreme of the normal population with regard to diminished femoral torsion. The actual injury at the time of an accident must result from the interaction of the direction and magnitude of mechanical forces with the position of the femur in relation to the acetabulum. The most important aspect of this position is the amount of torsion within the shaft of the femur. This concept may indicate a principle of accidental injury, namely that local anatomical features can determine the type of injury produced when excessive mechanical forces are applied to certain parts of the body.

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REFERENCES

- Bigelow HJ. *The mechanism of dislocations and fracture of the hip*. Boston: Little, Brown & Co, 1900.
- Brookes M, Wardle EN. Muscle action and the shape of the femur. *J Bone Joint Surg [Br]* 1962;**44-B**:398-411.
- de Jong JCD. *De torsio femoris in relatie tot andere kenmerken van het femur*. Academic Thesis. Amsterdam: Rototype, 1968.
- Epstein HC. Posterior fracture-dislocations of the hip: long-term follow up. *J Bone Joint Surg [Am]* 1974;**56-A**:1103-27.
- Ferguson AB, Donaldson WF, Goodman MC, Rodriguez EE, Skovron M, Gartland JJ. Traumatic dislocation of the hip in children: a report by the Scientific Research Committee of the Pennsylvania Orthopedic Society. *J Bone Joint Surg [Am]* 1960;**42-A**:705-10.
- Funsten RV, Kinser P, Frankel CJ. Dashboard dislocation of the hip: a report of twenty cases of traumatic dislocation. *J Bone Joint Surg* 1938;**20**:124-32.
- Glass A, Powell HDW. Traumatic dislocation of the hip in children: an analysis of forty-seven patients. *J Bone Joint Surg [Br]* 1961;**43-B**:29-37.
- Grattan E, Hobbs JA. *Injuries to the hip joint in vehicle occupants*. RRL report LR 126. Road Research Laboratory, Ministry of Transport, 1967.
- Letournel EL, Judet R. In: Elson RA, ed. *Fractures of the acetabulum*. Berlin, Heidelberg, New York: Springer-Verlag, 1981:7-12.
- Moulton A, Upadhyay SS. A direct method of measuring femoral anteversion using ultrasound. *J Bone Joint Surg [Br]* 1982;**64-B**:469-72.
- Parsons FG. The characters of the English thigh bone. *J Anat* 1914;**48**:238-67.
- Pearson K, Bell J. *A study of the long bones of the English skeleton*. part I. The femur. Cambridge University Press, 1917.
- Pringle JH, Edwards AH. Traumatic dislocation at the hip joint: an experimental study on the cadaver. *Glasgow Med J* 1943;**139**:25-40.
- Upadhyay SS, Moulton A. The long-term results of traumatic posterior dislocation of the hip. *J Bone Joint Surg [Br]* 1981;**63-B**:548-51.
- Upadhyay SS, Moulton A, Srikrishnamurthy K. An analysis of the late effects of traumatic posterior dislocation of the hip without fractures. *J Bone Joint Surg [Br]* 1983;**65-B**:150-2.
- Schlonsky J, Miller PR. Traumatic hip dislocations in children. *J Bone Joint Surg [Am]* 1973;**55-A**:1057-63.
- Stewart MJ, Milford LW. Fracture-dislocation of the hip: an end result study. *J Bone Joint Surg [Am]* 1954;**36-A**:315-42.
- Wilson JN, ed. *Watson-Jones Fractures and joint injuries*. 6th ed. Edinburgh, London and New York: Churchill Livingstone, 1982.
- Weiner DS, Cook AJ, Hoyt WA Jr, Oravec CE. Computed tomography in the measurement of femoral anteversion. *Orthopaedics* 1978;**1**(4):299-306.