# THE CHIARI PELVIC OSTEOTOMY

## A LONG-TERM REVIEW OF CLINICAL AND RADIOGRAPHIC RESULTS

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**We have reviewed a series of 94 Chiari pelvic osteotomies carried out from 1966 to 1982. In 83 hips the indication for surgery had been pain, and of these patients 73 (88%) had appreciable relief within one year of operation. The other 11 hips were all in children and were painless; in them the osteotomy had successfully stabilised progressive subluxation of the hip.**

**At review after a mean follow-up of 10 years (range, 2 to 18 years) 68 previously painful hips were reassessed. Although function of the hips had deteriorated slowly with time, four of the seven cases with 18 years' follow-up had good function and only minor symptoms.**

**A detailed analysis of the radiographic changes produced by the Chiari osteotomy was made, using computerised analysis of variance. The beneficial effects of the osteotomy resulted from complex changes, among which the provision of a stable fulcrum for the hip seemed to be the most important.**

We have reviewed retrospectively the long-term results of the medial displacement pelvic osteotomy of Chiari (1955) in order to give a more detailed assessment than is available in other larger series (Schulze and Krämer 1975; Winkler and Weber 1977; Chiari, Endler and Hackel 1978; Kerschbaumer and Bauer 1979). The operation provides a means of salvaging a subluxated hip in a young adult when pain is becoming worse in spite of conservative treatment. In this type of patient acetabular dysplasia and the associated deformation of the femoral head usually preclude a redirectional osteotomy of the acetabulum, and a proximal femoral osteotomy rarely proves to be sufficient. Although the Chiari osteotomy does not increase the existing area of contact between the femoral head and the acetabulum, it does reduce the load upon the hip by moving the joint medially. In addition, upward migration of the femoral head is halted; this may be an important factor in relieving pain.

We present a clinical, functional and radiographic assessment of the Chiari pelvic osteotomy, and investigate the relationship between pain relief and walking ability several years after the operation.

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0301-620X/87/3089 $2.00

## PATIENTS AND METHODS

From 1966 to 1982, 81 patients were treated by the Chiari pelvic osteotomy. There were 72 females (age range, 3 to 41 years) and 9 males (age range, 4 to 32 years); 13 had bilateral operations. The indications were pain in 70 patients (83 hips), and instability in 11 of the younger patients. Of these children, six had congenital dislocation of the hip, three had spina bifida and there was one case each of poliomyelitis and Hurler's syndrome. The mean age at operation for the whole group was 19 years and 49 of the 94 osteotomies were on the right side.

When pain was the presenting complaint, it had been present for an average of five years (range, 1 to 12 years). Osteoarthritic changes were not invariably present, but when they were it was considered to be important that a good range of hip movement had been preserved, with at least 90° of flexion, 15° of abduction and 20° of rotation.

A number of operations had been performed before the Chiari osteotomy. Some were preliminary procedures on patients presenting for the first time and some represent previous unsuccessful attempts to salvage the hip (Table I). Femoral osteotomy was usually carried out before the Chiari osteotomy if congruency of the hip could thereby be improved.

**Technique of operation.** Details of the standard method of osteotomy have been published elsewhere (Chiari 1955; Colton 1972; Mitchell 1974). We have made some modifications:

1. A transverse skin incision within the "bikini zone" is preferred to the iliofemoral incision for the slim patient

**Table I.** Operations performed on 43 of the 81 patients before their pelvic osteotomy

| | Number of operations |
|---|---|
| Femoral osteotomy (rotation/varus) | 42 |
| Open reduction of hip | 20 |
| Excision of limbus | 16 |
| Innominate osteotomy | 7 |
| Adductor tenotomy | 4 |
| Psoas release | 3 |
| Distal transfer of the greater trochanter | 3 |
| Shelf procedure | 2 |
| Femoral shortening | 1 |
| Psoas transfer | 1 |

(Fig. 1); this allows good exposure posteriorly and facilitates wound healing over the anterior superior iliac spine.

2. The anterior third of the iliac wing is routinely trimmed to reduce its postoperative prominence; a 2 cm strip of corticocancellous bone from the wing is used to augment anterolateral cover for the femoral head.

3. Compression screw fixation of the pelvic fragments is used to obviate the need for a plaster spica; the leg can then be rested in Hamilton Russell traction for a few days before starting physiotherapy. Partial weight-bearing with elbow crutches is possible in the first week after operation.

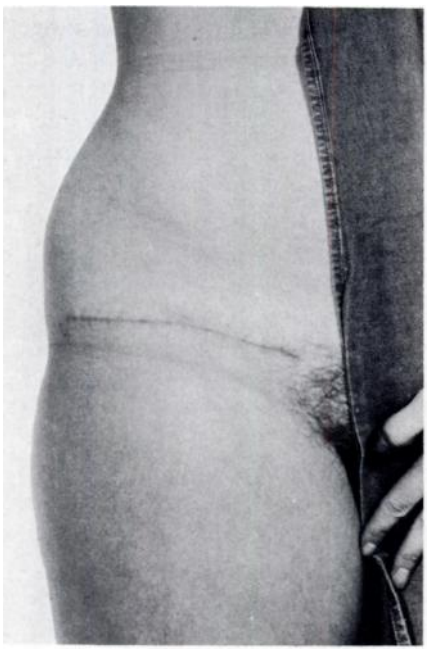

Fig. 1

The scar of a skin crease incision two weeks after the osteotomy.

**Anatomical study.** Chiari osteotomies were performed on two adult cadaveric hips, inclining the cut 10° upwards and medially. The whole pelvis was studied to assess the relationship between different degrees of medial displacement and the distance between the centre of the femoral head and the midline of the body. The effect of the osteotomy upon the pelvic outlet and its proximity to the sciatic nerve were assessed, as was the tendency for one pelvic fragment to rotate upon the other.

**Clinical review.** The patients had a detailed assessment at an average of 10 years after the Chiari procedure (range, 2 to 18 years). This review was by an independent observer who had not been involved in the clinical care of the patients and the following information was collected:

1. Symptoms and activity of the patients, using a pro forma based upon the Iowa hip rating for pain (Larson 1963).
2. Clinical examination, including the range of hip movement scored according to the Harris grading (Harris 1969), and the Trendelenburg test.
3. A 12-minute maximum walking speed test (Macnicol et al. 1980, 1981).
4. A standard anteroposterior radiograph of the pelvis taken with the patient standing with feet parallel. A number of radiographic indices were used to assess the pre-operative films, the immediate postoperative film and that taken at late review.

Of the original 81 patients, 69 attended for review (85%). Pain had been the main complaint in 58 patients, and the outcome of the 68 Chiari osteotomies carried out in this group forms the basis of this paper. The other 11 patients had been treated for painless instability of the hip; their results were not included in this analysis, which concentrates on pain relief. However, it is

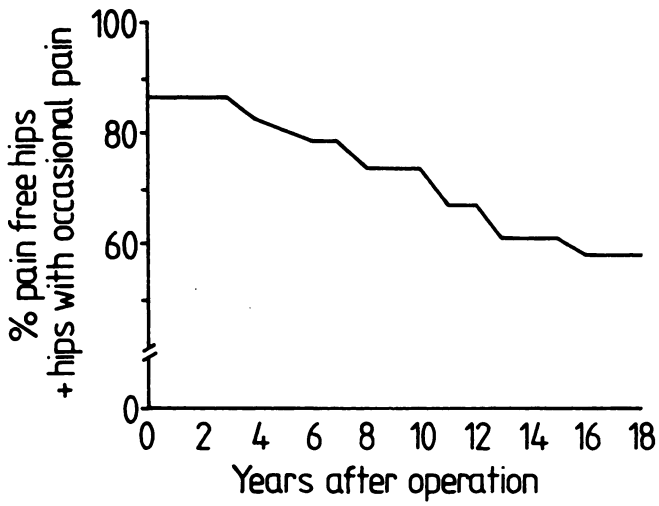


Fig. 2

Graph to show the percentage of patients who were pain-free or had only occasional pain after the Chiari operation. There was slow deterioration with time, but at 18 years four of seven patients were still without major problems.

noteworthy that stability of the hip had been achieved in every case.

Of the group treated for pain 48 patients had a unilateral operation, and 10 required bilateral procedures. Osteoarthritis of the hip was defined in terms of joint space narrowing, subchondral sclerosis, peripheral osteophytes and cyst formation, and the severity of these changes was graded on a scale from 0 to 4 where zero represents no arthritic change and four indicates gross changes. The average score for each hip was recorded at five-yearly intervals after the osteotomy. Each radiographic index was tested for significance against pain relief and against a modified Severin (1941) grading using computer analysis of variance.

## RESULTS

The relief of pain is classified and recorded in Table II for the 68 Chiari osteotomies, and is also related to the average age at operation. Pain relief was better in those patients who presented de novo, without earlier operations for congenital dislocation of the hip, and 95% of this group were largely relieved of symptoms. Of those patients in whom the diagnosis of congenital dislocation of the hip had been made before the age of three years 84% were improved to a similar degree.

With the passage of time, the percentage with pain relief fell progressively (Fig. 2), although cases showing significant re-modelling of the acetabulum and preservation of a good joint space invariably had a good prognosis (Figs 3 and 4). Of the hips with an 18-year follow-up 57% (4 of 7) had significant pain relief. On the Iowa rating scale for pain (Larson 1963), in which a maximum of 35 points represents complete relief, the average result was 30 points (range, 12 to 35 points). Table III compares the pain rating with the maximum walking speed over 12 minutes, the presence of a significant limp, and the Trendelenburg test. There is good correlation between pain relief and function.

**Table II.** Changes in level of pain 2 to 18 years after Chiari osteotomy in 68 patients

| Pain | Number of patients | Mean age (*years*) |
|---|---|---|
| Major relief | 26 | 19 |
| Moderate relief | 33 | 20 |
| No change | 7 | 22 |
| Made worse | 2 | (22,41) |

**Table III.** Relation between pain and function in 66 patients from 2 to 18 years after Chiari osteotomy (two of the 68 patients required hip arthroplasty and are excluded)

| | Iowa hip rating score for pain | | | | | |
|---|---|---|---|---|---|---|
| | **35** | **30** | **20** | **15** | **10** | **0** |
| Number of patients | 13 | 36 | 7 | 5 | 3 | 2 |
| Mean maximum walking speed (km/h) | 6.5 | 5.8 | 5.4 | * | † | ‡ |
| Number with a marked limp | 2 | 12 | 3 | 5 | 3 | 2 |
| Number with a positive Trendelenburg test | 4 | 9 | 3 | 4 | 3 | 2 |

* None of the five patients completed the walking test
† Only two of the three patients completed the walking test (4.7 and 2.3 km/h)
‡ Only one of the two patients completed the walking test (4.3 km/h)

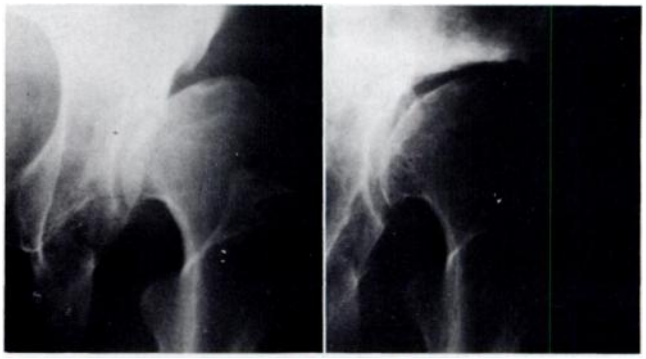

Fig. 3 Fig. 4

Radiographs of a woman with left CDH diagnosed at 18 months. At 15 years of age, after a varus-derotation osteotomy, the hip was painful. At 25 years of age, 10 years after a Chiari osteotomy, she has occasional pain during activity, a slight limp and an almost normal range of hip movement.

The range of movement at the hip had not been impaired by the Chiari procedure, although progressive osteoarthritis did eventually reduce this range. The mean Harris score for movement (Harris 1969) was 4.3 with a range of 0 to 5, the zero representing a joint that fused after excessive displacement of the osteotomy.

Of the 58 patients, 29 (50%) professed to be "very satisfied" with the results of the operation, and a further 24 patients were "satisfied". Three patients did not feel that the procedure had improved function, or relieved symptoms. All the patients were still active, with 41 in employment and the other 17 coping well with housework. Over the years, 37 of the women had married, and 30 had become pregnant. A caesarean section was advised for one quarter of those with a unilateral Chiari osteotomy, and all those who had had bilateral operations.

Using the radiographic indices shown in Figures 5 to 16, the changes produced by the osteotomy were recorded (Table IV). Although considerable remodelling had occurred in the first few years after the operation, the alterations in anatomy produced by the osteotomy had remained relatively unchanged.

The average height of the osteotomy above the acetabulum margin (Fig. 5) was 4 mm. This ranged from

0 to 18 mm, but in most cases the cut was less than one centimetre above the femoral head, being dictated in part by the thickness of the hip joint capsule. Even in the more superiorly placed osteotomies the ilium forming the new roof had become sclerosed. Statistical analysis revealed that pain relief was not related to the position of the osteotomy, presumably because capsular contact was always ensured.

There was also considerable variation in the angle of osteotomy (from −19° to 15°, a negative sign implying a downward slope) although the mean angle of inclination was 1.7° (Fig. 6). There was no correlation between this angle and medial displacement, the slope of the osteotomy being dictated in the more severely subluxated hip by the proximity of the hip joint to the sacro-iliac joint. Medial displacement (Fig. 7) averaged 60% (range 36% to 118%) of the available width of the ilium at the level of the osteotomy. Displacement of over 100% is possible because of associated outward rotation of the iliac wing (Benson and Evans 1976). This resulted in an increase in cover of the femoral head (Fig. 8) from a mean of 50% (range, 18% to 73%) to a mean of 95% (range, 63% to 134%). This substantial increase in femoral head buttressing was related linearly to an increase in the centre–edge (CE) angle (Wiberg 1939; Fig. 9), the acetabular angle (Sharp 1961) (Fig. 10) and the depth of the acetabulum (Fig. 11; Table IV). However, the postoperative CE angle varied greatly (7° to 77°) and all these estimates of the depth of the acetabulum are imprecise when there is marked deformity.

There had been excellent or good relief of pain in 59 of the 68 hips (87%). In the seven hips with no relief and the two hips with worse symptoms there was no obvious radiographic reason for the lack of success. The poor results did not relate to inadequate medial displacement, lack of postoperative cover for the femoral head, or to the height of the osteotomy above the acetabular rim.

Similarly, there was no statistical correlation between any of the various radiographic parameters of the osteotomy and the Severin (1941) grading based upon pain, limp and endurance. Using the modification proposed by Gibson and Benson (1982), 8 hips (12%) were in Group 1, 2 hips (3%) in Group 2, 29 hips (44%) in Group 3, and 27 hips (41%) in Group 4.

Although the osteotomy did not alter the incongruity (Fig. 12) or the lateral subluxation (Fig. 13) of the hip, further upward displacement of the femoral head was prevented, there being a negligible increase in the break in Shenton's line, from a mean of 16 mm pre-operatively to 18 mm (Fig. 14). Femoral head asphericity (Fig. 15) and size difference (Fig. 16) were also unchanged, while damage to the acetabular growth centre in younger patients, the so-called "anti-Chiari effect" (Purath 1979), was not seen.

Arthritic changes increased progressively with time (Fig. 17) and appeared to advance more rapidly when postoperative cover for the femoral head was less complete (Fig. 18). However, inadequate buttressing of the acetabulum characterised the more severely subluxated hips both before and after the osteotomy; these joints were therefore predisposed to arthritic change as

**Table IV.** Results of the measurement of radiographs before and after Chiari osteotomy in 68 hips (see captions to Figs 5 to 16 for details)

| Figure number | Measurement | | Before operation | | At long-term review | |
|---|---|---|---|---|---|---|
| | | | Mean | Range | Mean | Range |
| 5 | Height of osteotomy above acetabulum | (*mm*) | – | – | 4 | 0 to 18 |
| 6 | Angle of osteotomy | (*degrees*) | – | – | 1·7 | −19 to 15 |
| 7 | Medial displacement | (*per cent*) | – | – | *68* | *36* to *118* |
| 8 | Acetabular cover | (*per cent*) | *50* | *18* to *73* | *95* | *63* to *134* |
| 9 | CE angle | (*degrees*) | 5 | −37 to 28 | 38 | 7 to 77 |
| 10 | Acetabular angle | (*degrees*) | 53 | 41 to 67 | 43 | 21 to 61 |
| 11 | Acetabular depth | (*per cent*) | *145* | *73* to *225* | *240* | *91* to *374* |
| 12 | Incongruity | (*mm*) | 2 | 0 to 11 | 2 | 0 to 10 |
| 13 | *Lateral subluxation | (*mm*) | 23 | 0 to 48 | 23 | 0 to 62 |
| 14 | Break in Shenton's line | (*mm*) | 16 | 0 to 45 | 18 | 0 to 65 |
| 15 | Asphericity | (*mm*) | 4 | 0 to 13 | 6 | 0 to 13 |
| 16 | *Over-sized femoral head | (*per cent*) | *6* | *0* to *43* | *10* | *0* to *58* |

* Measured only in 48 unilateral operations

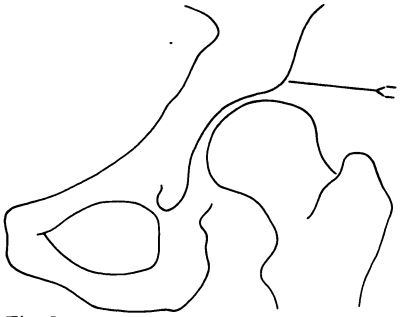

Fig. 5
The level at which the osteotomy is made is critical. Precision can only be ensured by the use of an image intensifier and a Steinmann pin during the operation.

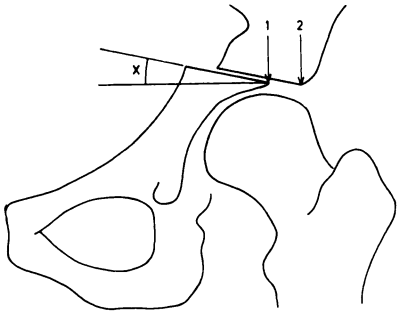


Fig. 6
The angle of osteotomy (X) can be measured from the postoperative radiograph, although lordosis may introduce an artefact. The "roof angle" of Colton (1972), measured at points 1 and 2, is difficult to define and was not used.

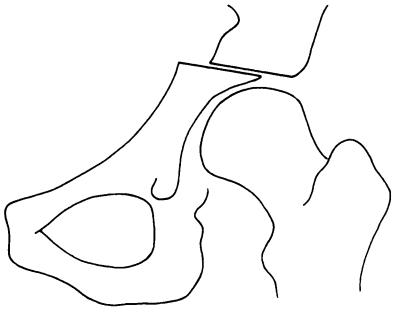

Fig. 7
The displacement of the osteotomy was defined as the medial shift of the lower fragment as a percentage of the width of the innominate bone at that level. Displacement of over 100% is possible (see text).

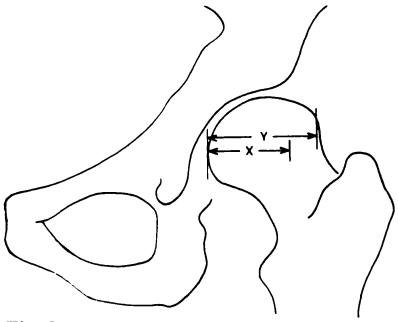


Fig. 8
Acetabular cover can be expressed as a percentage of the width of the femoral head (X/Y × 100), but this gives no indication of anterior cover and is not directly related to the true area of support.

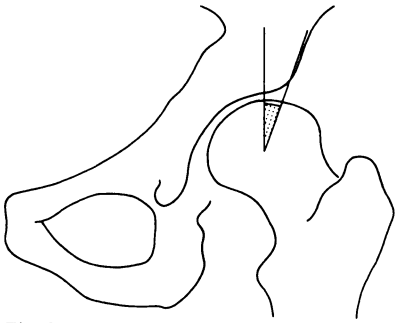

Fig. 9
The centre–edge (CE) angle of Wiberg (1939) may be uncertain because of deformity of the femoral head and the slope of the acetabular margin in the dysplastic hip. The angle and height of the osteotomy may also introduce errors.

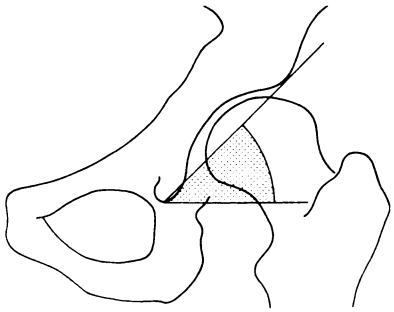

Fig. 10
The acetabular angle of Sharp (1961) is readily measured, but cannot be used in long-term comparison since many patients develop a new acetabular floor. The teardrop and the new acetabular edge are often difficult to define.

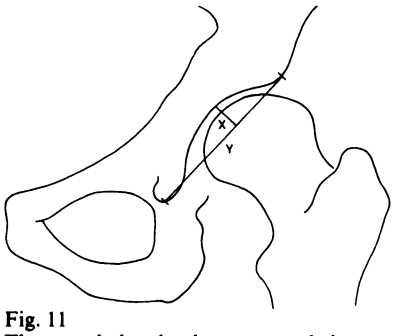


Fig. 11
The acetabular depth was recorded as a percentage of the width (X/Y × 100) (Cooperman, Wallensten and Stulberg 1983), but suffers from the same inaccuracies as Sharp's angle.

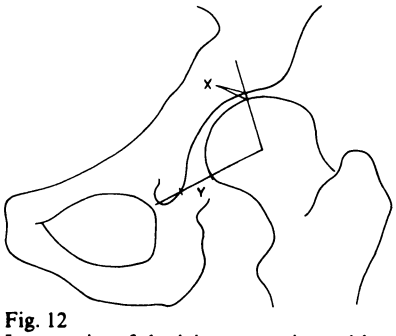


Fig. 12
Incongruity of the joint was estimated by subtracting the narrowest measurement of the joint space from the widest (Y − X). This gives an impression of the degree of congruence, but in only two dimensions.

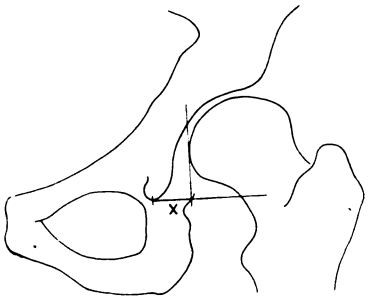


Fig. 13
Lateral subluxation of the femoral head was measured in comparison with the normal hip, as the distance (X) between a line dropped from the margin of the head and the lowest point of the tear drop.

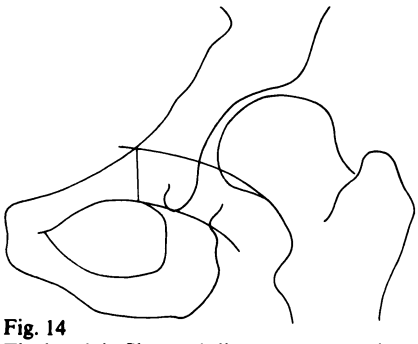

Fig. 14
The break in Shenton's line was measured by projecting the inferior surface of the femoral neck, and relating this to the obturator foramen. Femoral rotation greatly alters this measurement.

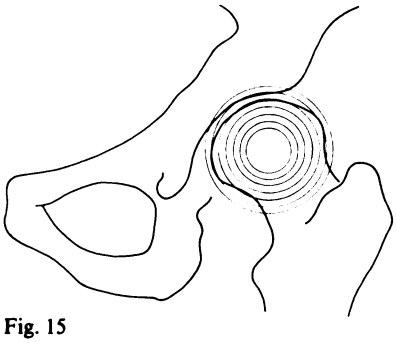

Fig. 15
The sphericity of the femoral head was gauged with Mose's rings. Loss of sphericity was recorded as the maximum difference between any two radii.

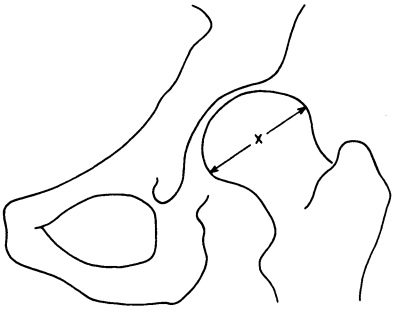


Fig. 16
The size of the femoral head was expressed as the percentage increase of the largest diameter (X) over the diameter of the femoral head on the normal side. This was not estimated in bilateral cases.

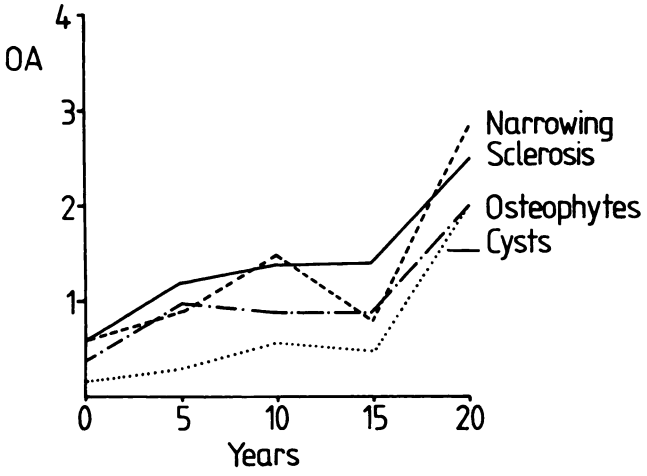


Fig. 17

The development of osteoarthritis (OA) with the passage of time after a Chiari osteotomy is shown in terms of joint space narrowing, subchondral sclerosis, osteophyte formation and the appearance of bone cysts. The mean score is recorded at five-year intervals using a 0–4 scale of radiographic severity.

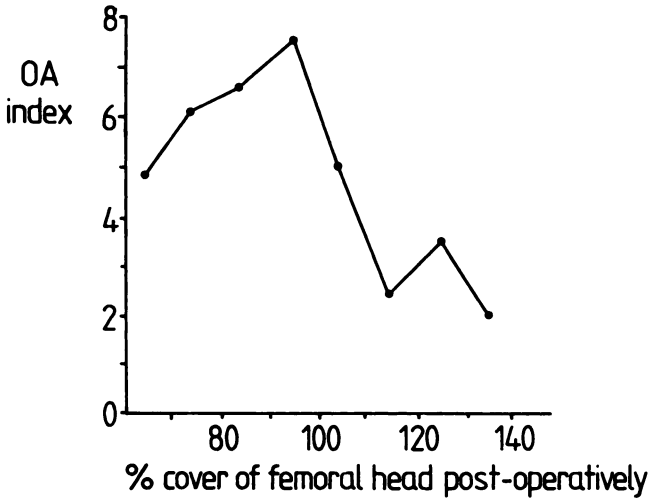


Fig. 18

An osteoarthritis (OA) index, the combined mean scores for radiographic severity as in Figure 17, is related to the percentage cover provided for the femoral head postoperatively. The trend is for less degeneration with better cover (or better medial shift).

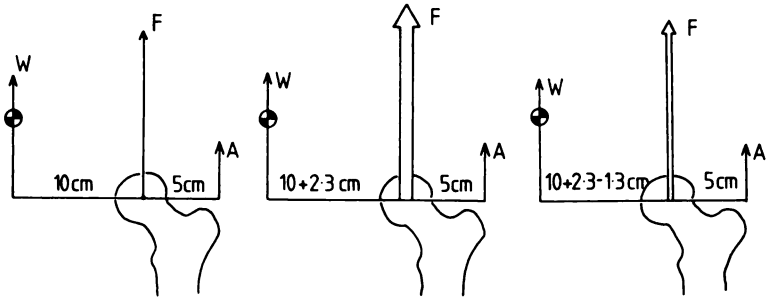


Fig. 19

Diagrams to depict the force (F) upon the femoral head. This includes the component (W) resisting the weight of the body, and component (A) resisting the balancing tension in the abductor muscles. On the left are the normal relationships, the central diagram shows the effect of 2.3 cm of lateral subluxation of the hip and on the right is shown the partial correction of 1.3 cm achieved by Chiari osteotomy.

much by the nature of the original abnormality as by features of the postoperative radiographic appearance. Femoral head cover in excess of 100% did not confer any particular advantages in respect of subsequent function or the progress of osteoarthritis. Equally there was no indication that outward movement of the anterior iliac wing had weakened the abductor muscles.

The average displacement of the osteotomy in the clinical series was 68%; this represents approximately 1.3 cm of medial shift of the femoral head. Since, in the unilateral cases, there was an average of 2.3 cm of lateral subluxation of the femoral head on the dysplastic as compared with the normal side, there was an average of one centimetre of uncorrected lateral displacement after osteotomy.

To give an example of the results of this displacement on the loading in a dysplastic hip, consider a patient weighing 60 kg (Fig. 19). During single-leg stance, the weight (W) to be supported will be 51 kg (60 kg less 15% for the weight of the leg). The total force (F) on the femoral head when the pelvis is balanced will normally be about 153 kg (the balancing abductor force being about twice the supported weight). This is shown in the left hand diagram of Figure 19. In a subluxated hip, where the femoral head has moved 2.3 cm away from the midline, the force to be resisted by the femoral head is increased to approximately 171 kg (central diagram). After a Chiari osteotomy the femoral head is medialised on average by 1.3 cm, but the joint is still one centimetre more lateral than normal. Hence the force on

the head will still be abnormally increased (163 kg) but the osteotomy has reduced the load by 8 kg (approximately 5%). There is probably a minor increase in abductor power after medialisation (Chiari 1955, 1979) but this has not been taken into consideration for these calculations.

The effect of the osteotomy upon the pelvic brim in the cadaver was that its transverse diameter was narrowed by 9% for every 25% of medial displacement. The average displacement in our series was 68%; this is equivalent to a 24% decrease in the transverse diameter of the pelvic brim in unilateral cases and up to 50% reduction after bilateral operations.

**Complications.** Table V lists the complications reported in the case notes of all 81 patients, and therefore refers to the complete series of 94 Chiari osteotomies. In six cases the initial displacement was excessive, with inward prolapse of the lower pelvic segment, but this technical error was corrected in all six and five of them have good function. Fixation with a Steinmann pin or a compression screw now prevents this problem.

The sciatic nerve was injured in one patient, producing a minor foot-drop. Permanent impairment of sensation in the distribution of the lateral femoral cutaneous nerve was noted in 36 cases. The prominence of the anterior iliac crest is inevitably increased after displacement osteotomy, and wound healing is not infrequently affected. A transverse skin crease incision (see Fig. 1) is preferred to the Smith-Petersen approach if there is no previous scarring.

**Table V.** Complications after 94 Chiari osteotomies

| | Number |
|---|---|
| *Early* | |
| Total displacement of the fragments (later corrected) | 6 |
| Superficial wound infection | 6 |
| Deep venous thrombosis | 3 |
| Pulmonary embolism | 1 |
| Sciatic nerve injury | 1 |
| Deep infection | 1 |
| *Late* | |
| Numbness in the distribution of the lateral femoral cutaneous nerve | 36 |
| Tenderness over the anterior iliac crest | 18 |
| Ankylosis of the hip | 1 |
| Delayed union of the osteotomy | 1 |

## DISCUSSION

This retrospective review of the results of the medial displacement osteotomy of Chiari confirms that substantial pain relief is afforded to over 80% of patients in the short term. The therapeutic effect of the osteotomy is still evident in over half of the patients examined 18 years after the operation. The variation in pain relief reported in the literature, ranging from 52% to 95%, may reflect differences in the length of follow-up as much as differences in the selection of patients and the criteria used to assess the results (Colton 1972; Mitchell 1974; Hoffman, Simmons and Barrington 1974; Schulze and Krämer 1975; Chiari and Schwagerl 1976; Lord and Samuel 1977).

Before osteotomy is considered, symptoms from the hip should be both progressive and resistant to conservative methods such as weight loss and physiotherapy. The onset of pain in late adolescence or early adult life indicates that symptoms will worsen with time unless the hip is stabilised. Operations on the proximal femur to correct persistent anteversion, excessive valgus or varus of the femoral neck and long-leg dysplasia should be used initially as they are technically easier and may prove sufficient to relieve symptoms.

The acetabulum may be so meagre in depth that effective buttressing for the femoral head can only be provided by the Chiari osteotomy, either as a primary operation or after a femoral osteotomy. When the hip has become incongruous, thus ruling out a redirectional pelvic osteotomy, the indications for the Chiari medial displacement osteotomy become even stronger.

A more limited application for the operation relates to its use in the child with a painless but unstable hip joint, usually where previous femoral and pelvic procedures have failed for reasons of neuromuscular imbalance. In these cases the Chiari osteotomy regularly produces a congruous articulation because of the remodelling of the soft tissues (Moll 1982) and the bone that characterises these younger patients. Even in the adult these adaptive changes may follow a correctly placed osteotomy.

In the middle-aged patient the Chiari osteotomy will produce a satisfactory result if a reasonable range of hip movement is present before surgery. We have defined this arbitrarily as a flexion arc of 90°, abduction of at least 15°, and a rotation arc of 20°. Painful impingement or advanced radiographic osteoarthritis will affect the outcome adversely, but are not absolute contra-indications, since the osteotomy effect alone may relieve symptoms for some years. Additionally, the improvement in acetabular bone stock makes total hip replacement technically easier at a later date.

Gait is frequently improved after a Chiari osteotomy, and the risk that limp may be made worse seems to have been exaggerated. The Trendelenburg test indicates that abductor power has improved (Chiari and Schwagerl 1976; Macnicol et al. 1981; Reynolds 1986), although this is not a universal finding (de Waal Malefijt, Hoogland and Nielsen 1982).

Our review of the radiographic changes after Chiari osteotomy failed to identify specific parameters that correlated with the success or failure of the operation. Certain technical aspects of the operation may therefore be less critical than has been suggested (Colton 1972) and pain relief, in particular, was not unequivocally dependent upon any recognisable pattern of radiographic change.

Secondary features such as a valgus femoral neck, deformity of the femoral head and increasing subluxation are characteristic changes of hip dysplasia. Since some patients with high dislocation of the hip have no pain, and osteoarthritis is not always present to account for symptoms, it seems likely that pain is produced, at least in the early stages, by increasing capsular tension. Shearing forces at the site of contact of the femoral head may also cause symptoms.

The Chiari pelvic osteotomy effectively stabilises the fulcrum of the hip joint, and when pain is significantly relieved there is a concurrent halt in any increase of lateral subluxation or of the break in Shenton's line. The medialisation of the hip produced by the osteotomy is unlikely to decrease femoral head loading by more than 5%, although Chiari (1979) found a somewhat bigger reduction; hence the relief of symptoms seems to be principally the result of the stabilisation of the joint.

Certain details of technique are worthy of note. The height of the osteotomy above the lateral lip of the acetabulum is dictated to a great extent by the thickness of the joint capsule after any adherent portions have been dissected from the lateral wall of the ilium. An indication of level can be gained from the position of the reflected tendon of rectus femoris, but the level of cut can be accurately assessed only if an image intensifier and a Steinmann pin are used during the operation; it can be recorded by radiography at this stage (Waigand 1965).

Although gentle traction upon the leg is of value during the operation, the use of an external traction device, as recommended by Fernandez, Isler and Müller (1984), may be hazardous since it could cause the osteotomy to be placed too low, thus breaching the joint, or causing undue pressure on the femoral head. It is also inadvisable to open the joint capsule as a means of establishing the level of the acetabular rim, since this will compromise the cushion of the superior capsule which is required to protect the articular cartilage of the femoral head from the raw cancellous bone placed above it by the displacement.

Outward rotation of the iliac wing upon the sacro-iliac joint increases the buttress over the anterior portion of the femoral head, and appears to be an important component of the operation. Improvement in anterolateral cover can also be produced by supplementing the new acetabular rim with bone grafts, conveniently removed from the anterior iliac crest. This is necessary when the principal deficiency is anterior rather than lateral since medial displacement cannot solve this problem.

The angle of the cut has been described as extremely important and Colton (1972) suggested that the upward inclination of the osteotomy determined to a large extent the degree of the medial displacement of the inferior fragment. The variation between dysplastic hips, some of which are characterised by a relatively large femoral head and others by an extremely dysplastic acetabulum, makes any regular prescription for the angle of cut impossible. For example, a high-riding greater trochanter will often prevent the cut being placed at the ideal angle, and where the femoral head has subluxated superiorly, it may be necessary to carry out the osteotomy horizontally or even in a distal direction in order to avoid the sacro-iliac joint. We found no clear relationship between the angle of the cut and the degree of medial displacement achieved, and therefore believe that the inclination of the osteotomy is not as critical as has been suggested.

Curvature of the upper face of the osteotomy improves the congruence of the new buttress; it should be contoured to the shape of the femoral head. This curvature should not be considered to be a means of preventing posterior displacement of the inferior pelvic segment, since this fragment is moored anteriorly at the pubic symphysis. As the hip is thrust medially after osteotomy, the inferior pelvic segment moves in an arc around the symphysis, but not posteriorly. It can not be displaced backwards, though excessive medial displacement may tilt the true acetabulum into a more vertical position, and there is also the very real hazard of prolapsing the hip into the pelvis.

The osteotomy remodels considerably, changing the shape of the pelvic brim, even after bilateral operations which have produced much distortion. Childbirth per vaginam is unlikely to be obstructed in most cases. Kotz and Wagnebichler (1973) found that the caesarean section rate was 18% after a unilateral Chiari osteotomy and 50% after bilateral operations. In our series the figures of 25% and 100% reflect a policy decision to advise caesarean section after bilateral osteotomies.

In conclusion, our review confirms that gratifying relief of pain can be expected in most patients after a properly executed Chiari osteotomy. Symptomatic improvement may take two years to become established but then lasts for many years; over half the patients we reviewed at 18 years after operation experienced little or no discomfort. There was a good correlation between the degree of pain relief and the function of the hip, assessed clinically and by a standardised 12-minute walking speed test. The range of the hip movement decreased slowly with age, but this seemed to be the result of gradually increasing osteoarthritis. Medial displacement had produced an improvement in abductor power and we found nothing to suggest that any limp had been made worse. The technique of operation is important if an adequate

degree of buttressing is to be achieved without undue risk to the patient, but the radiographic changes did not correlate closely with the clinical result.

The authors are indebted to Mr G. P. Mitchell who established the use of the Chiari pelvic osteotomy in Edinburgh, and warmly thank Michael Devlin for the photographs.

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