EXTRA-ARTICULAR AUGMENTATION FOR RESIDUAL HIP DYSPLASIA

RADIOLOGICAL ASSESSMENT AFTER CHIARI OSTEOTOMIES AND SHELF PROCEDURES

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The Chiari osteotomy and various shelf procedures are used to augment the weight-bearing area in dysplastic acetabula. The new articular surface derives by metaplasia from the acetabular rim and joint capsule, and is therefore of poorer quality than congruous hyaline cartilage.

We reviewed 32 patients after augmentation procedures, using conventional radiographs and three-dimensional reconstruction from CT scans. We showed that Chiari osteotomy and shelf procedures generally achieve less than complete cover, especially over the posterolateral quadrant of the femoral head.

Our results suggest that alternative methods which reorientate the whole of the acetabulum are the treatment of choice. Augmentation procedures remain as a salvage option when reorientation is inappropriate or the original hyaline cartilage surface is absent, as in subluxed joints with a secondary acetabulum. Computerised assessment is recommended before operation to assess existing cover and the possible extent of provision of new cover.

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In an adult with hip dysplasia, the extent of articular cover for the femoral head is the most critical factor for the prognosis of secondary degeneration (Pauwels 1976). This cover is usually evaluated on conventional plain radiographs. Many different angles and factors have been described and measured (Tönnis 1987), but there has been no assessment of the quantitative relationship between these and the potential risk of degeneration.

The operations used to improve a dysplastic acetabulum can be considered in two groups: those which reorientate the whole acetabulum in relation to the ilium (LeCoeur 1965; Hopf 1966; Salter, Hansson and Thompson 1984), and those which augment the acetabulum with an additional, extra-articular buttress (Lance 1925; Chiari 1953; Fig. 1).

The enlargement of the weight-bearing surface achieved by augmentation reduces the unit pressure on articular surfaces and the shear forces caused by instability. It is believed to prevent or delay degenerative arthritis (Pawlansky, Slavik and Kubat 1976), but such bony augmentation, with interposed capsule, cannot be fully congruent with the original joint surface. The capsule is attached to bone only at the rim of the old acetabulum and is not in continuity with the original

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hylaine cartilage. The limbus is also attached to bone, deep to the capsule. This attachment is vulnerable, and prone to the development of intraosseous ganglia (Itoigawa, Azuma and Kako 1980; Klaue, Durnin and Ganz 1991). Detachment of the limbus is probably the first step towards degeneration in the untreated dysplastic acetabulum and has been suggested as one cause of failure after Chiari osteotomy (Nishina et al 1990). After a Chiari osteotomy there is an obvious incongruency opposite the upper part of the femoral head (Fig. 1).

Augmentation procedures are extra-articular, and the unknown thickness and structure of the interposed soft tissue make it difficult to assess the efficiency of the bony buttress by standard early imaging. In the long term, however, functional remodelling can be recognised by increasing density and conformity, and failure by progressive resorption.

The operative technique was that of Chiari, but eight hips had an additional anterior roof plasty to provide optimal correction in the anterior part of the joint (Fernandez, Isler and Muller 1984).

The 14 shelf procedures were performed in the same period as the Chiari osteotomies, using the technique of Lance (Judet and Judet 1965). The mean age at surgery was 20.8 years (15 to 34) with follow-up of 2 to 11 years (mean 6.1).

Radiology. Radiological assessment was performed by conventional radiography to measure the CE angle (Wiberg 1939), and by CT scanning. For the latter the patient was supine, with iliac crests level and in a transverse plane, knees extended, legs and feet parallel and together. A series of 4 mm transverse plane cuts was performed through the acetabular roof and the joint. The films were magnified to normal size and evaluated on a digitising tablet (Calcomp 3000; Californian Computer Products Inc, Anaheim, California).

An alternative method of assessment is to measure the true articular coverage of the femoral head in three dimensions (Klaue, Wallin and Ganz 1988). We have assessed the cover achieved by the Chiari osteotomy and by a shelf procedure, using CT-based graphical reconstructions.

PATIENTS AND METHODS

We examined 16 patients with 19 Chiari osteotomies, and 13 patients with 14 shelf procedures. The Chiari group had a mean age at surgery of 24.3 years (11 to 51), with follow-up of 3 to 12 years (mean 6.8). One of the patients was operated on by Chiari himself. All the hips had subluxation due to residual dysplasia, and three of them already had radiological signs of degeneration. Five of the patients had had two to four previous operations.

Diagrams to show the CT examination for assessment of extra-articular augmentation procedures. Transverse plane cuts are performed from the augmented roof down to the equator of the femoral head. Figure 2a - Femoral head cover is defined in four quadrants, measured from the centre as seen in axial projection. Because, in most cases, the femoral head is not a perfect sphere, its apex or pole is positioned slightly away from the geographical centre. Figure 2b - Superposition of both groups of curves allows cover to be expressed in mm$^2$ or as a percentage of the subtended area of the femoral head.

Fig. 2a

Fig. 2b

The contours of the acetabular roof and of the surrounding part of the pelvis were digitised. A second set of contours was digitised for the femoral head, from its apex to its widest part or equator (Fig. 2). For precise description, the femoral head was divided into four quadrants, defined from the geometrical centre of the head (Fig. 2a). Data for both sets of curves were stored on a VAX 11/780 computer (Digital Equipment Corp, Maynard, Massachusetts). Examination of the superimposed groups of contours along the longitudinal axis allowed us to create an intersection diagram, from which the cover of the femoral head could be deduced (Fig. 2b). Heyman and Herndon (1950) described a comparable technique, but in two dimensions only, and using anteroposterior radiographs.
The computed results gave absolute and relative values for surface apposition of the acetabulum against the femoral head (Fig. 3). To allow comparison with normal joints, we performed the same examination on 26 hips of patients who needed CT scans for non-orthopaedic reasons.

RESULTS

These are given in Table I which shows clearly that both the Chiari osteotomy and the shelf procedure provide very deficient cover over the posterolateral quadrant of the femoral head. This insufficiency is not shown up by classical radiography and measurement of the CE angle (Fig. 4), and is difficult to assess by any other conventional technique (Figs 5 and 6).

DISCUSSION

The early stabilisation of a dysplastic hip by reorientation of the acetabulum has been shown to achieve a satisfactory and lasting clinical outcome (LeCoeur 1965; Salter et al 1984; Wilkinson 1987). Long-term studies of shelf procedures for dysplasia have shown that degenerative changes are not prevented, but are delayed to later than in the natural course of the disease (Wainwright 1976; Love, Stevens and Williams 1980; White and Sherman 1980; Le Saout et al 1985). Reports of the outcome after Chiari osteotomy are inconsistent, mainly because of the varying indications for the procedure (Fuhrman 1972; Strauss, Kreutzer and Daum 1973; Schulze and Krämer 1975; Chiari and Schwägerl 1976; Kerschbaumer and Bauer 1979; Le Saout et al 1983; Kempf and Persoons 1985; Reynolds 1986; Calvert et al 1987; Högh and Macnicol 1987; Lack et al 1991; Windhager et al 1991).

For either augmentation procedure there will be discrepancies in the results, depending on whether the assessment is made by conventional radiography or by CT (Benson and Evans 1976; Bläsius and Wimmer 1984). Our CT assessments for the Chiari osteotomy agree with the earlier findings of Bläsius and Wimmer (1984), but in addition we have been able to localise with precision those areas left uncovered. Our computer-evaluated CT technique also highlights the inherent incongruency between the original joint surface and the augmented area (Fig. 1). Jacquemier, Christain and Bouyala (1982) reported the first quantitative measurements of femoral head cover calculated by a comparable method.

The planning for correction, by whatever means, should include assessment of the posterior cover likely to be achieved in all planes in any particular case. Overcorrection may lead to unexpected problems, and it is interesting that early descriptions of reorientation procedures included cases of subsequent posterior dislocation of the femoral head (Bollini 1980). It is relevant that in certain activities, such as rising rapidly from a sitting position, the posterior wall of the acetabulum is subject to more than twice the force exerted on the apex of the acetabulum during jogging (Hodge et al 1989). Our method of CT-based reconstruction can predict the probable femoral head cover before the surgery is performed. It is possible to predict any deficiency of the important posterior aspect of the hip and take action to avoid it (Klaue et al 1986).

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Chiari osteotomy in a 45-year-old woman. Figure 5a – Preoperative radiograph. Figure 5b – Six years postoperatively, a significant step is seen at the apex of the joint, but the CE angle is greater than normal. On close examination, the posterior wall is seen to be deficient. Figure 5c – Planimetric cover. There is a deficiency crossing the weight-bearing area, which corresponds to the original soft acetabular rim. The posterior femoral head lacks cover.

Shelf procedure on the left hip of a 21-year-old woman. Figure 6a – Preoperative radiograph. Figure 6b – Ten years later, the shelf is incorporated but the posterior wall of the acetabulum is inadequate. Figure 6c – Planimetric evaluation confirms the lack of posterior cover (diagram reversed for comparibility with Figures 3 and 5c).
REFERENCES


