CHANGES IN THE INTERPOSED CAPSULE AFTER CHIARI OSTEOTOMY
AN EXPERIMENTAL STUDY ON RABBITS WITH ACETABULAR DYSPLASIA

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We have investigated the changes in the interposed capsule after a Chiari pelvic osteotomy, in an experimental study on dysplastic hips in 20 adolescent rabbits. Radiographic, macroscopic and microscopic observations were made up to 12 months after operation.

The new acetabular roof had incorporated the interposed capsule and remodelled completely by six months. By 12 months there was a new, stable hip with continuity between the capsule and the original acetabular cartilage. Histologically, the capsule underwent metaplastic change to fibrocartilaginous tissue after six months, with some hyaline-like cartilage near the joint surface. These changes in the interposed capsule play an important role in the formation of a new joint after a Chiari pelvic osteotomy.

The Chiari pelvic osteotomy is an effective operation for osteoarthritis secondary to acetabular dysplasia in adults (Chiari 1955; Inoue 1989; Lack et al. 1991). The strong bony buttress that can be obtained, and the biomechanical improvement of medial displacement of the femoral head (Chiari 1974; Kawamura, Hosono and Yokogushi 1982) suggest that it should be considered, even for severe degeneration, in young adults as an alternative to total arthroplasty (Inoue, Higuchi and Shiba 1990).

The fate of the new joint capsule between the acetabular roof and the femoral head, however, is not yet clear. We investigated changes in this interposed capsule after Chiari pelvic osteotomy in rabbits with hip dysplasia.

MATERIALS AND METHODS

We used 20 white Japanese rabbits, four to six weeks old, weighing approximately 600 g each.

Induction of acetabular dysplasia. Under anaesthesia from 25 mg/kg sodium pentobarbital injected into the peri-
toneal cavity, each rabbit had its left knee immobilised in extension by a metal splint held by a plaster bandage (Michelsson and Langenskiold 1972). The animals were kept in cages and had weekly radiographs. After three to four weeks, subluxation of the hip was usually present. In four cases, complete dislocation of the hip had taken place and the fixation was removed. The other 16 rabbits were splinted until fusion of the triradiate cartilage was shown radiographically, at the age of about four months. By then the rabbits were mature, weighing approximately 2.5 kg. We then performed a Chiari operation on the
subluxed hip with its acetabular dysplasia. The unaffected hip in each rabbit was used as a control.

**Operative technique.** Under intravenous anaesthesia with 50 mg/kg of Thiopental, a lateral approach was made to the left hip through the gluteus superficialis. The greater trochanter was detached and reflected with the other gluteal muscles exposing the outer pelvic wall above the attachment of the capsule. The position of the joint space was confirmed by needling, and an osteotomy at the correct level and angle was performed with a 5 mm flat chisel. It started directly above the attachment of the capsule at an angle of about 10° craniomedially. After the osteotomy, the leg was abducted and the distal fragment made to displace medially. When the proximal fragment adequately covered the femoral head, the osteotomy was fixed with a 1.2 mm Kirschner wire (Fig. 1). The greater trochanter was then fixed at its original position and the wound washed and closed.

Postoperatively, no external fixation was applied and the rabbit was allowed to move freely in a cage.

**Observation methods.** Four rabbits were killed at each of one, three, six and 12 months and examined radiographically, macroscopically, and by histology, using fixation in 10% neutral formalin and decalcification by EDTA. Sections cut at 6 μm were stained with haematoxylin and eosin, and with safranin O.

**RESULTS**

Radiographs. In all 20 rabbits, radiographs before the Chiari operation showed acetabular dysplasia with subluxation of the left hip and fusion of the triradiate cartilage. The proximal femoral epiphysis had still not completely fused, but no deformity of the femoral head was seen (Fig. 2a).

Immediately after operation, the distal fragment was seen to be shifted inwards enough to reconstruct the roof, and to cover the femoral head completely. A step could be seen between the original acetabulum and the newly-formed acetabular roof (Fig. 2b).

At three months after the operation, the osteotomy had almost completely consolidated and the newly-formed acetabular roof covered the femoral head, fitting its contour. The step was no longer visible (Fig. 2c).

At six months the newly-formed roof and the original acetabulum were one smooth and continuous surface, well-matched to the contour of the femoral head.

At 12 months there was complete remodelling of the new acetabular roof about the femoral head, forming a new, stable hip (Fig. 2d).

**Macroscopic and histological findings.** Soon after the Chiari operation, the hip capsule covering the subluxated femoral head became thickened and milky white, compared with the surrounding unloaded parts, but the border between the acetabular cartilage and the inner surface of the joint capsule was still obvious. Histologically, the dense collagen fibres of the thickened joint capsule were aligned irregularly, and an increased number of round-oval cells were observed. Under safranin O staining, the ground substance of these cells was dyed rose-pink and consisted of an amorphous substance with collagen fibres and fibrils. One to two
layers of synovial cells were seen on the new joint surface (Fig. 3).

At one month the interposed capsule was still milky white and was apparently harder than before the operation. The border between acetabular cartilage and the interposed capsule was still clearly visible. Histologically, the capsule showed moderately dense collagen fibres with moderate vascularity, and round-oval cells with a distinct nucleolus, often seen in pairs. The joint surface of the interposed capsule had a remarkable proliferation of synovial cells (Fig. 4a). There was granulation tissue between the cancellous bone of the proximal osteotomy fragment and the capsule, with several layers of undifferentiated mesenchymal cells on the cancellous trabeculae of the proximal fragment (Fig. 4b).

At three months the original acetabulum and the interposed capsule were smoothly continuous but the difference was still apparent and the capsule was still

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**Fig. 3**
Photomicrograph of the inner surface of the new capsule soon after osteotomy. The dense collagen fibres are aligned irregularly, and there are increased numbers of round-oval cells. One or two layers of synovial cells are seen on the joint surface (safranin O $\times$ 55).

**Fig. 4a**
Photomicrographs at one month. Figure 4a – The cells in the capsule are paired in various places, and the joint surface shows proliferation of synovial cells ($\times$ 55). Figure 4b – At the osteotomy there is granulation tissue (G) between the cancellous bone of the proximal fragment and the interposed capsule, with several layers of undifferentiated mesenchymal cells on the trabeculae (T) of the cancellous bone ($\times$ 55).

**Fig. 5a**
Photomicrographs at three months. Figure 5a – In the capsule, paired round-oval-shaped cells have proliferated ($\times$ 110). Figure 5b – At the osteotomy, the undifferentiated mesenchymal cells on the trabeculae (T) of the cancellous bone have differentiated to resemble chondrocytes (black arrow) ($\times$ 55).
Photomicrograph at six months. Figure 6a – The interposed capsule shows metaplastic changes to fibrocartilaginous tissue and the synovial cells have disappeared. At the new articular surface, the chondrocytes are in groups of two or three and have cartilage lacunae. There is a tendency to transformation into hyaline-like cartilage (× 220). Figure 6b – At the osteotomy level, fibrous tissue is perpendicular to the articular surface (× 110).

Figure 7a – Photomicrograph of the new acetabulum at 12 months. The original acetabular cartilage (open arrow) is continuous with the metaplastic cartilage (black arrow) (× 5). Figure 7b – The articular surface of the metaplastic cartilage (× 110). Figure 7c – At the osteotomy (× 55).

softer than the old articular cartilage. Histologically, pairs of round-oval-shaped cells had proliferated in the interposed capsule, but there were only one or two layers of synovial cells on the new joint surface. The previously undifferentiated mesenchymal cells on the cancellous trabeculae of the proximal fragment now appeared to be chondrocytes (Fig. 5).

At six months the interposed capsule had become as hard as the original acetabular cartilage, was slightly transparent, and showed some continuity with the old
surface. Histologically, almost all the interposed capsule had become fibrocartilaginous and the synovial cells on the articular surface had disappeared. The newly-formed articular surface showed chondrocytes with cartilage lacunae, in groups of two or three, with an appearance like hyaline cartilage (Fig. 6a). The fibres at the articular surface in the interposed capsule were seen to be arranged parallel to this surface, while near the bone, in the deepest layers, their orientation was perpendicular (Fig. 6b).

At 12 months the macroscopic and histological findings were almost the same as at six months (Fig. 7), with no further recognisable differentiation of the metaplastic cartilage.

**DISCUSSION**

Chiari (1974) hypothesised that the capsule interposed between the acetabular roof and the femoral head after his osteotomy could become fibrocartilaginous, and that a congruent roof would develop by ossification of the granulation tissue between capsule and cancellous bone. Colton (1972) suggested that ossification occurred in the interposed capsular tissue. Chiari's hypothesis has received some support from clinical studies, but has not yet been fully substantiated (Moll 1982). Ieda (1977) studied the histology of the interposed capsule in normal rabbit hips and found some transformation into fibrocartilaginous tissue after six to eight weeks. The capsule is thin in normal rabbits, however, and the use of normal hips for the operation cannot give a proper weight-bearing area (Bitan et al 1989). Böhler et al (1985) also observed fibrocartilage in the capsule of dysplastic hips in young dogs after Chiari's operation.

We used a dysplastic hip model in young rabbits, maintained until fusion of the triradiate cartilage was complete, and found that the interposed capsule changed to fibrocartilaginous tissue within six months and was partially transformed into hyaline-like cartilage on the articular surface. These findings were unchanged at 12 months. Zlatic et al (1988) found hyaline-like cartilage in the weight-bearing part of the capsule in a patient when total hip arthroplasty was performed 11 years after a Chiari operation. We consider that such metaplasia to hyaline cartilage may require a considerable time.

On the new joint surface, we observed transitory proliferation of synovial cells, which disappeared when the remodelling was complete. These synovial fibroblasts may be involved in the metaplasia of the interposed capsule, and may proliferate in response to incongruity between the new acetabulum and the femoral head.

During the first month after the osteotomy, vascular granulation tissue was seen between the capsule and the cancellous bone, where there were several layers of undifferentiated mesenchymal cells on the trabeculae. Enchondral ossification then led to remodelling of the new acetabulum.

The interposed capsule became harder with time, and the orientation of its fibrous tissue, superficially parallel to the articular surface and perpendicular in deep layers, led us to believe that the metaplastic cartilage of the interposed capsule can offer adequate weight-bearing support. We conclude that after a successful Chiari operation the interposed capsule changes and plays an important role in the formation of a new joint.

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**REFERENCES**


