A simple bone cyst in the upper end of the humerus presents a common surgical problem. It is usually diagnosed in childhood or adolescence because of a pathological fracture. Rarely the cyst heals after fracture; usually it persists and needs surgical treatment if the risk of recurrent fractures is to be avoided. Curettage of the cyst and packing of the cavity with bone chips is the usual treatment; this may be successful, but often the cyst recurs so that repeated operations are needed. Recurrence is attributed to incomplete removal of the membrane lining the cyst.

Our operation consists of subperiosteal excision of the whole of the cyst-bearing part of the diaphysis, which includes removal of all the membrane lining the cyst. The case histories of three patients reported here show that radical operation can be performed with no greater inconvenience to the patient than the less certain procedure of curettage.

CASE REPORTS

Case 1—A youth of seventeen broke the shaft of the right humerus when throwing a cricket ball. On examination he had a mobile fracture and an incomplete radial nerve palsy. The radiograph showed a large cyst in the shaft of the humerus, through which a pathological fracture had occurred. At operation the shaft of the humerus was approached along the line of the lateral intermuscular septum. The spiral fracture was below the cyst but a further fracture line ran up the shaft of the bone and through the cyst almost to the

* Deceased.
upper epiphysis. The radial nerve lay behind, between the major fragments, and was compressed by them. The upper limit of the cyst was determined by radiographs after the insertion of guide wires. The periosteum was stripped circumferentially from the upper fragment of the bone, which was then divided transversely above the cyst and removed. The spike of bone on the lower fragment was seen to be normal. The empty periosteal sheath was packed with chips of homogenous banked bone and reconstituted with catgut sutures (Fig. 1). A hanging plaster was applied and traction by weights and pulley arranged. Four days later the traction was discontinued and the patient was allowed up with the arm in a sling.

The plaster was removed seven weeks after the operation and radiography showed that union had occurred (Fig. 2). Figure 3 shows the radiograph seven years later. The arm was normal on clinical examination; the length of the humerus was the same as the opposite side.

Case 2—A boy of nine sustained a fracture through a large cyst in the upper metaphysis of the right humerus. The fracture united readily but the cyst remained. Four months later it was curetted and packed with bone chips, but it soon recurred. Further operation was delayed because of intercurrent disease and six months after the curettage radiographs revealed almost complete absorption of the bone graft and extension of the cyst. A year later subperiosteal resection of the whole of the upper metaphysis of the humerus was carried out. The epiphysial growth cartilage was exposed where it formed the roof of the cyst. The periosteal tube was reconstituted and filled with homogenous banked bone chips. The limb was immobilised in a thoraco-brachial plaster for six weeks.

Figure 4 shows the radiological appearance ten years after the operation. The limb was normal in all respects and the humeri were of equal length. The bone scar was several inches from the upper end of the bone, confirming that growth had continued normally despite total removal of the metaphysis.

Case 3—A boy of six fell from a swing and broke the upper shaft of the left humerus through a large cyst (Fig. 5). Operation was delayed for three weeks to allow him to recover from an attack of acute tonsillitis. The humerus was approached through the delto-pectoral groove. Subperiosteal excision of the upper third of the humeral diaphysis, containing the cyst, was carried out. The epiphysial growth cartilage was seen where it formed the roof of the cyst (Fig. 6). The periosteal tube was then packed with homogenous banked bone chips. A plaster cast was applied from the shoulder to the wrist with the elbow flexed to a right angle.

Histological examination of the excised bone revealed an aneurysmal bone cyst.

Traction was applied for the first ten days, the weight being attached to the plaster at the elbow by a cord which passed over a pulley fixed to the bed. On the tenth day after operation traction was discontinued and the patient was allowed up with the plaster supported in a
collar and cuff, and he was discharged home five days later. When the plaster was removed four weeks after operation the humerus was clinically united. A light plaster U-slab with a collar and cuff was worn for a further four weeks and then discarded to allow full use of the arm. Radiographs at this stage showed advanced organisation of the bone chips with 15 degrees of varus angulation of the humeral shaft (Fig. 7).

![Radiograph showing an aneurysmal bone cyst extending up to the epiphysial growth cartilage and complicated by a fracture.](image1)

**Case 3.** Figure 5—Radiograph showing an aneurysmal bone cyst extending up to the epiphysial growth cartilage and complicated by a fracture. Figure 6—Radiograph taken during the operation. The cyst-bearing portion of the bone has been excised subperiostally. The epiphysial cartilage has been denuded. Figure 7—Eight weeks after the operation. Union has occurred with a little angulation. Figure 8—Fifteen months after operation. Growth has continued and the bone scar now lies 2 centimetres from the epiphysial cartilage.

Radiographs taken a year later showed further organisation of the graft (Fig. 8). Growth had occurred normally at the upper epiphysis and the bone scar lay more than half an inch from the epiphysial growth cartilage. The limb was clinically normal.

**OPERATION**

Successful repair after diaphysectomy depends upon careful preservation of the periosteal tube. The incision is carried directly down to the periosteum which is incised longitudinally over the cyst. All the dissection is carried out in the subperiosteal plane. Metal markers are placed and radiographs confirm that the levels of section lie beyond the limits of the cyst. If the cyst wall is next to the epiphysial growth cartilage this must be completely denuded to ensure total removal of the cyst membrane. Small portions of the thin juxta-epiphysial cortex tend to adhere to the growth plate and should be removed.

The incision into the periosteal tube is accurately repaired for three-quarters of its length with a continuous catgut suture. Finely minced cancellous bone chips are then introduced through the remaining gap and packed firmly into the partly reconstituted tube. When the cavity is full, closure of the periosteal incision is completed. The periosteal "stocking," tightly packed with bone, is remarkably rigid and provides considerable stability.
DISCUSSION

Partial diaphysectomy can safely be performed in children and adolescents, because healthy periosteum quickly repairs the defect. Study of the radiographs of our patients confirms that union was almost entirely the result of rapid and copious formation of subperiosteal new bone, and that the bone chips did little more than maintain patency of the periosteal tube.

The humerus, which is the commonest site for simple cysts, is specially suitable for this operation as gravity maintains bone length in the upright position during consolidation. In two patients the epiphysial cartilage was completely exposed without interfering with the subsequent growth of the bone.

Diaphysectomy has been widely practised in the past for osteomyelitis and it is well known that the growth cartilage survives. The cartilage is nourished exclusively by the epiphysial blood vessels, and if they remain intact growth continues despite the destruction of vessels from the diaphysis.

Our patients spent two weeks in hospital and used their arms normally eight weeks after operation. Hospital treatment was hardly longer than in the less certain operation of curettage. Indeed, when the cyst presents as a pathological fracture, curettage is usually delayed for technical reasons until union has occurred and therefore involves a considerably longer period of incapacity than radical operation carried out straight away.

Curettage is an uncertain method of removing the cyst lining and for this reason is unreliable. Partial diaphysectomy leaves no doubt as to the completeness of the excision, and we believe it is the better course.

The method of treatment described in this paper was devised by the late Mr J. C. Agerholm, and he performed the operations on the patients reported here.