RADIO-ULNAR FUSION FOR DEFECTS IN THE FOREARM BONES

H. G. LOWE, STAFFORD, ENGLAND

Formerly Senior Orthopaedic Registrar, Prince of Wales Orthopaedic Hospital, Cardiff, Wales

When part of the shaft of the radius or ulna is deficient in young children a deformity results from unequal growth of the two forearm bones. If the ulna is absent in part there is relative overgrowth of the radius, with consequent dislocation of the radio-humeral joint and ulnar deviation of the hand. When the defect is in the radius the relative overgrowth of the ulna results in dislocation of the inferior radio-ulnar joint and radial deviation of the hand. The amount of deformity will depend on the cause of the defect, its extent and the age of onset.

Among the pathological conditions causing unequal growth of the radius and ulna are congenital absence of part of the radius or ulna, osteomyelitis with sequestration of the diaphysis of one or other bone, benign bone tumours—particularly osteochondromata—and injury. Congenital defects in the radius and ulna are variable in amount and are often associated with deformities in the hand or other parts of the body. In adults similar problems are presented in the forearm when there is a considerable defect in either the radius or ulna after injury or infection.

The problem that a deformity presents will vary. Each case must be considered individually and careful selection is necessary before operation is advised.

The choice of treatment of a gap defect in a forearm bone usually lies between a replacement graft and radio-ulnar fusion to provide a single-bone forearm. If the defect is in the diaphysis, and if the “ends” of the radius or ulna are still present, grafting is a possibility. Even in these conditions, however, grafting is not always feasible, especially if the cause of the defect is osteomyelitis and the gap is wide. The site of old infection is a risky area for bone grafting, and the remaining upper and lower ends of the bone are often too small and atrophic to receive a graft satisfactorily.

When the defect includes one of the epiphyses of the bone grafting is less feasible. In an adult growth is not a problem but it must be considered in a child, in whom successful grafting may be followed by discrepancy of growth between the two forearm bones with further deformity. In adults, as Watson Jones (1934) pointed out, bone grafting is not always satisfactory because it is difficult to restore correct relationships at the inferior radio-ulnar joint.

Radio-ulnar transposition is an alternative to bone grafting but produces a single-bone forearm with the loss of rotation, although rotation at the shoulder will compensate for this satisfactorily. Correction of the deviation of the hand on to a solid forearm gives a much stronger grip, and elbow and wrist movements are not impaired. The requirements for radio-ulnar transposition are intact radio-carpal and humero-ulnar joints. As Vitale (1952) said, “the ulna ‘makes’ the elbow and the radius ‘makes’ the wrist.” Given these conditions radio-ulnar fusion can be a useful procedure for several problems resulting from a gap deficiency in one of the forearm bones. In the child growth discrepancy between the two bones is no longer a problem, and once continuity is established between the upper end of the ulna and the lower end of the radius longitudinal growth can proceed producing a better forearm cosmetically and functionally.

Previous reports—The operation of radio-ulnar transposition was devised by Hey Groves (1921) of Bristol who did the operation in an adult for a gap fracture of the radius which had twice failed to unite after bone grafting; the distal end of the ulna was transplanted into
the remaining lower end of the radius. To facilitate the transplantation Hey Groves designed a special lever consisting of a straight arm deeply grooved and ending in an upturned curve (Fig. 1). Hey Groves advocated that the hand be put in a position of neutral rotation.

Greenwood (1932) reported a successful result in a child of ten and a half years who had lost most of the lower shaft of the radius after osteomyelitis. Greenwood divided the ulna about two inches from its distal end, which was left as buttress for the wrist joint. This child was followed up until the age of seventeen when the forearm was four inches short. Watson Jones (1934) recorded a case of radio-ulnar transposition done in a girl of nineteen years for loss of most of the diaphysis of the radius after osteomyelitis, and he showed that Greenwood's modifications of the original technique of Hey Groves were unnecessary if the lower end of the ulna was resected subperiosteally because then a new buttress developed from the periosteal tube; he also observed that the use of Hey Groves's technique gave greater length to the transplanted ulna and removed the disfiguring and prominent lower end of the ulna.

Radio-ulnar transposition in two children was reported by Vitale (1952). In one child the defect was congenital and in the other it followed resection of the lower half of the ulna for a large osteochondroma. The first child was four but was only followed up for two and a half years, and the second was also done in a child of four but was followed up for nine years. In both children there was a good functional and cosmetic result.

TABLE 1

<table>
<thead>
<tr>
<th>Case number</th>
<th>Diagnosis</th>
<th>Age in years</th>
<th>Follow-up in years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osteomyelitis of the ulna</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>Chondroma of the ulna</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Chondroma of the ulna</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>Congenital defect of the ulna</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Osteomyelitis of the radius</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Osteomyelitis of the radius</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Non-union after fracture of the radius and ulna</td>
<td>48</td>
<td>17</td>
</tr>
</tbody>
</table>

CLINICAL MATERIAL

Seven patients have had radio-ulnar transposition at the Prince of Wales Orthopaedic Hospital, Cardiff, all the operations being done by Mr A. O. Parker. Table I gives the indications for the operation, the age at that time, and the length of follow-up.
CASE REPORTS

Case 1—A girl aged thirteen was admitted for a deformity of the left forearm. At the age of three osteomyelitis had caused the loss of the distal half of the ulna. The radius had continued to grow, with consequent ulnar deviation of the hand and dislocation of the head of the radius. In August 1936 the head and neck of the radius were excised and a month later radio-ulnar transposition was done. Non-union ensued owing to faulty apposition of the radius to the ulna, for the extreme bowing of the radius made it difficult for the bones to lie parallel. In March 1937 an onlay tibial bone graft was done and three months later union had occurred. No details of the operations are available. In 1960, twenty-four years later, the patient made no complaint. She not only did her housework but also worked as a part-time nurse. There was one and a half inches of shortening of the forearm and the hand was in 45 degrees of supination. The grip was strong and wrist and elbow movements were good (Figs. 2 to 4).

Case 2—A girl of eight with multiple osteochondromata was admitted for a deformity of her right arm, in which there was a large chondroma of the distal half of the ulna. There was relative overgrowth of the radius and dislocation of the radial head. In June 1935 the head and neck of the radius were excised. Three and a half years later radio-ulnar fusion was done.
through a posterior incision exposing almost the whole length of the ulna. The distal half of the ulna was found enlarged to three times its normal size by the chondroma, and was excised. The incision was then carried forwards over the upper end of the radius, which was exposed and made to protrude proximally by pushing on the hand. One and a half inches of the proximal end of the radius was excised, and the interosseous membrane was divided at its attachment to

the ulna and lifted posteriorly so that the medial border of the shaft of the radius could be exposed on the volar surface of this membrane. Thus the posterior interosseous nerve was not seen. The radius and ulna were then found to overlap by about two inches. The adjacent surfaces of the radius and ulna were denuded of cortical bone and were held together by catgut with the wrist in 20 degrees of supination. The incisions were closed and a full-arm plaster was
applied. There was considerable swelling of the hand after the operation, but this improved after the plaster was split. The arm was kept in plaster for seventeen weeks, when union had occurred.

The patient was re-examined in 1960, twenty-two years after the operation (Figs. 5 to 8). She made no complaints and in addition to her housework was employed as a florist and was able to garden. There was three inches of shortening in the forearm. Elbow movements were full and wrist movements were about 90 per cent of the normal. The hand was fixed in 20 degrees of supination, and the grip was strong.

Case 3—A girl of five was seen on account of a deformity of her right arm (Fig. 9). Radiographs showed that the lower half of the ulna was replaced by a chondroma and that there was relative...
overgrowth of the radius with dislocation of the radial head (Fig. 10). Movements at the elbow were normal, as was rotation. The wrist and hand were normal. In January 1938 the lower half of the ulna and the chondroma (Fig. 13) were excised and radio-ulnar fusion was done through a single longitudinal incision on the posterior surface of the forearm. The distal ulna with the chondroma was excised through healthy bone. The interosseous membrane was divided allowing the volar muscles to bulge through between the bones. The supinator muscle was reflected from its ulnar attachment and the upper half of the radius freed. The head and neck of the radius were resected and the shaft was filleted until it could be easily placed parallel with the remaining uppermost third of the ulna. The adjacent surfaces were rawed and the two bones were held together by two pieces of catgut, with the hand in neutral rotation. The arm was immobilised in a plaster which had to be split because the hand became swollen after the operation. Four months later union had occurred. When seen in 1960 the patient made no complaints. She was able to do all her housework. There was one and a half inches of shortening and the hand was held in neutral rotation (Figs. 11 and 12). Elbow and wrist movements were normal and the grip was strong.

Case 4—A boy aged four years was admitted in 1940 for a deformity of the left forearm. Radiographs showed that the ulna was deficient in its lower half, with relative overgrowth of the radius and dislocation of the head of the radius (Fig. 14). The hand was normal. At operation the upper part of the radius was excised and radio-ulnar fusion done through an incision over the back of the ulna extending distally from the olecranon for six inches. The dislocated head of the radius was exposed and the supinator muscle lifted off in the form of a cuff so as

![Image](image)

Fig. 14

Case 4. Figure 14—Radiograph of the arm at the age of four. Figures 15 to 17—Radiographs and photographs twenty years after radio-ulnar fusion.

![Image](image)

Fig. 15

![Image](image)

Fig. 16

![Image](image)

Fig. 17

to leave about one and a half inches of radius protruding; this was excised. The radial nerve was not seen. The tapering sclerotic end of the distal part of the ulna was then excised. The two bones were approximated through the interosseous membrane by blunt dissection. The proximal end of the radius was tapered and pushed into the medullary cavity of the ulna where it was firmly held, with the hand in 45 degrees of supination. A plaster was applied which had to be split for swelling after the operation. Six months after operation union was sound and the child was allowed to mobilise the arm. When re-examined in 1960 the patient
made no complaints. He drove a heavy lorry and occasionally played cricket. There was two inches of shortening of the forearm; the hand was in 45 degrees of supination and there were 20 degrees of cubitus valgus at the elbow (Figs. 15 to 17). Wrist and elbow movements were full and the grip was strong.

Case 5—A boy aged thirteen was admitted for a deformity of his left forearm. He had broken the left radius at the age of six and suffered osteomyelitis. He had had five previous operations which had left him with a defect in the centre of the radial shaft. The ulna had continued growing and caused considerable radial deviation of the hand; the ulna was bowed laterally and posteriorly. The hand was useful and the grip was good. In September 1935 radio-ulnar fusion was performed but details of the operation are not available (Figs. 18 and 19). Some ten years later he emigrated to Canada after passing the medical examination.

Case 6—A boy aged twelve years was admitted for a deformity of the left arm from osteomyelitis of the radius. The greater part of the radial shaft had been removed at previous operations and the ulna had continued to grow, with consequent deviation of the hand. In March 1936 radio-ulnar fusion was performed, but no operation notes are available. Union was successful. In 1948 he emigrated to Australia, having passed the medical examination (Figs. 20 to 22). A letter from the patient in April 1961 stated: "I have been able to do all types of manual work and I was also in the Royal Navy from 1943 until 1946 and my arm was no inconvenience to me whatsoever on duty, such as loading 4-inch guns and rowing boats..."

Case 7—A man aged forty-eight was admitted with ununited fractures of the left radius and ulna (Fig. 23). Three operations had been done elsewhere in attempts to gain union, but had been unsuccessful. One operation had been an open reduction and two had been for bone grafting, but the details are not known. In October 1939, three years after the injury, there
was three and a half inches of shortening in the forearm. The fingers were stiff, but exercises for six weeks restored almost normal movements. In December 1939 radio-ulnar fusion was done through a single posterior incision. After exposure of the lower end of the radius the previously inserted bone graft, which appeared quite inert, was found attached to the sclerotic end of the radius by a wire loop. The graft and the sclerotic end of the radius were removed, and the upper end of the ulna was exposed through the same incision and its sclerotic end excised. The ulna was then passed from the medial to the lateral side of the forearm in the plane of the interosseous membrane. The gap in the interosseous space was opened by blunt dissection to avoid damage to blood vessels and nerves. The radius and ulna were put in apposition after rawing the contiguous surfaces and were held together by catgut; the hand was in neutral rotation. A plaster was applied. After the operation the fingers were blue and cold but the circulation recovered after the plaster was split. After nine months clinical and
radiological union had occurred (Fig. 24) and the patient was allowed to mobilise the arm. He died in 1956 from chronic bronchitis. A letter from his daughter, who was a nurse, said: "The operation on his arm was a great success and he was able to lift and grip quite comfortably. He was also able to dig the garden with a spade."

SUMMARY

1. The problem of gap defects in the forearm bones and its solution by radio-ulnar fusion is discussed.
2. Seven patients with radio-ulnar fusions are presented. In four patients the operation was done for defects in the ulna, in two for defects in the radius, and in one for non-union of the radius and ulna after fracture.
3. The good cosmetic and functional result after radio-ulnar fusion is emphasised.

I wish to express my gratitude to Mr A. O. Parker for permission to study his cases. I am grateful to Miss Beryl Wales and Mr Graham Haddock of the Departments of Radiography and Clinical Photography at the Prince of Wales Orthopaedic Hospital for their help.

REFERENCES


