A 6-month-old 8.0-kg (17.6-lb) female crossbred dog was admitted to the Veterinary Hospital of the Faculty of Veterinary Medicine and Animal Science for diagnosis and treatment of a deformity of the right forelimb that had been present since birth. The dog’s littermates were clinically normal. The right forelimb was nonfunctional. Varus deviation of the forepaw and flexion contracture of the interphalangeal joints were evident on physical examination (Figure 1). The elbow joint had good mobility, and there were no signs of pain on manipulation of the joint. Radiography of the limb revealed good congruency of the humeroulnar joint, complete absence of the radius, hypoplasia of the ulna without bowing of the ulna, 90° varus deviation of the ulnocarpal joint, missshapen carpal bones, and flexion deformity of the interphalangeal joints (Figure 2). The diagnosis was radial hemimelia (congenital absence of the radius). Results of a CBC and urinalysis were within reference ranges. No other coexistent clinical abnormality was found on physical examination.

The dog underwent 3 surgeries for correction of the deformity. The first 2 surgeries used a circular external fixator. This apparatus consists of full or partial rings that encircle the affected limb and are connected to one another by threaded rods. Tensioned wires connect bones or bone fragments to the support elements of the fixator. The apparatus also allows for gradual distraction of the rings along the threaded rods, which stimulates new bone formation (distraction osteogenesis) within the widening osteotomy site; correction of multiplanar deformities can be performed simultaneously. After premedication with buprenorphine (15 μg/kg [6.8 μg/lb], IV) and chlorpromazine hydrochloride (0.5 mg/kg [0.23 mg/lb], IV), anesthesia was induced with thiopental (10 mg/kg [4.5 mg/lb], IV) and maintained with isoflurane. Initial surgical treatment consisted of a transverse osteotomy through the distal ulnar physis, rotation of the distal ulnar fragment (epiphysis) together with the forepaw in a lateral direction to achieve contact with the end of the proximal ulnar segment (shaft of the ulna), and application of a circular external fixator. All fixator components were made from stainless steel. This procedure resulted in straightening of the distal portion of the limb. The circular external fixator was assembled so that 1 ring encircled the proximal segment of the ulna and the other ring encircled the proximal portions of the metacarpal bones. The rings were connected with 3 threaded rods. Two transosseous wires (1.5 mm diameter) were placed on each ring, with 1 wire above and 1 below each ring. Wires were oriented perpendicular to the long axes of the bones (proximal segment of the ulna and metacarpal bones). The wire intersection angles were between 60° and 90°. An additional transosseous wire was placed through the midportion of the shaft of the ulna; both ends of this wire were connected to the proximal ring of the fixator by use of a male post (post with a threaded rod coming out the
end). Another transosseous wire was placed through the metacarpal bones, and both ends were connected to the distal ring of the fixator in a similar manner. The wires were secured by fixation bolts and nuts and tensioned to 90 kg or less by use of a dynamometric wire tensioner. Ampicillin (22 mg/kg [10 mg/lb], PO, q 8 h) was administered for 5 days, and flunixin meglumine (1.1 mg/kg [0.5 mg/lb], SC, q 24 h) was administered for 3 days. Buprenorphine hydrochloride (5 µg/kg [2.3 µg/lb], IM) was administered as required.

Two months after surgery and before complete healing of the osteotomy site was achieved, the external fixator was removed because of instability of the fixator resulting from osteolysis around the transosseous wires. A cast was applied to the limb and maintained for 2 months. Two months after cast removal, the dog had partial weight-bearing when walking as a result of correction of the forepaw deviation; however, the limb was substantially shorter than the contralateral limb. Radiographs of the limb revealed that the osteotomy site had healed; however, a varus deviation of the forepaw was still evident. Although we initially intended to preserve mobility of the ulnocarpal joint, this joint had fused naturally by this time.

An external fixator was used in the second surgery to induce lengthening of the ulna. One ring of the fixator encircled the proximal segment, and the other ring encircled the distal segment of the ulna. The rings were connected with 4 threaded rods. Two transosseous wires (1.5 mm diameter) were placed on each ring and perpendicular to the long axis of the ulna. The wire intersection angles were between 60° and 90°. The wires were tensioned to 90 kg or less by use of a dynamometric wire tensioner. A subperiosteal osteotomy of the ulnar diaphysis was performed at a site midway between the proximal and distal rings via a lateral approach. The dog was treated with ampicillin, flunixin, and buprenorphine after surgery. After a latency period (delay period before distraction was begun) of 10 days, the bone lengthening procedure was initiated. The rings were distracted via adjustment of the connecting threaded rods at a rate of 0.5 mm/d (ie, 0.25 mm every 12 hours). After 17 days of bone lengthening, the dog developed radiographic signs of osteomyelitis involving the ulnar diaphyses, probably in association with wire placement, and was treated with cephalixin (30 mg/kg [13.6 mg/lb], PO, q 8 h) for 20 days. At the same time, bone lengthening was interrupted for 10 days and then reinitiated at a rate of 0.5 mm/d in increments of 0.25 mm every 12 hours. This rate was used because regenerated bone was of poor quality on follow-up radiographs. After the ulna had increased in length by 25 mm, the apparatus was left in place for an additional 4 months (consolidation period) until regenerated bone had matured (Figure 3). The fixator was removed at the end of this period.

Three months after removal of the fixator, an osteotomy was performed in the distal portion of the ulna at the point of the deformity to treat deviation of the forepaw. The distal segment was rotated, and the site was stabilized by use of 2 crossed Steinmann pins. A splint was applied to the caudal surface of the forelimb for addi-

Figure 2—Lateral radiographic view of the right forelimb of the dog in Figure 1 before surgical correction. Notice the good congruency of the humeroulnar joint, complete absence of the radius, 90° varus deviation of the ulnocarpal joint, misshapen carpal bones, and flexion deformity of the interphalangeal joints.

Figure 3—Lateral radiographic view of the right forelimb of the dog in Figure 1 during the neutral fixation period after induction of bone lengthening by use of the Ilizarov external fixator. Notice the bone-lengthening area (site of osteotomy).
tional support and maintained for a period of 3 months. The Steinmann pins were removed by the referring veterinarian. During the final evaluation 2 years after the third surgery, the dog had an improvement of its gait and would bear weight on the affected limb when standing. Mild to moderate lameness was evident when the dog would walk or run. Flexion contracture of the interphalangeal joints and residual deviation of the forepaw were still evident (Figures 4 and 5). Radiography revealed bone proliferation at the humeroulnar joint, likely as a result of wire placement in the ulna during the second surgical procedure. Subluxation of the humeroulnar joint, a complication that may develop after correction of radial hemimelia, did not develop even though the dog bore weight on the limb. Although the radiograph had some small degree of magnification, the humerus and metacarpal bones of the left forelimb were larger than those of the right forelimb, probably as a result of the underlying condition and difference in the amount of weight born by the forelimbs.

Congenital absence of the radius (radial hemimelia) is not common in dogs and cats. The etiology in animals is unknown; however, hereditary or toxic causes are suspected. In humans, environmental (irradiation, viral infection, and chemical products) and genetic factors may be involved. A cause for the abnormality in the dog of this report could not be determined.

Clinical evidence of radial agenesis is observed shortly after birth, as absence of the radius results in functional and aesthetic problems. The condition is generally unilateral but may be bilateral. In most cases, the affected limb is shorter than the contralateral limb and generalized muscle atrophy as a result of disuse is evident; a rotational deformity associated with limitation of flexion and extension of the elbow and ulnocarpal joints is also present. Signs of pain are not present unless a fracture or other injury has occurred. In humans, 4 types of radial dysplasia, classified on the basis of radiographic findings, have been described: type I, short distal radius (the growth of the distal radial epiphysis is decreased, causing a normal appearing but short radius); type II, hypoplastic radius; type III, partial absence of the radius; and type IV, complete absence of the radius. According to this classification, the dog of this report had type IV radial dysplasia; this is the most common abnormality reported in humans. Occasionally, in humans, a bowed ulna is observed; this deformity usually develops secondary to soft tissue contracture.

Treatments for radial hemimelia that have been described for veterinary species include restitution of the radius by use of a rib graft fixed with a Kirschner

Figure 4—Photograph of the dog in Figure 1 two years after the final surgery for correction of radial hemimelia. Notice the greater apparent length of the right forelimb, residual deviation of the forepaw, and flexion contracture of the interphalangeal joints.

Figure 5—Lateral radiographic views of the right forelimb of the dog in Figure 1 two years after the final surgery for correction of radial hemimelia (A) and of the clinically normal left forelimb of the same dog (B). Notice the fusion of the ulnocarpal joint, residual deformity of the forepaw, and flexion deformity of the interphalangeal joints. Although there is a little magnification, the humerus and metacarpal bones of the left forelimb appear larger than those of the right forelimb.
The goals of centralization of the carpus over the ulna are a stable antebrachio-carpal joint centralized on the distal end of the ulna and maintenance of functional antebrachio-carpal joint motion. In general, the distal portion of the ulna is exposed, the capsular attachments to the carpal structures are freed, and the carpus is reduced over the end of the ulna. To provide stability, a Kirschner wire is inserted through the shaft of the third or fourth metacarpal bone and out through the metacarpal head. It is then introduced through the center of the distal ulnar epiphysis and into the medullary canal of the ulna.

Bone-lengthening methods have also been described as complementary procedures. Currently, complex skeletal deformities, especially in humans, are treated by use of the Ilizarov technique, with amputation considered only as a final option.

The technique used in the dog of this report was based on one of the Ilizarov techniques used to treat radial dysplasia in humans. The advantage of this technique is that the forepaw can be realigned with low risk of damage to neurovascular structures. This is because it is not necessary to section tendons or perform releases of soft tissue and joint capsule, as is performed during traditional centralization techniques in humans. However, in the dog of this report, it was difficult to obtain perfect contact between the end of the proximal ulnar segment and the distal ulnar fragment. A second surgery was required to equalize the length of the forelimbs by use of a bone-lengthening technique, and a third surgery was required to correct the remaining deviation of the forepaw.

The technique of distraction osteogenesis has been used in the treatment of hypoplasia of the ulna in dogs with ectrodactyly with good results.

The Ilizarov method has been used successfully to treat short and bowed ulna, which is the result of radial club hand deformity treated by use of the Ilizarov technique of distraction osteogenesis. The bone infection that developed in the dog of this report was considered a serious complication; however, it resolved with conservative treatment.

Flexion contractures of the elbow, antebrachio-carpal, and interphalangeal joints may occur as a result of forearm lengthening surgery in humans. Flexion contracture of the interphalangeal joints observed in the dog of this report is one of the deformities associated with radial club hand deformity in humans. The flexion contracture did not progress with bone lengthening; however, it interfered with the final functional result. In general, there is a limit in the ability to completely correct congenital skeletal deformities. The surgical treatment used in the dog of this report allowed use of the limb and a better quality of life.

References