Ipsilateral vascularised ulnar transposition autograft for limb-sparing surgery of the distal radius in 2 dogs with osteosarcoma

G S Irvine-Smith[a][*] and R G Lobetti[a]

ABSTRACT

Canine osteosarcoma is the most commonly diagnosed primary bone tumour in the dog, affecting mainly large and giant breed dogs with the predilection site being the metaphysis of long bones, specifically the distal radius, proximal humerus, distal femur and proximal tibia and fibula. Treatment options are either palliative or curative intent therapy, the latter limb amputation or limb-sparing surgery together with chemotherapy. This article describes the use of an ipsilateral vascularised ulnar transposition autograft as well as chemotherapy in 2 dogs with osteosarcoma of the distal radius. Both dogs showed minimal complications with the technique and both survived over 381 days following the surgery. Complications seen were loosening of the screws and osteomyelitis. The procedure was well tolerated with excellent limb use. This technique is indicated for use in cases with small tumour size that have not broken through the bone cortex.

Key words: bone cancer, chemotherapy, radius, surgery, vascularised autograft.

INTRODUCTION

Canine osteosarcoma is the most commonly diagnosed primary bone tumour in the dog (85 %), affecting mainly large and giant breed dogs[2,5]. The predilection site for osteosarcoma is the metaphysis of long bones, specifically the distal radius, proximal humerus, distal femur and proximal tibia and fibula[1]. Although there is a small peak in incidence at 1–2 years of age, the majority of cases are seen in dogs between the ages of 7–9 years[5]. Reported risk factors are size, height, and neutered dogs, the latter having a 2-fold greater risk of developing osteosarcoma of the appendicular skeleton compared to intact dogs[5]. Although only 10 % of cases have radiologically detectable pulmonary metastases at the time of diagnosis, up to 98 % of cases have pulmonary micro-metastases[1,4]. Thus, as osteosarcoma of the appendicular skeleton metastasises very early in the course of the disease, aggressive therapeutic measures must be employed to treat both the local and metastatic disease. Treatment options are either palliative or curative intent therapy. Palliative therapy includes analgesics, radiation therapy, and limb amputation. Curative intent therapy must address both local and metastatic disease. Limb amputation or limb-sparing surgery is required for local tumour excision and chemotherapy is required to address metastatic disease[12]. Mortality with curative intent therapy in cases of canine osteosarcoma is greater that 80 %. This is due to the fact that osteosarcoma of the appendicular skeleton is a highly aggressive malignant tumour with early metastasis[6]. Median survival time for dogs with osteosarcoma undergoing amputation alone is 122 to 313 days with a 1-year survival rate of 11–21 %[6]. Median survival time for dogs undergoing surgery (amputation or limb-sparing) and chemotherapy is 235 to 366 days with a 1-year survival rate of 33–65 %[7]. Dogs that have limb-sparing surgery and then develop postoperative infection have longer survival times than those cases that do not develop infection[7].

Limb amputation is the most widely used method of treating canine appendicular osteosarcoma. It is generally well tolerated by dogs, with good function and appearance, even in large and giant breeds[4,5]. Limb-sparing procedures may be considered in extremely large or obese animals, presence of generalised osteoarthrosis, neurological disease, and with client reluctance to amputation[6]. There is no difference in prognosis between limb amputation and limb-sparing surgery.

Limb-sparing techniques include the use of fresh frozen cortical allografts, bone transport osteogenesis using a modified Ilizarov apparatus, free vascularised auto graft with micro-vascular anastamosis, pasteurised autograft, and ipsilateral vascularised ulnar transposition autograft[8,10,11]. The distal radius is the site most amenable to limb-sparing techniques[6].

Cortical allograft is the most commonly used limb-sparing technique[9,10], but this procedure requires access to a bone bank, which is expensive to maintain and not freely available. Complications experienced with cortical allograft limb-sparing include infection (39–70 %), implant failure (11 %), and tumour recurrence (up to 28 %)[6,10,11]. Postoperative infection rates are high with cortical allografts because of the long surgical times, extensive exposure, poor soft tissue coverage, large amount of metallic implants, large allograft, and concurrent chemotherapy[6,10]. In severe cases surgery may be required to remove the allograft, implants or in certain cases limb amputation may be required for uncontrolled infections.

The use of a vascularised autograft could decrease complications associated with cortical allograft limb-sparing, specifically postoperative infections,[10] and would eliminate the need for a bone bank. The 2 options are using a free vascularised autograft or an ipsilateral vascularised ulnar transposition. A free vascularised autograft requires harvesting a section of ulna with its arterial supply and draining vein, positioning it in the defect created by excision of the tumour and then micro-vascular anastamosis of the blood vessels. This requires specialised equipment and skills with an increased surgical time[6,10]. The ipsilateral vascularised ulnar transposition technique or ulna rollover technique allows the use of a vascularised autograft without micro-vascular anastamosis or the prolonged time involved with transport osteogenesis. Bone transport osteogenesis involves the slow movement distally of a section of the radius across the defect to eventually meet the radio-carpal bone. The rollover technique was first described as a technique using a fibula graft in distal tibial

[a]Bryanston Veterinary Hospital, PO Box 67092, Bryanston, 2021 South Africa.

*Author for correspondence. E-mail: gregi-s@mweb.co.za

defects and applied in dogs in 2003[10].

The ipsilateral vascularised ulna transposition technique is dependent on blood supply from the caudal interosseous blood vessels and the mucoperiosteal cuff consisting of the *pronator quadratus, abductor pollicus longus* and ulnar head of the deep digital flexor[10]. Using this ulna transposition up to 40 % of the radius can be removed. The styloid process is excised together with the radius, which alleviates the need for dissection between the tumour and the styloid process. The ulna graft is then carefully rotated 90 % degrees into the defect. The *pronator quadratus* is left intact proximally but transected at the distal end of the ulna graft, the ulna head of the deep digital flexor is left intact proximally and distally while the *abductor pollicus* is transected proximally and distally. An appropriately sized dynamic compression plate is placed from the proximal radius to the distal aspect of the 3rd or 4th metacarpal bone. Two screws are placed in the ulna graft[10].

The placement of the ipsilateral vascularised ulnar autograft has several potential advantages: (1) the vascularised graft achieves clinical union more rapidly owing to its intact blood supply and also undergoes less bone resorbtion; (2) the graft undergoes hypertrophy and is more resistant to infection; (3) as the graft is obtained from the same limb it reduces morbidity and surgical time; and (4) there is no need for micro-vascular anastamosis. These factors all potentially reduce the risk of infection, fatigue fractures, and implant failure[10].

Potential disadvantages of the technique include incomplete resection of the tumour, damage to the caudal interosseous artery and vein when drilling, tapping and placing screws and shortening of the limb due to excision of part of the styloid process with the ulna. Surgical margins of the tumour may be compromised while trying to avoid damage to the caudal interosseous blood vessels and the soft tissue attachments on the ulna[10].

This paper describes the use of an ipsilateral vascularised ulnar transposition autograft together with chemotherapy in 2 dogs with osteosarcoma of the distal radius.

CASE REPORT

Case 1

An 8-year-old, 54 kilogram, neutered male rottweiler was presented with a weight bearing left thoracic limb lameness of approximately 1-month duration. Clinical examination revealed swelling of the cranial aspect of the left distal forelimb,

just proximal to the radio-carpal joint. Pain was present on flexion and extension of the radio-carpal joint. Survey radiographs of the distal forelimb showed lysis of the distal radius with a sun-burst periosteal reaction and cortical thinning (Fig. 1). A radiological diagnosis of osteosarcoma was made. Survey thoracic radiographs (left and right laterals, dorsoventral, and ventrodorsal views) showed no detectable pulmonary metastasis. Ultrasound examination of the left distal radius showed defects in the cortex of the radius. An ultrasound guided fine-needle aspirate was performed, which on cytological examination confirmed the radiological diagnosis of osteosarcoma. As the dog had bilateral osteoarthrosis of the elbows secondary to elbow dysplasia and bilateral coxarthrosis secondary to hip dysplasia, an ipsilateral vascularised ulnar transposition was done. The distal 9 cm of the left radius was excised *en bloc* including the involved soft tissues while maintaining the caudal interosseous blood vessels. A 14-hole, narrow (4.5 mm) DCP was applied to the cranial aspect of the left antebrachium and the dorsal aspect of the third metacarpal bone (Fig. 2). Perioperative analgesia was achieved with morphine (0.5 mg/kg every 4 hours, Morphine sulphate-Fresenius, Intramed, Port Elizabeth, South Africa) and carprofen (2.2 mg/kg bid, Rimadyl Injectable, Pfizer Laboratories, Sandton, South Africa). The antebrachium was shortened 23 mm from a preoperative length of 222 mm, equating to a 10.4 % shortening of the limb. After the surgery the limb was placed in a modified Robert Jones bandage. The bandage was changed after 48 hours and then every 7–10 days. The limb was kept in a modified Robert Jones for the first 8 weeks postoperatively.

Histopathology results confirmed an osteoblastic osteosarcoma and showed incomplete excision at the caudal margin.

Carboplatin (Abic Carboplatin, Teva Pharmaceuticals, Industria, South Africa) chemotherapy was started 2 days prior to surgery and repeated at 3-week intervals for 5 treatments. For each treatment the dose used was 300 mg/m^2 given intravenously.

Follow-up radiographs taken on day 12 showed no loosening of the implants and on day 28 showed good callus formation, with hypertrophy of the viable ulna graft, and no implant loosening.

On day 71 the dog was presented with a weight bearing lameness of the left foreleg. Radiographs revealed clinical union of the ulna graft to the radio-carpal bone distally but not proximally. The ulna graft had also undergone significant

Fig. 1: **Survey radiograph of the distal radius of Case 2 showing lysis of the distal radius with a sun-burst periosteal reaction and cortical thinning.**

hypertrophy. No implant failure was detected and no radiological evidence of reoccurrence of the neoplasia was detected. Radiographs taken on day 82, showed no pulmonary metastasis, complete clinical union, soft tissue swelling at the caudal aspect of the antebrachium and loosening of the most proximal screw in the radius. The loose screw was subsequently removed but the client declined a biopsy of the soft tissue swelling.

On day 126 the dog was presented with severe swelling of the distal left antebrachium, which on biopsy showed an anaplastic malignant sarcoma (Fig. 3). On day 200 the dog was presented with a complete non-weight bearing lameness of the left foreleg and severe swelling. Thoracic radiographs were clear of detectable metastases. A forelimb amputation including the scapula was performed. Histopathology of the prescapular lymph node revealed no neoplastic transforma-
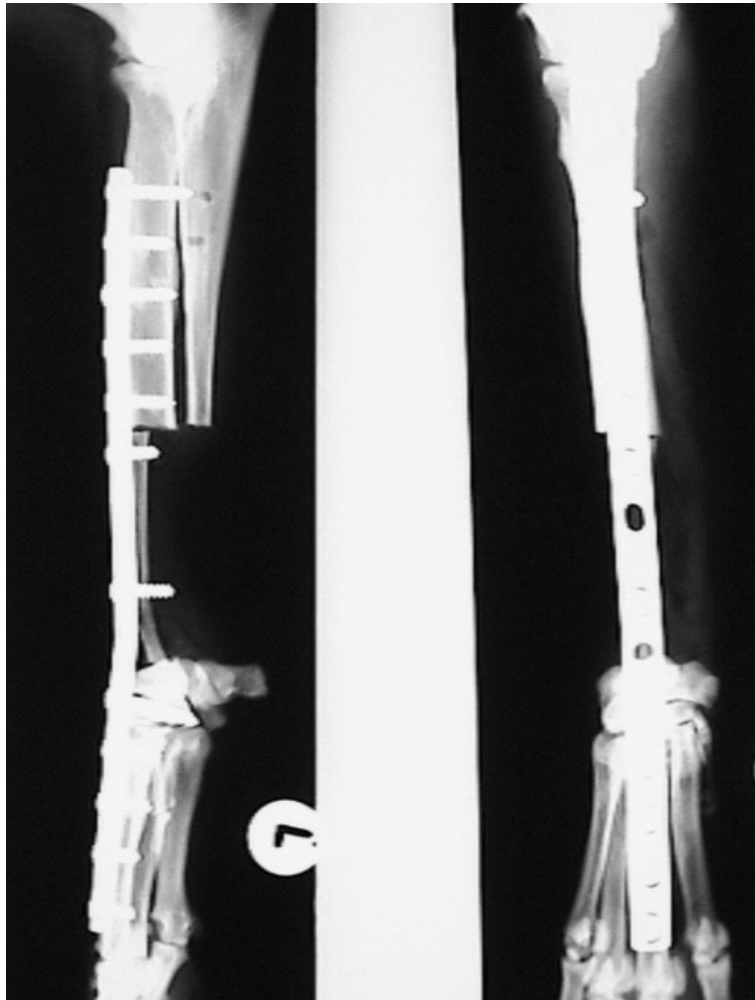
Fig. 2: **Latero-medial and cranio-caudal radiographs of Case 1 taken immediately after limb-sparing surgery.**

Fig. 3: **Radiograph of Case 1 showing soft tissue swelling** (thin arrows) **and increased radiopacity caudal to the ulna graft. This was biopsied and proved to be local tumour recurrence. Hypertrophy of the ulna graft is clearly visible** (thick arrows).

tion. Post surgery the dog made an uneventful recovery and coped well with the amputation. The dog was euthanased on day 464 because of severe generalised osteoarthrosis.

Case 2

A 10-year-old, 53 kilogram neutered male Pointer cross was presented with a histologically confirmed osteosarcoma of the left distal radius. On clinical examination pain and swelling were evident around the left distal antebrachium. Survey thoracic radiographs (left and right laterals, dorsoventral, and ventrodorsal views) showed no detectable pulmonary metastasis.

An ipsilateral vascularised ulnar transposition graft was performed. A narrow 4.5 mm DCP was applied to the cranial aspect of the remaining radius and the dorsal aspect of the third metacarpal bone. Perioperative analgesia was achieved with morphine (0.5 mg/kg every 4 hours, Morphine sulphate-Fresenius, Intramed, Port Elizabeth, South Africa)) and carprofen (2.2 mg/kg bid, Rimadyl Injectable, Pfizer Laboratories, Sandton, South Africa). The antebrachium was shortened

21 mm from a preoperative length of 212 mm, equating to a 10 % shortening of the limb. The limb was placed in a modified Robert Jones bandage, which was changed after 48 hours and then every 7–10 days. The limb was kept in a modified Robert Jones for the first 8 weeks postoperatively.

Carboplatin (Abic Carboplatin, Teva Pharmaceuticals, Industria, South Africa) chemotherapy was started on the day of surgery and repeated at 3-weekly intervals for 3 treatments. The dose used was 300 mg/m^2 given intravenously.

On day 16, follow-up radiographs showed that the ulna graft appeared viable but there was loosening of the screws placed in the radius as well as a longitudinal fissure in the distal end of the radius (Fig. 4). The loose screws were replaced with longer screws that engaged the ulna as well. The limb was maintained in a modified Robert Jones bandage.

On day 45 radiographs showed loosening of the 3 proximal screws with evidence of osteomyelitis. The loosened screws were replaced, once again engaging the ulna, and nuts were placed on the screws caudal to the ulna (Fig. 5). A swab taken
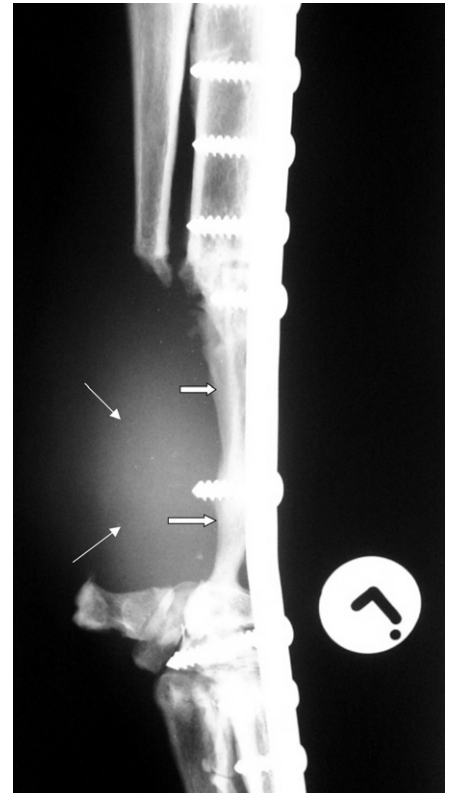
from the surgical site yielded a pure growth of *Pseudomonas aeruginosa*. The dog was treated with ciprofloxacin (Ciploxx, Cipla Life Sciences, Belville, South Africa) at 11 mg/kg bid for 21 days.

Follow-up radiographs on day 57 showed no progression of the osteomyelitis and
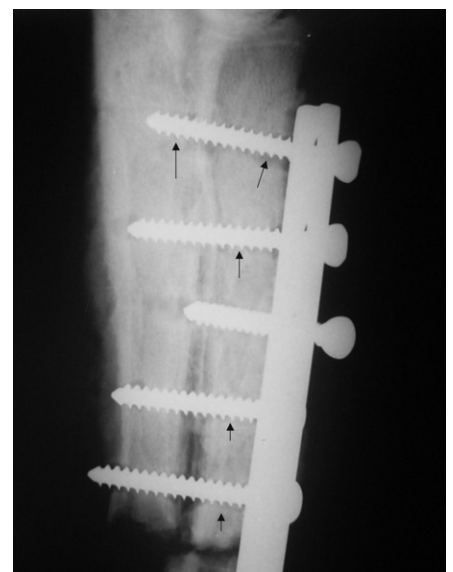

Fig. 4: **Radiograph of the proximal radius of Case 2 showing loosening of all 5 screws, with clear lysis present around all screws** (black arrows).
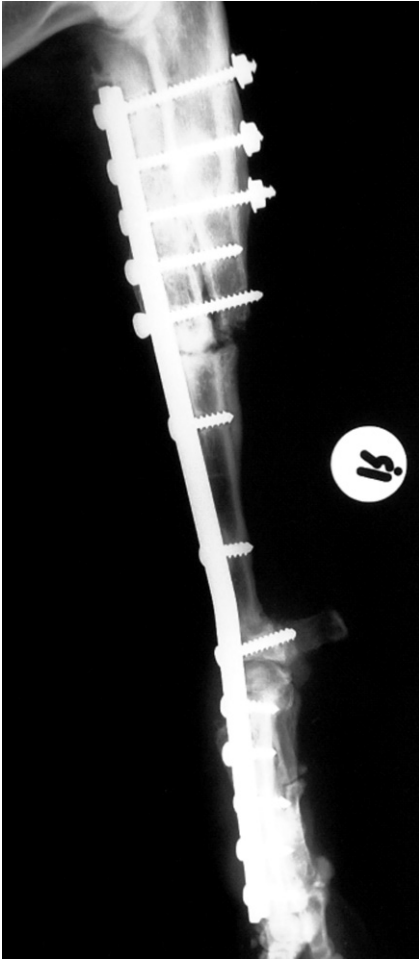
Fig. 5: **Case 2 following revision surgery and placement of nuts on the three proximal screws. Hypertrophy of the ulna is clearly evident.**

no loosening of the implants. By day 66 the limb function had improved significantly and thoracic radiographs detected no evidence of pulmonary metastasis. Radiographs of the limb revealed that the osteomyelitis was resolving and no implant loosening was evident. At that point new bone formation was evident between the ulnar graft and radius proximally and radio-carpal bone distally and the graft was showing hypertrophy.

On day 86 radiographs showed complete resolution of the osteomyelitis with no implant loosening. By day 130 function of the operated limb was excellent and thoracic radiographs were clear of metastatic disease. Clinical union of the ulna graft to the radius and radio-carpal bone was observed on radiographs taken on day 157.

On day 341 the dog was presented with acute left forelimb lameness. Radiographs showed loosening of all the screws and the distal end of the plate had lifted off the dorsal surface of the third metacarpal bone (Fig. 6). As the ulna graft was completely fused to the radius and radio-carpal bone, the plate and all screws were removed (Fig. 7). Post-surgery limb
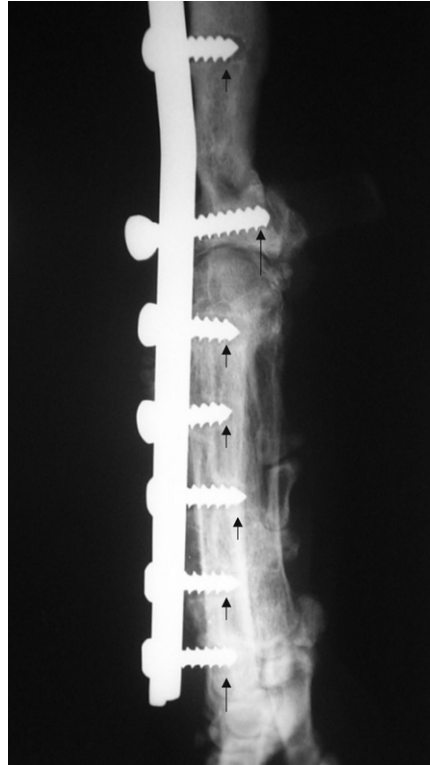

Fig. 6: **Loosening of all screws in Case 2, showing clear areas of lysis are visible around all the screws** (black arrows).

function remained excellent.

On day 381 the dog presented with a history of sudden episodes of pain and crying. Clinical examination revealed no limb pain or discomfort and limb function was good. Neck pain was detected, especially on dorso-flexion and left lateral flexion. Survey radiographs of the cervical vertebrae revealed a narrowed disc space between C_5 and C_6. A cisternal myelogram showed a left sided extradural compression of the spinal cord in the mid body of C_6. Mild lysis was also detected in the left pedicle and left cranial articular facet of C_6. A MRI scan confirmed the myelogram findings and was suggestive of neoplasia. The diagnostic imaging findings were confirmed on dorsal laminectomy, performed from C_5 to C_7. Impression smear cytology from the tissue exerting pressure on the spinal cord showed anaplastic cells suggestive of a sarcoma. Owing to the hopeless prognosis the dog was euthanased. Histopathology confirmed a poorly differentiated sarcoma.

DISCUSSION

Osteosarcoma is the most common primary bone tumour in dogs, with the distal radius the most common site affected[1,2,4,5,7,10,11]. Treatment options include limb amputation or limb salvage procedures with or without chemotherapy[5]. Treatment without chemotherapy is, however, seldom if ever curative, as more than 90 % of cases have micrometastases
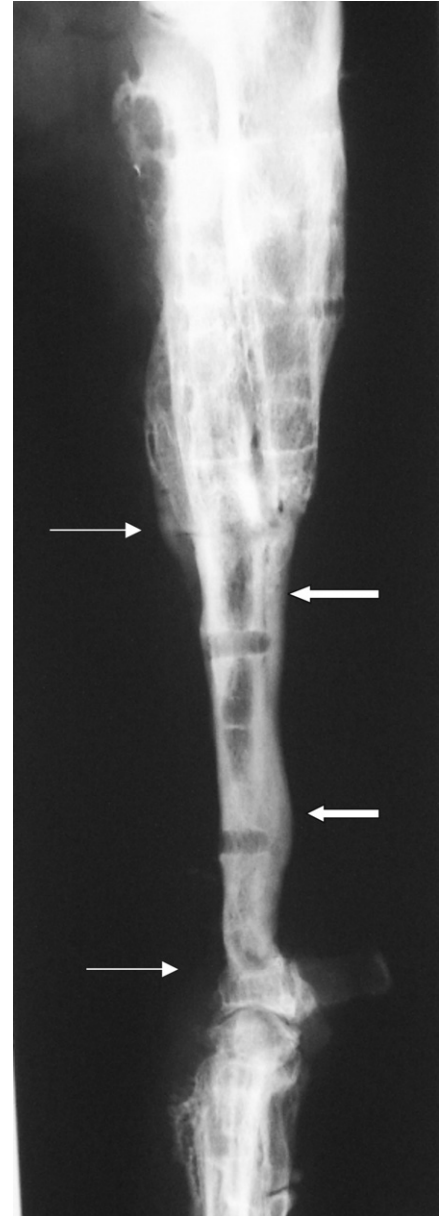

Fig. 7: **Case 2 following implant removal. There is complete union between the ulna and radius proximally and the ulna and radio-carpal bone distally** (thin white arrows). **Hypertrophy of the ulna is also clearly evident** (thick white arrows).

at the time of diagnosis[5]. Limb amputation may not be an option in certain cases, because of musculoskeletal disease, neurological disease or client refusal. In these cases limb-sparing procedures combined with chemotherapy would be the treatment option of choice.

Fresh frozen cortical allograft from a bone bank is the most widely used technique for limb-sparing surgery of the distal radius. A major disadvantage of this technique is the availability, expense, and maintenance of a bone bank[3,6,7,9,11].

The ulnar rollover technique described in these 2 cases alleviated the need for access to a bone bank. The rollover technique has the advantage over free vascularised autograft and micro-vascular

anastamosis in that it does not require specialised equipment and expertise while still having the advantage of supplying a vascularised graft[10]. It has an additional advantage of reduced morbidity (no distant donor site) and reduced surgical time.

The complications seen in Case 1 were local tumour recurrence and loosening of 1 screw. The loosening of the proximal screw after 82 days is not an uncommon complication[13] and was addressed by removing the screw with no further complications. Local recurrence of the tumour in this case was most likely due to incomplete tumour resection on the caudal aspect of the tumour. Attempts to maintain vascularity of the ulna graft during surgery may have contributed to incomplete tumour removal. In retrospect the size and extent of the tumour in this case probably made this case a poor candidate for this technique; however, the local recurrence and subsequent forelimb amputation did not compromise the overall treatment of the disease. Postsurgery the dog survived for 464 days and was euthanased for unrelated reasons.

The complications seen in Case 2 included osteomyelitis, fracture of the proximal radius, and loosening of the screws in the proximal radius. The loosening of the proximal radius screws was addressed by replacing the screws with longer screws, which penetrated the radius and ulna as well as utilising nuts on the ends of the screws. The osteomyelitis resolved uneventfully once the instability was eliminated and the dog treated with antibiotics. Complete loosening of all the screws and the plate occurred by day 341 by which time clinical union had been achieved and the implants were removed. This dog survived for 387 days following the initial surgery and was euthanased after 387 days due to the development of, most likely, a metastatic sarcoma in the body of C_6.

Clinical union was successfully achieved in both these cases, by day 82 in Case 1 and day 157 in Case 2. The delay in Case 2 was most likely due to the implant loosening, osteomyelitis, and 2 revision surgeries. Hypertrophy of the autograft was clearly visible radiologically from an early stage in Case 1. This indicates that vascularity of the graft was maintained and aided in strengthening the graft.

Bio-mechanically the ulna rollover technique is not as strong as a cortical allograft technique. The ulna rollover graft was shown to fail by cranial bending of the plate in a biomechanical cadaver study[10]. This was not seen in either of the clinical cases described in this report. As with pancarpal arthrodesis, 80 % or greater coverage of the metacarpal bone with the plate significantly reduces the risk of metacarpal bone fracture[13]. The results of the biomechanical study suggest that ulna rollover limb-sparing cases should have external coaptation bandages for the immediate postoperative period. Both cases in this report had modified Robert-Jones bandages for a minimum of 8 weeks postoperatively.

In these 2 cases, limb shortening did not appear to result in major mobility problems. Limb function was evaluated subjectively by both the authors and owner and was judged to be good to excellent. The gait abnormalities seen were due to the pancarpal arthrodesis and thus mechanical in nature.

Both dogs were treated with carboplatin chemotherapy as this is a well-tolerated chemotherapeutic drug that can be given safely every 21 days at a dose of 300 mg/m^2. In a study using limb amputation combined with carboplatin the median survival time was 321 days[2], which is comparable with the dogs reported in this article.

Although both cases developed complications associated with the surgery, the ulna rollover technique is a technique that can be considered for limb-sparing surgery in the dog. The risk of major infection associated with this technique is reduced to a certain extent and the ability to resolve any infection is also increased by the vascularity of the graft. The most significant potential problem in our opinion is that of complete tumour excision. This technique is therefore best used for those cases with small tumour size that have not broken through the cortex, especially caudally.

REFERENCES

1. Berg J 1996 Canine osteosarcoma – amputation and chemotherapy. *Veterinary Clinics of North America: Small Animal Practice* 26: 111–121
2. Bergman P J, MacEwen E G, Kurzman I D, Henry C J, Hammer A S, Knapp D W, Hale A, Kruth S A, Klein M K, Klausner J, Norris A M, McCaw D, Straw R C, Withrow S J 1996 Amputation and carboplatin for treatment of dogs with osteosarcoma: 48 cases (1991 to 1993). *Journal of Veterinary Internal Medicine* 10: 76–81
3. Buracco P 2002 Pasteurised tumoural autograft as a novel procedure for limb sparing in the dog: a clinical report. *Veterinary Surgery* 31: 525–532
4. Dernell W S 2003 Limb-sparing surgery for dogs with bone neoplasia. In Slatter D (ed.) *Textbook of small animal surgery* Vol. 2 (3rd edn). W B Saunders, Philadelphia: 2272–2284
5. Garzotto C 2003 Canine appendicular osteosarcoma. In Slatter D (ed.) *Textbook of small animal surgery* Vol. 2. (3rd edn). WB Saunders, Philadelphia: 2460–2474
6. Liptak J M, Dernell W S, Ehrhart N, Withrow S J 2004 Canine appendicular osteosarcoma: diagnosis and palliative treatment. *Compendium on Continuing Education for the Practicing Veterinarian* 26: 172–182
7. Liptak J M, Dernell W S, Ehrhart N, Withrow S J 2004 Canine appendicular osteosarcoma: Curative intent treatment. *Compendium on Continuing Education for the Practicing Veterinarian* 26: 182–196
8. MacEwen E G 1996. Canine osteosarcoma: Amputation and chemo-immunotherapy. *Veterinary Clinics of North America: Small Animal Practice* 26: 123–133
9. Morello E 2003 Pasteurised tumoral autograft and adjuvant chemotherapy for the treatment of canine distal radial osteosarcoma: 13 cases. *Veterinary Surgery* 32: 539–544
10. Pooya H A, Séguin B, Mason D R, Walsh P J, Taylor K T, Kass P H, Stover S M 2004 Biomechanical comparison of cortical radial graft versus ulnar transposition graft limb-sparing techniques for the distal radial site in dogs. *Veterinary Surgery* 33: 301–308
11. Sequin B 2003 Use of an ipsilateral vascularised ulna transposition autograft for limb-sparing surgery of the distal radius in dogs: an anatomic and clinical study. *Veterinary Surgery* 32: 69–79
12. Straw R C 1996 Limb-sparing surgery *versus* amputation for dogs with bone tumors. *Veterinary Clinics of North America: Small Animal Practice* 26: 135–143
13. Whitelock R G, Dyce J, Houlton J E F 1999 Metacarpal fractures associated with pancarpal arthrodesis in dogs. *Veterinary Surgery* 28: 25–30