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Revision Surgery of Osteolysis of Carpal Bones Caused by Osteomyelitis after Pancarpal Arthrodesis with an En bloc Corticocancellous Bone Autograft

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Abstract

Various complications have been reported after pancarpal arthrodesis, but to our knowledge, no reports of complete carpal bone osteolysis leading to failure of the pancarpal arthrodesis have been described. Possible causes in our cases include primary or surgical trauma, as well as bone infections. The revision surgery in our cases employed a corticocancellous bone autograft from the iliac wing, which has been successfully used in nonunion fractures to refill bone defects. In both cases the graft was accepted well, complete bone fragment ingrowth and remodelling, and a stable arthrodesis of the carpal joint was achieved. In subsequent rechecks, the animals displayed good weight-bearing on the afflicted limbs.

Keywords
- surgical-site infection
- revision surgery
- bone defect healing

Introduction

Pancarpal arthrodesis is a salvage procedure after carpal trauma, degenerative joint disease, and hyperextension injuries of the carpal joint.[1] Good clinical results have been previously reported. Owner questionnaires have reported an improvement in gait in 97% of cases and more than two-thirds described no or only a mild lameness.[2,3]

Pancarpal arthrodesis can be achieved using plates with screws or external skeletal fixator configurations to provide stability while the fusion progresses.[1] Complications occur in 7 to 50% of patients.[4–7] Common complications including implant failure such as screw loosening and implant breakage, infection, metacarpal bone fractures, implant sensitivity, incomplete bone fusion, and continual gait abnormalities.[4–7] In the veterinary literature, osteolysis of carpal bones has been reported spontaneously without any specific trauma in three cases.[8–10] Repetitive trauma and vascular pathologies were the suspected etiologies and the lameness resolved after pancarpal arthrodesis.[8–10] In human medicine, osteolysis of the carpal bones, such as Kienboeck's and Preiser's disease, is recognized. The etiology of these is unclear, but repetitive trauma, immune-mediated diseases, and the activation of inflammatory and coagulation factors (potentially genetic) are suspected etiologies that trigger intraosseous venous thrombosis and resulting in osteolysis of the proximal carpal bones.[11,12]

En bloc corticocancellous bone grafts are reported to treat larger bone defects in small animals and human medicine.[13,14] In addition to the osteogenic, osteoinductive, and osteoconductive aspects, immediate mechanical support is provided to the construct when compared with the commonly employed cancellous autografts.[14]

This report describes two cases of pancarpal arthrodesis with complications resulting in osteolysis of the intermedioradial carpal bone treated successfully with revision surgery including an en bloc corticocancellous bone autograft.

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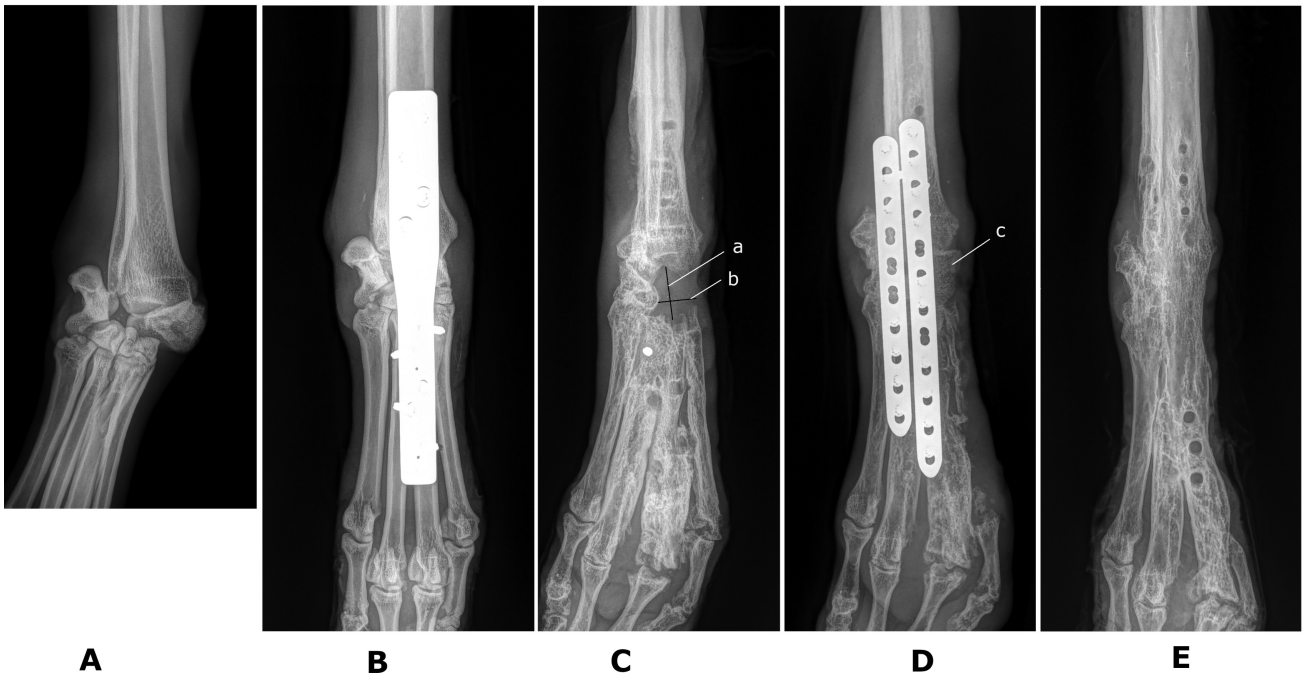

Fig. 1 Serial dorsopalmar radiographs of the affected right carpus of Case 1. (**A**) Preoperative radiograph. Dorsopalmar (oblique) view of the right carpal region with luxation of the carpus through the ulnocarpal/intermediocarpal joint and intercarpal joint. (**B**) Postoperative radiograph. The arthrodesis was stabilized with a dorsally positioned 3.5/2.7 Castless Pancarpal Arthrodesis Plate. (**C**) Dorsopalmar radiograph following implant removal, five months after arthrodesis surgery. Note the bone loss in the proximomedial region of the carpal joint and the osseous deformations of the metacarpal bones. Dimensions of the defect: a = 17 mm; b = 12 mm. The metallic residue in the 4th metacarpal bone is a broken screw. (**D**) Dorsopalmar radiograph after the revision surgery: the bone defect was filled with a corticocancellous bone autograft. Two dorsal positioned 2.7-mm LCP plates positioned dorsally on the third and fourth metacarpal bones were used to stabilize the arthrodesis. The corticocancellous graft is locked in place with two locking screws placed through the medial plate. c = corticocancellous graft. (**E**) Dorsopalmar radiograph after full implant removal 11 months after revision surgery. Note the complete ingrowth of the graft and the remodeling of the carpal area.

Case 1

A 7-year-old 24 kg Galgo Español was referred after a fall from a height. The dog sustained a multifragmentary diaphyseal radius and ulna type 1 open fracture on the left side and a carpal hyperextension injury with luxation of the carpus through the ulnocarpal/intermediocarpal joint and intercarpal joint on the right side (►**Figs. 1**, **2**). One the patient was stable intravenous antibiotic (amoxicillin/clavulanic acid 20 mg/kg) on an empirical basis. Postoperatively, antibiotics were continued orally three times per day (amoxicillin/clavulanic acid 20 mg/kg). General anesthesia was induced (methadone 0.4 mg/kg; midazolam 0.2 mg/kg; propofol 2 mg/kg, and inhalation anesthesia sustained by isoflurane) and the antebrachial fractures were stabilized with a 2.7-mm LCP plate (DePuy Synthes Vet, Johnson & Johnson, West Chester, Pennsylvania, United States) placed medially on the radius and a 2.7-mm LCP plate laterally on the ulna. Robert Jones bandages were applied bilaterally. After 4 days, a standard pancarpal arthrodesis was performed on the right side using a dorsal approach to the carpus.[15,16] The intermedioradial carpal bone was reduced, the articular cartilage was removed with a high-speed burr to the level of the subchondral bone, a cancellous bone graft was harvested from the ipsilateral ileal wing and placed in each level of the debrided joint. A 3.5/2.7 Castless Pancarpal Arthrodesis Plate (Orthomed West Yorkshire, United Kingdom) was used to stabilize the carpus with screws in the distal radius, intermedioradial carpal bone, and metacarpal bones 3 and 4 without interfragmentary compression (►**Figs. 1**, **2**). A Robert Jones bandage was applied. Three days after surgery, the toes were colder and edematous. A week later, the distal phalanx of the third and fourth toes began to produce purulent discharge from the nail base and was cold and painful, indicating insufficient distal limb perfusion and necrosis. Seventeen days following surgery, the surgical wound showed signs of redness and discharge as well as a distal wound breakdown. A bacteriological culture was taken and *Enterobacter cloace* was cultured with a multiple resistance pattern. Antibiotic treatment was adjusted based on the sensitivity results to marbofloxacin (2 mg/kg oral every q 24 hours for 6 weeks). Clinical signs improved but the distal phalanx of the third and fourth toes had to be amputated in the distal interphalangeal joint under general anesthesia (methadone 0.4 mg/kg, midazolam 0.2 mg/kg, propofol 2 mg/kg, and inhalation anesthesia sustained by isoflurane).

Six weeks later, a plate break of the radius occurred. The fracture was revised with a dorsal positioned 3.5-mm LCP plate. In the subsequent follow-ups, the fracture healed uneventfully.

Five months postoperatively, the animal developed a swelling at the site of the carpal arthrodesis. Infection and an unstable implant were suspected and we elected to remove the implant. In the postoperative radiographs, bone loss in the area of the intermedioradial carpal bone

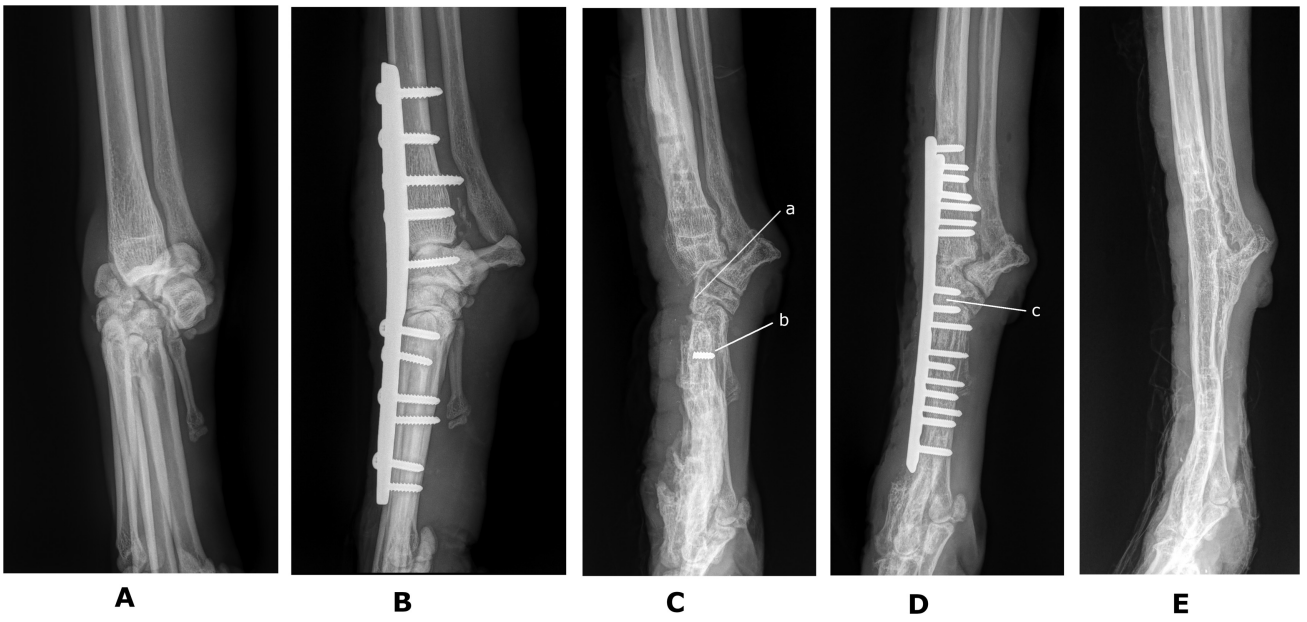

Fig. 2 Serial mediolateral radiographs of the affected right carpus of Case 1. (**A**) Preoperative radiograph. Mediolateral (oblique) view of the right carpal region with luxation of the carpus through the ulnocarpal/intermediocarpal joint and intercarpal joint. (**B**) Postoperative radiograph. The arthrodesis was stabilized with a dorsally positioned 3.5/2.7 Castless Pancarpal Arthrodesis Plate. (**C**) Mediolateral radiograph following implant removal, 5 months after arthrodesis surgery. Note the bone loss in the proximal region of the carpal joint and the osseous deformations of the metacarpal bones. The metallic residue in the metacarpal bone is a broken screw. (**D**) Mediolateral radiograph after the revision surgery. The bone defect was filled with a corticocancellous bone autograft. Two dorsal positioned 2.7-mm LCP plates positioned dorsally on the third and fourth metacarpal bones were used to stabilize the arthrodesis. The corticocancellous graft is locked in place with two locking screws placed through the medial plate. c = corticocancellous graft. (**E**) Mediolateral radiograph after full implant removal 11 months after revision surgery. Note the complete ingrowth of the graft and the remodeling of the carpal area.

was evident (►**Figs. 1**, **2**). A Robert Jones bandage was applied and antibiotics were administered according to an antibiogram for 3 weeks (*Actinomyces* spp. treated with amoxicillin/clavulanic acid 20 mg/kg q 12-hour oral). After 4 weeks, there was no evidence of infection and a pancarpal arthrodesis was planned. Consequently, the bone defect was measured on dorsopalmar radiographs (12×17 mm) (►**Fig. 1**) and a slightly bigger corticocancellous bone graft (13×20 mm) from the iliac wing was harvested as described by Camilletti and d'Amato.[13] An incision was made along the craniodorsal edge of the contralateral iliac wing. The gluteal muscle was elevated and two dorsoventral and a lateromedial cut across the cranial dorsal iliac spine were made using an oscillating saw. Thus, we harvested a graft with three open edges (►**Fig. 3**).

The graft was then fitted to the defect with the previous dorsal surface medially and the arthrodesis was fixed with two 2.7-mm LCP plates positioned dorsally on the third and fourth metacarpal bones (►**Figs. 1**, **2**). The graft was locked in place with two locking screws placed through the medial plate. A partial excision of the second metacarpal bone was necessary due to its instability and to assist wound closure. Prophylactic antibiotics were administered for 10 days (-amoxicillin/clavulanic acid 20 mg/kg q 12-hour oral) and a Modified Robert Jones bandage was applied. After 12 weeks, the animal developed a fistula in the lateral part of the carpus. Radiographically, radiolucent halos around the proximal screws were noted and an infection was confirmed with a bacteriological culturation. *Bacteroides* spp. was cultured and antibiotics were started according to the antibiogram (amoxicillin/clavulanic acid 20 mg/kg q 12-hour oral) until 5 months after revision surgery, the lateral plate was removed and a following negative bacteriological swab. Because residual infection remained, the implant was fully removed 6 months later (►**Fig. 4**). In subsequent checkups, the animal demonstrated good weight-bearing of the affected limb, with only slight lameness on hard ground. This was

Fig. 3 Laterolateral oblique view of the left ileal wing of Case 1. Dimensions of the harvested corticocancellous graft; a = 20 mm; b = 13 mm.

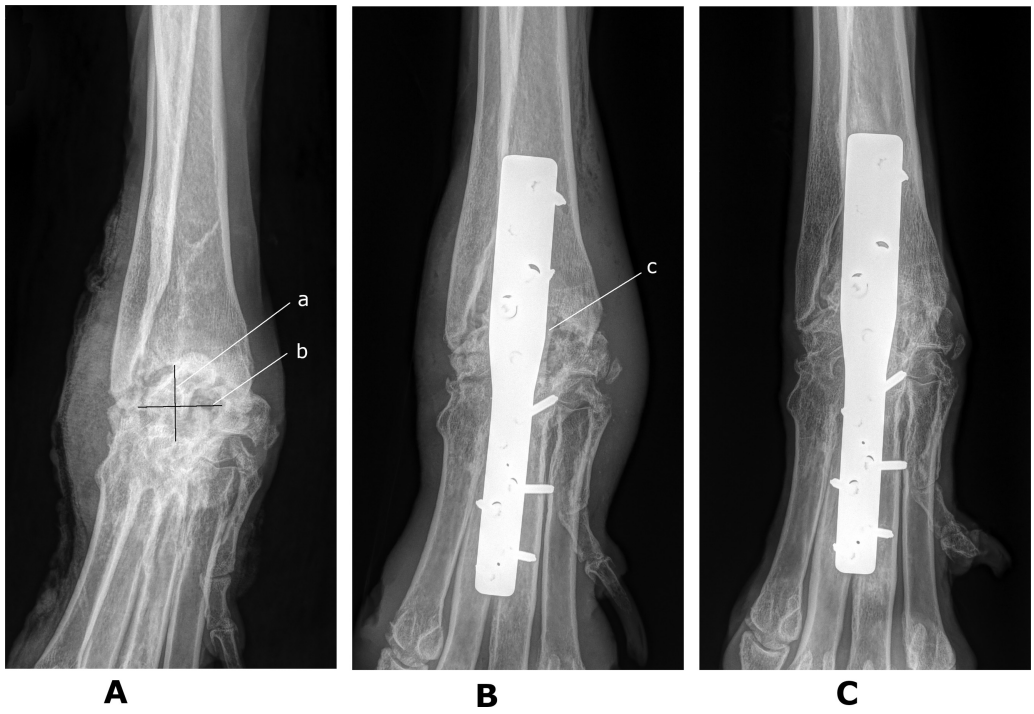

Fig. 4 Serial dorsopalmar radiographs of the affected right carpus of Case 2. (**A**) Dorsopalmar radiograph of the right carpal region. Note the osseous defect in the proximal axial area. Dimensions of the defect: a = 18 mm; b = 22 mm. (**B**) Postoperative radiograph. The bone defect was filled with a corticocancellous bone autograft and the carpus was stabilized with a dorsal positioned 3.5/2.7 Castless Pancarpal Arthrodesis Plate. The corticocancellous graft is locked in place with a cortex screw placed through the plate. c = corticocancellous graft. (**C**) Twelve-week postoperative. The implants are in situ and the autograft is well incorporated.

linked to alterations in the digits. The bone transplant was well incorporated and bridged on radiographs.

Case 2

A 2-year-old 46 kg Rhodesian Ridgeback was presented with bilateral forelimb lameness. One year ago, the animal suffered a bilateral hyperextension injury of the carpal joint. Bilateral arthrodesis had been performed. Some months later, the animal developed a bilateral deep infection, and the implants were removed 7 months after surgery. On presentation, the dog had a bilateral forelimb lameness with pain and instability in the carpal joints. The left carpus had a dorsopalmar instability of 10 degrees and radiographically there was no visible fusion to the antebrachiocarpal joint level. The right carpus had a dorsopalmar instability of 25 degrees, a painful dorsal swelling, and the superficial cervical lymph node on the right side was enlarged. Two weeks later, a standard pancarpal arthrodesis was performed on the left side and both limbs were kept under soft padded bandages.[16] The left leg healed uneventfully. Computed tomography scans from the right carpus showed a loss of bone matrix in the central/lateral intermedioradial carpal bone (►**Fig. 5**). In the following surgery, the suspected lytic and infected area was debrided with the removal of all visually altered tissue and samples were taken for bacteriological and histologic analysis (►**Figs. 5**, **6**). The area was flushed and permitted to heal as an open wound by second intention supported with a Robert Jones bandage (►**Fig. 1**). Histologically, a chronic infection containing hair follicles was apparent with no evidence of neoplasia. Bacteriological culture confirmed the infection with *Staphylococcus pseudintermedius* and antibiotics were adjusted according to the sensitivity results for 4 weeks (amoxicillin/clavulanic acid 20 mg/kg q 12-hour oral).

Eight weeks later, the wound had healed by second intention with no clinical evidence of infection. A pancarpal arthrodesis was performed. With a dorsal approach, the articular cartilage was debrided to the level of subchondral bone with a high-speed burr. A corticocancellous graft was

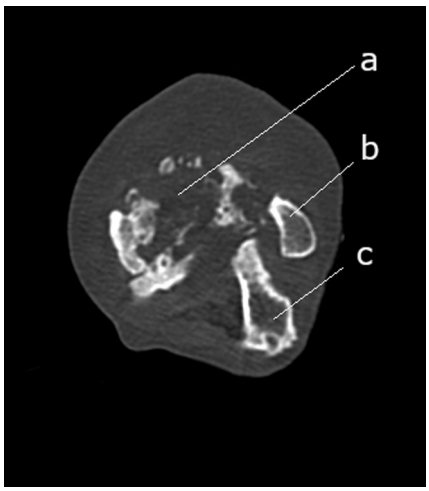

Fig. 5 Transversal computed tomography image of the affected right proximal carpal row of Case 2. Osteolysis in the region of the intermedioradial carpal bone is evident. (a) intermedioradial carpal bone, (b) ulnar carpal bone, (c) accessory carpal bone.

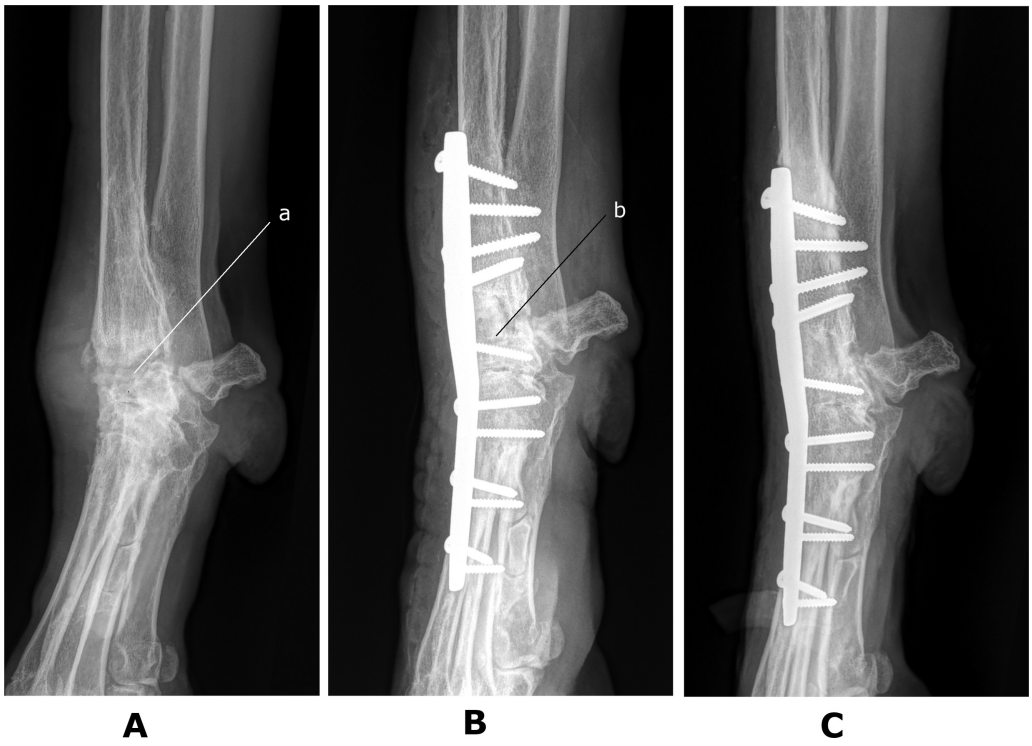

Fig. 6 Serial mediolateral radiographs of the affected right carpus of Case 2. (**A**) Mediolateral radiograph of the right carpal region. Note the osseous defect in the proximal axial area. a: osseous defect. (**B**) Postoperative radiograph. The bone defect was filled with a corticocancellous bone autograft and the carpus was stabilized with a dorsal positioned 3.5/2.7 Castless Pancarpal Arthrodesis Plate. The corticocancellous graft is locked in place with a cortex screw placed through the plate. b = corticocancellous graft. (**C**) Twelve-week postoperative. The implants are in situ and the autograft is well incorporated.

harvested from the ipsilateral ileal wing similar to Case 1. The prior dorsal cortical surface of the graft was removed to open the medullary cavity. The graft was fitted to the bone defect with the prior dorsal surface proximal and the arthrodesis was stabilized with a dorsal positioned 140-mm 3.5/2.7 Castless Pancarpal Arthrodesis Plate without interfragmentary compression. The graft was locked in place with a cortex screw placed through the plate (►**Figs. 4**, **6**). Prophylactic antibiotics were administered for 2 weeks (amoxicillin/clavulanic acid 20 mg/kg q 12-hour oral). Robert Jones bandages were applied for the first 4 weeks with regular bandage changes. In the postoperative follow-ups after 6 and 12 weeks, good healing and symmetric weight-bearing were observed with no evidence of infection (►**Fig. 3**).

Discussion

This manuscript describes osteolysis of carpal bones as a complication in two cases following pancarpal arthrodesis, which was successfully treated with an en bloc corticocancellous bone autograft. This is a complication that has not been reported before in veterinary literature. To our knowledge, this is also the first mention of revision surgery on a pancarpal arthrodesis applying an en bloc corticocancellous bone autograft.

Both patients had bilateral forelimb trauma, needing surgical stabilization on both sides. As with other bilateral orthopaedic operations, this can increase the complication rate.[17] Pancarpal arthrodesis has a high postoperative complication rate, which is rather significant when compared with other orthopaedic surgeries. Both of our cases developed surgical-site infections that necessitated implant removal. Osteomyelitis can cause destruction and necrosis of trabecular bone as well as lysis of bone tissue.[18,19] So far, however, osteolysis of carpal bones has not been reported in the literature. To lower the postoperative risk of infection following carpal arthrodesis, the use of antibiotic-impregnated beads might be considered, as stated in a prior study.[20]

Other causes of bone lysis include stress shielding, disuse and loose implants, significant vascular injury, excessive interfragmentary motion, and, in later stages, fracture-associated sarcoma.[21] In Case 2, a histological examination indicated a persistent infection without any signs of neoplasia. The following follow-up assessments in neither of our cases showed any signs of neoplasia.

Vascular injury should be considered in the development of bone lysis. In Case 1, the intermedioradial carpal bone was completely luxated, and the animal showed reduced perfusion in the distal limb a few days following pancarpal arthrodesis fixation. The vascular supply of the scaphoid and lunate bones (corresponding to the intermedioradial carpal bone) has been extensively investigated in human medicine. The majority of the blood supply for the scaphoid bone originates in a branch of the radial artery, and vascular injury to these arteries plays a role in the development of the condition.[22] Such detailed description is not available in veterinary medicine. Anatomical illustrations depict vascular foramina in the bone's middorsal

and palmarodistolateral surfaces. The dorsal nutrient artery is considered to receive blood from the dorsal carpal rete through the radial artery and a branch of the caudal interosseous artery.[23] The palmar vascular supply originates from the deep palmar arch.[23] Trauma and luxation of the intermedioradial carpal bone in Case 1, as well as the standard procedure of removal of the articular cartilage for pancarpal arthrodesis, can contribute to vascular damage. Additionally, Case 1 experienced inadequate distal limb perfusion following surgery. A reason might be increased interstitial pressure following wound closure or an ischemic bandage injury caused by the postoperative bandages.

Screw insertion problems have been reported as a complication of Castless Pancarpal Arthrodesis Plates, as seen in Case 1's postoperative radiographs. (►**Figs. 1**, **2**).[4]

Cancellous autografts are routinely used during pancarpal arthrodesis to encourage fusion. The osteogenic, osteoinductive, and osteoconductive activities, as well as the graft's mild immunologic reactivity, making it extremely beneficial in carpal arthrodesis.[14] En bloc corticocancellous bone autografts provide an additional advantage of mechanical stability and provide substance for larger bone defects.[14] In veterinary medicine, they are successfully used for larger bone defects like atrophic nonunions or carpal arthrodesis and are usually harvested from the iliac wing or a rib.[13,24,25] We accepted the increased operating time and the possibility of donor-site complications, which did not occur in our two patients. The postoperative radiographs showed a good incorporation of the graft with no signs of sequestrum formation, although postoperative infection was present in Case 1. A reasoned case report describes how a 3D-printed porous titanium implant was used to treat a larger bone defect in the antebrachium.[26] Such implants could have been an alternative in such cases.

This case report describes two cases of carpal bone lysis following pancarpal arthrodesis, most likely caused by infections or vascular injuries. En bloc corticocancellous bone autografts were used successfully to restore the bone defects. Both cases demonstrated robust graft incorporation without lysis as well as full carpal union. En bloc corticocancellous bone autografts showed good clinical results and may therefore be considered as a therapy option for bigger bone defects when performing pancarpal arthrodesis.

Authors' Contributions

M.S. assisted in the surgeries, obtained follow-up, and wrote the manuscript. P.R.K. edited the manuscript and the radiographs. M.U. performed the surgery, obtained follow-up, and edited the manuscript.

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None.

Conflict of Interest

None declared.

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