Use of an Autologous Bone Graft Derived from Three Caudal Vertebrae for Reconstruction in a Dog with Radioulnar Atrophic Nonunion and Osteomyelitis

Masato Goto[1,2] Hitoshi Ikeda[1]

[1] All Heart Animal Referral Centre, Machida, Japan
[2] Daktari Animal Hospital Machida Doggy League, Machida, Japan

Address for correspondence Masato Goto, DVM, All Heart Animal Referral Centre, 1-22-14 Kanaigaoka, Machida, Tokyo 195-0076, Japan (e-mail: mdrgums07@gmail.com).

VCOT Open 2022;5:e93–e97.

Abstract

This case report describes the case of a 4-year-old toy poodle who underwent reconstruction using an autologous caudal vertebral graft for nonunion and osteomyelitis of a left radioulnar fracture. Radial reconstruction was performed 14 days after the removal of existing implants. Three autologous caudal vertebrae mounted onto a titanium T-plate were used to fill the radial bone defect. Rehabilitation was initiated 3 weeks after surgery. By the fifth week after surgery, the dog showed weight bearing on the affected limb. One year after the reconstruction surgery, revision surgery for replacing all implants was performed due to increased radiolucency of the graft. The dog remained clinically stable, and radiographic bone union was complete 3 years and 2 months after the first surgery. An autologous caudal vertebral graft was successfully used for the treatment of a large radial defect in a dog suffering from atrophic nonunion. Clinical improvement was prompt, and the long-term functional outcome was satisfactory.

Keywords
- vertebrae graft
- large bone gaps
- nonunion

Introduction

Nonunion is a serious complication of bone fracture management and is caused by inappropriate reduction, inadequate stability, insufficient blood supply, infection, and bone defects.[1] Radioulnar nonunion is more common in toy breeds than in large breed dogs, likely due to reduced intraosseous blood supply at the distal radius.[2]

Although amputation may be considered in such cases of uncontrollable infection or extensive bone resorption, bone grafting is a valid treatment option to preserve the limb and to achieve reduction and healing. Cortical bone grafting provides mechanical support and contributes to structural stability and thus might be necessary to bridge larger bone defects.[3] In small-animal surgery, the ilium and ribs are generally used as autologous cortical bone grafts.[3] However, disadvantages associated with the use of autografts include limitations of donor sites and bone mass. We performed and reported autologous bone grafting using vertebrae harvested from the dog's tail for bridging of a large radioulnar bone defect as a consequence of nonunion in a toy-breed dog.

Materials and Methods

Case History

A 2.7-kg, 4-year-old, male toy poodle was referred for left radioulnar diaphyseal nonunion. On initial presentation, the dog was alert with non-weight-bearing lameness on the left forelimb (numeric lameness score: 5/5) with severe pain (Colorado State University pain scale score: 4/4).[4,5] The plasma C-reactive protein concentration was also elevated (2.95 mg/dL, RI: 0–1 mg/dL). Radiographic examination revealed implant loosening and atrophic nonunion (►**Fig. 1A**).

received
June 20, 2021
accepted after revision
May 13, 2022

DOI https://doi.org/10.1055/s-0042-1751070.
ISSN 2625-2325.

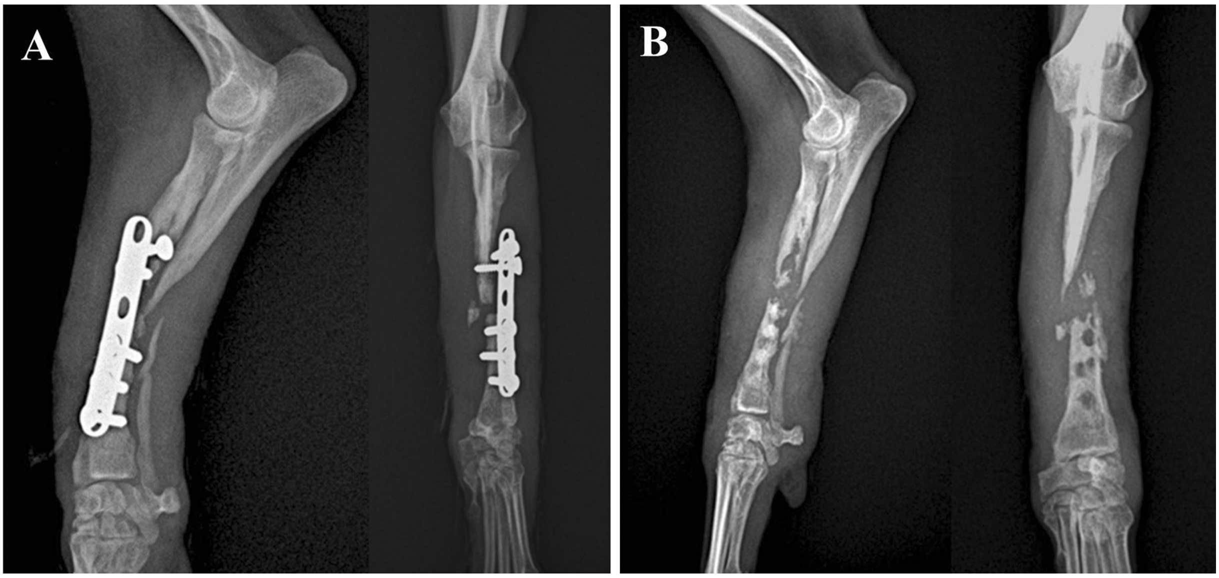

Fig. 1 (**A**) Lateral (*left*) and craniocaudal (*right*) radiographs of the left radius and ulna at initial presentation. Implant loosening and atrophic nonunion of the left radius and ulna were noted. The radiolucency was increased at the proximal one-third of the radius. (**B**) Lateral (*left*) and craniocaudal (*right*) radiographs of the left forelimb after implant removal. Bone defects, severe bone atrophy, and swollen soft tissues were present in the left forelimb.

Implant Removal and Bacterial Culture

Infection and osteomyelitis were suspected based on the radiographic findings and blood test results; therefore, the implants were removed, and the affected area was thoroughly cleansed under general anesthesia on first presentation (►**Fig. 1B**). Bacterial culture and antibiotic susceptibility testing revealed methicillin-resistant coagulase-negative staphylococcus infection; therefore, Fosfomycin (23 mg/kg, orally, twice a day) was administered for 2 weeks.

Autologous Bone Grafting Procedure

Surgery with grafting was performed 2 weeks after implant removal. The dog was anaesthetized using a routine protocol with endotracheal intubation and isoflurane in oxygen. The tail was docked and the sixth to eighth caudal vertebrae were aseptically collected and prepared for implantation (►**Fig. 2A, B**). Soft tissue and cartilaginous tissue surrounding the vertebrae were trimmed using a rongeur and a No. 11 blade. The cancellous bone on each epiphysis of the vertebra

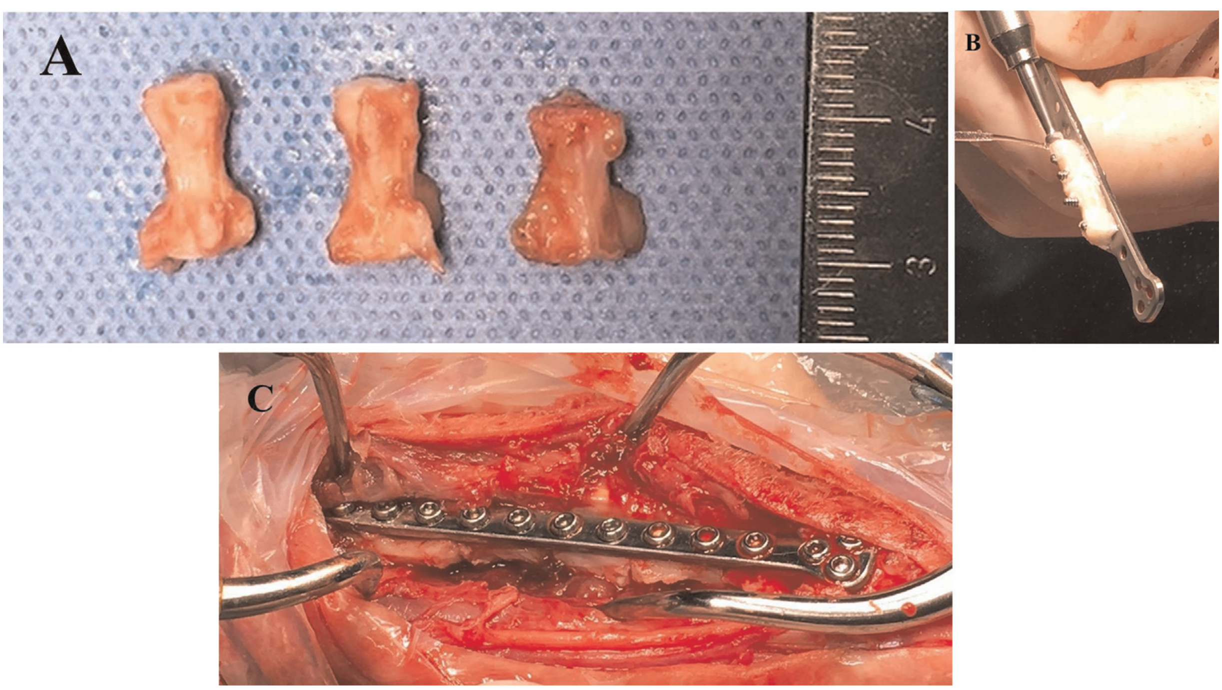

Fig. 2 Photographs taken during reconstructive surgery. (**A**) Three harvested caudal vertebrae, 10-mm long and 4 to 5-mm wide. The vertebrae had sufficient bone mass for screw insertion. (**B**) Plate fixation to the caudal vertebrae. (**C**) Transplant of three caudal vertebrae into the bone defect region followed by plate fixation.

was partially exposed using a round burr (Stryker TPS System, Stryker, Kalamazoo, Michigan, United States). The bone specimen was packed and protected in saline-soaked sponges until implantation. A craniolateral approach was performed on the left forelimb to expose the gaping radial lesion. The stumps of the atrophic bone ends were excised, and the adjacent medullary cavity was reamed. A 1.5-mm titanium *T*-shaped conventional plate (Radius Reduction Plate TH type, Platon Japan, Japan) was placed over the bone defect whereby two screws each were applied to purchase and transfix each caudal vertebra transplant (►**Fig. 2B**). Only three caudal vertebrae (the total length was $\sim$ 3 cm) could be fitted into the gap, because of the shortening effect of chronic muscle contracture at the fracture site. Four screws were placed in the distal radius fragment, and three in proximal (►**Fig. 2C**). Cancellous bone was harvested from the ipsilateral greater tubercle and implanted at the radial fracture ends and around the autologous caudal vertebrae graft. Additionally, an autologous iliac wing bone graft was also transplanted at the medial site of the vertebral graft. A long limb cylinder cast was kept in place for 2 weeks postoperatively. Buprenorphine (Buprenorphine Inj., NISSIN, Japan, 0.01 mg/kg IV, every 12 hours) was administered as an analgesic for 3 days, followed by tramadol (2 mg/kg, orally, every 12 hours) administration for 7 days. Fosfomycin (23 mg/kg,

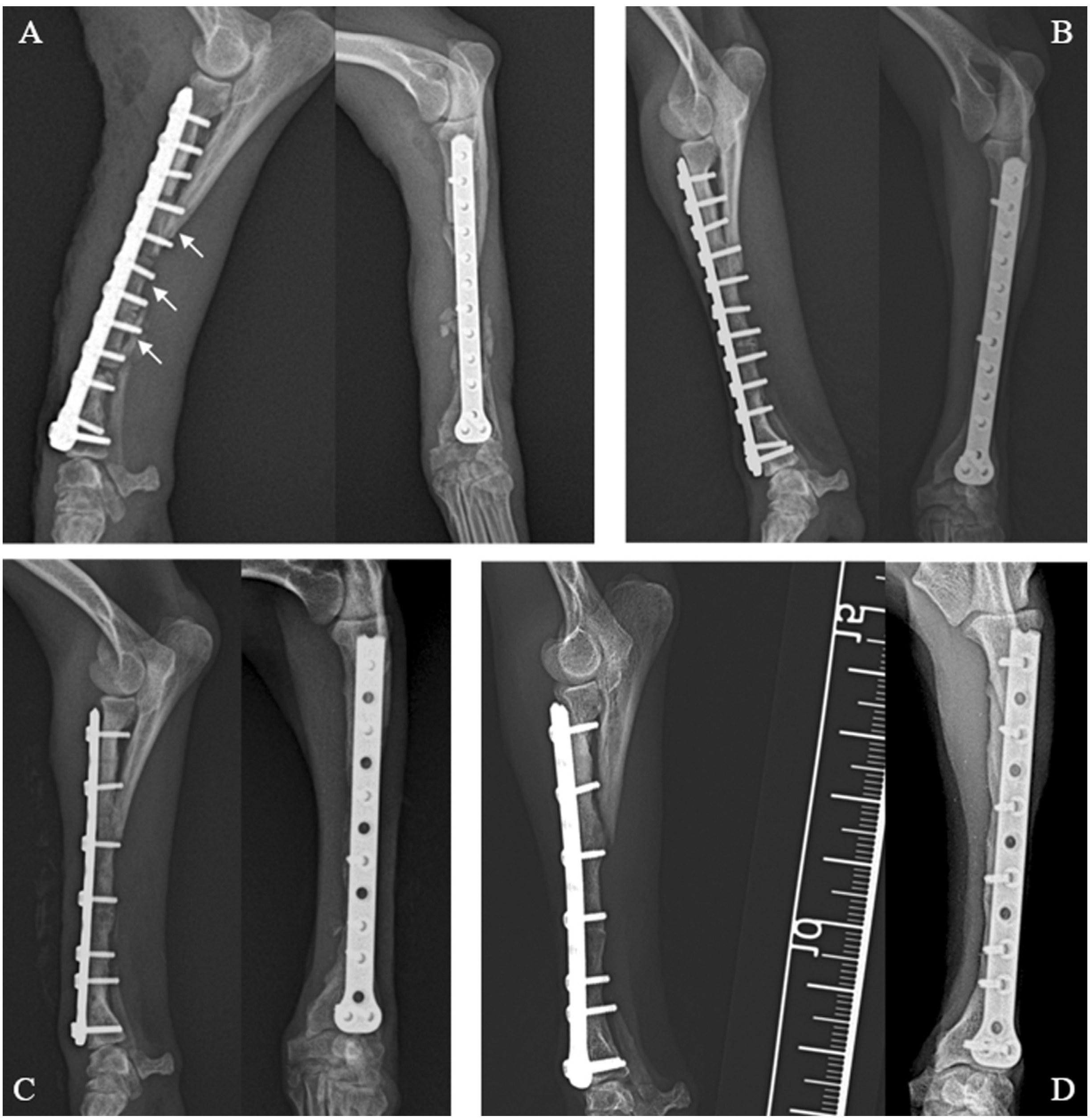

Fig. 3 Radiographs of the left forelimb after reconstructive surgery. (**A**) Lateral (*left*) and craniocaudal (*right*) radiographs of the left radius and ulna immediately after surgery. Three caudal vertebrae were placed into the bone defect and fixed with a plate using two conventional screws in each vertebra (*arrow*). (**B**) Five months after reconstructive surgery. The gap between each caudal vertebral autograft had almost disappeared. (**C**) One year after reconstructive surgery. A new, identical plate was placed with screws inserted in every other hole. (**D**) Three years and 2 months after reconstructive surgery. Complete bone healing and no implant loosening or damage were observed.

orally, twice a day) was given during the 14-day postoperative period. Rehabilitation using an underwater treadmill was started 3 weeks after surgery. Radiographic follow-up examination was performed until 1 year postoperatively.

Outcome

The limb length discrepancy between the left and right forelimbs was improved from 48 to 20% after vertebral grafting surgery. The numeric lameness score was two-fifths, and the Colorado State University pain scale score was one-fourth at 3 weeks. At 5 weeks postoperatively, there was stable weight bearing on the affected limb and no pain on palpation, and lameness was not apparent. The range of motion of the left elbow joint was 100 degrees (normal range of motion: 130 degrees [flexion 36 degrees and extension 165 degrees]) 1 month after surgery due to muscle contracture.[6] The range of motion improved to 120 degrees by the end of the 2-week rehabilitation period (that is, 5 weeks after surgery). There was no obvious implant loosening or refracture on radiographs until 3 months postoperatively. The 5-month postoperative radiographic examination revealed a progressive increase in the radiolucency of the fracture gap (►**Fig. 3B**). The implants were stable, and periosteal callus formation was noted.

Fig. 4 Three-dimensional computed tomography image of the left radius and ulna 3 years and 2 months after reconstructive surgery.

Revision Surgery

Radiographic examination 1 year after surgery revealed further increase of radiolucency of the vertebral grafts (►**Fig. 3C**). Therefore, revision surgery was performed to avoid stress concentration. During screw removal, a slight plate bending toward medial was observed, and replating was done. A soft bandage was applied postoperatively and was maintained for 1 week. During the first week, the dog was kept on activity restriction

After revision surgery, the dog remained clinically well. Three years and 2 months after the first surgery, radiographs and computed tomography images revealed complete bone healing and no implant loosening (►**Figs. 3D** and **4**). There was no apparent lameness at this point.

Discussion

The transplanted tail vertebrae were suitable spacers for the plate fixation of a large radial bone defect in this case because of their size and bone mass. Apparently, several caudal vertebrae could be placed to reach the length required to fill the bone defect. Caudal vertebrae contain cortical bone that provides structural support. The ratio of cortical to cancellous bone in canine caudal vertebra has not been reported. Although difficult to compare, in humans, approximately 70% of a lumbar vertebra is cancellous bone.[7] Therefore, caudal vertebra may be considered useful as grafts for long bone defects because of the structural support, osteoconductivity, and osteoinductivity.

Increased radiolucency of the grafts suggesting incomplete bone healing was a major complication 1 year after the initial surgery. It may have been caused by creeping bone substitution. Also, it may have been better to place the second bridging plate on the lateral side of the radius to avoid plate bending.

According to one report, dogs can compensate forelimb length deficits up to 15% by extending the joints.[8] In our case, the discrepancy was approximately 20% after reconstructive surgery and might have contributed to initially observed lameness. The positive result of gap healing with plate and vertebral spacers may have been due, in part, to the dog's small size. In addition, it was possible that some lameness was masked by short and rapid successive strides.

The surgical result achieved in this single case demonstrates the feasibility of using tail vertebrae as autologous bone graft and may encourage further evaluation when treating large bone gaps in radioulnar nonunions, especially in canine toy breeds.

Note
This case report was presented in 2018 at the conference of the Japanese Society of Veterinary Anesthesia and Surgery in Omiya, Japan.

Authors' Contribution

M.G. and H.I. performed the surgery described in this case report. M.G. drafted and revised the manuscript. Both the authors approved the submitted manuscript.

Funding
None.

Conflict of Interest
None declared.

Acknowledgments
The authors thank Tomomi Minamoto, DVM, PhD, and Taryn Rand, DVM, at Evergreen Vet Research and Publication for their translation and editing services. They also thank American Journal Experts (AJE) for their proofreading and Dr. Masaaki Katayama, DVM, Iwate University, for technical advice.

References

1 Sumner-Smith G. Delayed unions and nonunions. Diagnosis, pathophysiology, and treatment. Vet Clin North Am Small Anim Pract 1991;21(04):745–760
2 Welch JA, Boudrieau RJ, DeJardin LM, Spodnick GJ. The intraosseous blood supply of the canine radius: implications for healing of distal fractures in small dogs. Vet Surg 1997;26(01):57–61
3 Decamp CE, Johnston SA, Déjardin LM, Schaefer SL. Bone grafting. In: Decamp CE, Johnston SA, Déjardin LM, Schaefer SL, eds. Brinker, Piermattei and Flo's Handbook of Small Animal Orthopedics and Fracture Repair. 5th ed. St. Louis, MO: Elsevier; 2016: 153–162
4 Burton NJ, Owen MR, Colborne GR, Toscano MJ. Can owners and clinicians assess outcome in dogs with fragmented medial coronoid process? Vet Comp Orthop Traumatol 2009;22(03):183–189
5 Hellyer PW, Uhrig SR, Robinson NG. Canine Acute Pain Scale and Feline Acute Pain Scale. Fort Colins, CO: Colorado State University Veterinary Medical Center; 2006
6 Jaegger G, Marcellin-Little DJ, Levine D. Reliability of goniometry in Labrador Retrievers. Am J Vet Res 2002;63(07):979–986
7 Defino HLA, Vendrame JRB. Morphometric study of lumbar vertebrae's pedicle. Acta Ortop Bras 2007;15(04):183–186
8 Rovesti GL, Schwarz G, Bogoni P. Treatment of 30 angular limb deformities of the antebrachium and the crus in the dog using circular external fixators. Open Vet Sci J 2009;3:41–54

