BF-1880
[1-6]

CASE STUDY

Indian Journal of Animal Research

Ulnar Bone Grafting for the Repair of Radial Fracture in a Dog with Degloving Injury

Shin-Ho Lee[1], Jeonghyun Seo[2], Jae-Hyeon Cho[3]

10.18805/IJAR.BF-1880

ABSTRACT

Background: A one-year-old female Poodle weighing 1.7 kg sustained an open wound and radial bone fracture due to a bicycle accident. The injury resulted in significant skin and bone loss. Skin reconstruction using an advancement flap and radial bone repair using an autologous ulnar bone graft were performed to restore limb function and appearance.

Methods: The dog underwent surgery for skin and bone reconstruction. Necrotic tissue was debrided and an advancement flap was used to repair the skin. The radial bone defect was treated with an autologous ulnar graft and stabilized with a titanium plate. Postoperative care included pain management, antibiotics and restricted activity. Periodic radiographs were taken to monitor bone healing.

Result: The dog experienced good recovery, with the skin healing fully within 15 days despite some initial necrosis. The ulnar bone graft successfully fused with the radial bone, allowing the dog to bear weight on the limb by day 65. By day 233, the bone had fully integrated and the dog showed no signs of lameness.

Key words: Bone autograft, Dog, Lameness, Open wound, Skin flap.

INTRODUCTION

There is a high incidence of cases involving extensive skin damage or loss in small animal clinics (Durrani *et al.*, 2023). Open wounds can be characterized by the loss of a layer of full-thickness skin, carry a risk of infection due to exposure to a foreign material and result from traumatic degloving and shear injuries, lacerations, avulsions, envenomation, burns, abscesses, necrotizing vasculitis, incisional dehiscence and open surgery (Repellin *et al.,* 2021). Treating skin defects of the limbs in dogs and cats can be challenging due to limited skin availability (Crowley *et al.,* 2020). The advantages of reconstruction with a skin flap is the blood flow supply of the flap and the staged primary closure (Miller *et al.,* 1991).

A diagnosis of fracture nonunion is based on radiological evidence, such as hypertrophy or atrophy of bone fragments, defects between the fracture ends, sclerosis and a closed bone marrow cavity (Frölke and Patka, 2007). Internal fixation is the preferred method for achieving early stabilization and promoting faster functional recovery (Jain *et al.,* 2023). Implant failure and re-fracture occur and the radius, ulna and femur seemed to be the most affected (Phillips, 1979). Bone grafting is a surgical procedure used to repair partial bone defects resulting from disease, trauma, or tumor removal (Rashmi *et al.,* 2020). Cancellous bone grafting has proven to be a very successful method for treating primary fractures showing nonunion and delayed healing, as well as arthritis and chronic myelitis, in dogs. This technique is highly regarded in the field of orthopedics because it promotes bone formation and stimulates the healing of fractures, making it the gold standard among such procedures (Johnston and Tobias, 2012). Segmental defects and delayed union for fractures of long bones continue to present significant challenges for orthopedic surgeons. Complex open fractures can create asymmetry in essential anatomical structures, leading to impaired functionality (Sheller *et al.,* 2004). Another study suggested that tail vertebral autografts are a new source of long bone defects in dogs (Cho *et al.,* 2023).

The aim of this study is to introduce the use of ulnar bone grafting and skin flap reconstruction for radius bone defects and open wounds in a dog.

[1]Department of Companion Animal Health, Tongmyong University, Busan 48520, Korea.
[2]24h Time Animal Medical Center, Daejeon, 35233, Korea.
[3]Institute of Animal Medicine, College of Veterinary Medicine, Gyeongsang National University, Jinju 52828, Republic of Korea.

Corresponding Author: Jae-Hyeon Cho, Institute of Animal Medicine, College of Veterinary Medicine, Gyeongsang National University, Jinju 52828, Republic of Korea.
Email: jaehcho@gnu.ac.kr
Orcids: https://orcid.org/0000-0003-1126-9809

How to cite this article: Shin-Ho, L., Jeonghyun, S. and Jae-Hyeon, C. (2024). Ulnar Bone Grafting for the Repair of Radial Fracture in a Dog with Degloving Injury. Indian Journal of Animal Research. 1-6. doi: 10.18805/IJAR.BF-1880.

Submitted: 27-08-2024 **Accepted:** 18-10-2024 **Online:** 09-12-2024

MATERIALS AND METHODS

Case presentation

History and clinical examination

This study began in 2022 and was conducted over one year at Tongmyong university, department of companion animal health, located in Busan, South Korea. A one-year-old spayed female Poodle dog weighing 1.7 kg was brought in with non-weight-bearing lameness, an open wound and a fracture in the right forelimb. The dog had fallen off the bicycle being ridden by its owner, causing its right forelimb to be caught in the wheel. Clinical examination revealed non-weight bearing on the right forelimb with visible abrasions and lacerations on the skin. Subcutaneous tissues and muscle were visually exposed due to laceration of the metacarpal and the 2nd, 3rd and 4th digit pads (Fig 1B). Large amount of skin loss was also seen from the shoulder joint to the inside of the distal part of the forelimb (Fig 1A). Radiography confirmed the fracture of diaphysis of the 1st phalanx, severely damaged middle and distal phalanx of 5th digit. A bone defect of approximately 1.8 cm was identified in the radial diaphysis and there was no specificity for the chest, abdomen, or both hindlimbs except for minor abrasions on the left forelimb (Fig 1C). On ultrasonography, there was no specificity except for the presence of echogenic sludge in the urinary bladder.

The dog was hospitalized for 3 days to confirm any other major injury. Injection butorphanol (0.1 mg/kg, Myungmoon Pharm Co., Korea) was injected as a first aid. In addition, Hartman-D (Hartman-D Solution 500 mL, HK inno. N Corp, Korea) was infused at a rate of 5 ml/kg/hr intravenously to maintain adequate perfusion and circulation. The TLK complex [tramadol (tramadol loading dose (2 mg/kg) and infusion of tramadol (1.3 mg/kg/hour), lidocaine (3 mg/kg/hour, 2% Lidocaine Inj, Jeil Pharmaceutical Co., Korea) and ketamine (0.6 mg/kg/hour, Ketamine HCl Injection Huons, HUONS Co., Korea)] (1 ml/hr IV by constant rate infusion) was administered for pain control; cefotaxime IV (20 mg/kg TID) and metronidazole (10 mg/kg IV, q12h) were administered for secondary infection; and famotidine (0.5 mg/kg, q12h, IV, Gaster, Donga ST, Korea) was administered for gastrointestinal protection for three days during hospitalization. The open wound was managed by applying sugar twice a day. Three days after injury, a surgical procedure was carried out to remove the necrotic tissue in the right forelimb, which had lacerations and to reconstruct the skin.

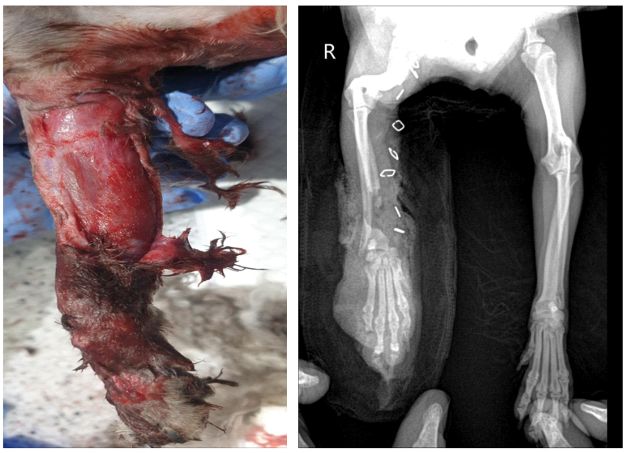
Preoperative management and anesthesia for skin reconstruction

Cefazolin (25 mg/kg, q12h, Cefazolin Inj. Chong Kun Dang Pharm, Korea) and meloxicam (0.1 mg/kg, q24h, Meloxicam inj., Boehringer Ingelheim Vetmedica GmbH, Germany) was injected intravenously and fluid line was maintained prior to surgery. Butorphanol (0.1 mg/kg, Myungmoon Pharm Co., Korea) was administered as a premedication for anesthesia. Propofol (10 mg/kg, Provive, Myungmoon Pharm, Korea) was injected intravenously for anesthesia induction and endotracheal intubation (Rushelit, size ID 3.5 mm, OD 5.3 mm, Teleflex, Malaysia). The dog was placed in dorsal recumbency and the anesthesia was maintained on isoflurane (Ifran, Hana Pharm, Korea) mixed in 100% oxygen. The surgical site was aseptically prepared.

Surgical procedures and postoperative management

The skin had a long open wound from the axillary part to the carpal joint medially. There were some black necrotizing tissues around the periphery of the skin (Fig 2A). The blackened necrotizing skin tissue was trimmed for suturing and the spare tissue was identified to align the apposition (Fig 2B). The skin was sutured in a reverse Y-shape with 4-0 nylon sutures in an interrupted suture pattern (Fig 2C). Postoperative analgesia was induced with gabapentin (10 mg/kg, q12h, Gabalep Cap., Chong Kun Dang Pharmaceutical Corp., Korea) and tramadol (2 mg/kg, Tridol Inj. Wuhan Corp, Korea) every 12 hours for 5 days. Prophylactic intravenous antibiotics, cefazolin (25 mg/kg, q12h, IV) and famotidine were used for gastric protection twice a day for five days.

Two days after surgery, the middle of the sutures turned black and necrosis continued to progress (Fig 2D). The forearm was also swollen and serous exudate was observed between the sutures. Sugar dressing was applied to the



(A) (B)

(A) At the time of hospital admission, skin laceration and abrasion were evident. (B) In the radiograph, the radius was defective.

Fig 1: Images of the wound, skin and bone defect on the right forelimb.

necrotizing tissues. Ten days after surgery, the necrotic area was naturally detached and a healthy granulation bed was identified. The skin was seen epithelializing at the periphery and showed no signs of infection or complications (Fig 2E). Fifteen days after surgery, the open wound on the skin was fully repaired.

Surgical intervention for an ulnar bone autograft

The dog underwent surgical intervention with ulnar bone autografts seven days after skin healing. The blood test results were unremarkable. The entire process of anesthesia induction, the type and dose of drugs administered and the disinfection procedure for surgery were performed in the same manner as in skin reconstruction. Both forelimbs and the right proximal humerus region were aseptically prepared. The proximal humerus region was prepared to collect cancellous bone graft and the left ulna for bone graft.

Intraoperative procedure

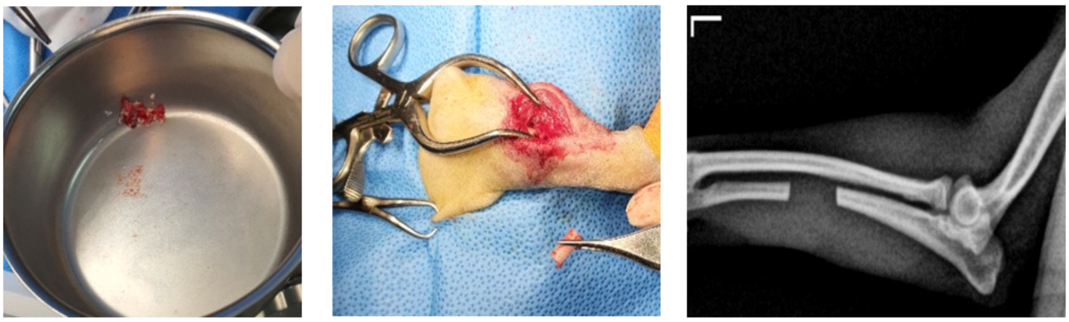
The dog was placed in the left lateral recumbency with the affected limb upwards. For the collection of the cancellous bone graft, the greater tubercle of the humerus was exposed and the entry point was located immediately cranial to the insertion of the infraspinatus tendon. A hole was created using a 1.5 drill bit which was extended through the bone cortex by using a bone curette and the cancellous bone was collected. It was stored with recombinant human bone morphogenetic protein-2 (rhBMP-2, Novosis, Dewoong Pharmaceutical Company, Seoul, Korea) into a sterilized bowl with blood-soaked gauze until it was transplanted (Fig 3A). The wound was closed in a routine manner.

For autologous ulnar transplantation, 15 mm of the diaphysis of the left ulna was collected through an incision

(A) (B) (C) (D) (E)

(A) Open wound with exposed subcutaneous tissue and muscle. (B) Necrotizing tissues were removed and trimming was performed for suturing. (C) The suture was complete. (D) Two days after surgery, necrotizing tissues were observed in the middle of the suture. (E) Twelve days after surgery, second intention wound healing aided by the application of sugar was observed. It appeared to be epithelialization.

Fig 2: Photographic image of the advancement flap and wound bed on the medial aspect of the right forelimb.



(A) (B) (C)

(A). Cancellous bone (collected from the left humerus) and bone morphogenic protein were mixed. (B) Photograph showing collection of left ulnar graft. (C) Radiograph showing the defect at the site of graft collection.

Fig 3: Autogenous cancellous bone and ulnar bone collection.

in the middle using a sagittal saw (Stryker TPS System, Stryker, Kalamazoo, Michigan, United States) (Fig 3B). The collected ulnar bone was protected with gauze soaked in saline until transplantation. The incision in the left forearm was routinely sutured. A cranial lateral approach to the right forearm was used for the transplantation of the radius bone defect (Fig 3C). The edge of the atrophied bone was arranged using a single bone rongeur (12 cm, Mabson Industry, Pakistan) and the bone marrow cavity was widened using a 1.2 mm K-wire (1.2 mm×229 mm, General Vet Products, Australia). A 1.5 mm titanium T-shaped plate (Radius Reduction Plate TH type, Doiff, Korea) was used to repair the fracture (Fig 4A). A 1.5 mm screw was inserted into the proximal radius bone and the remaining 1.5 mm screws were inserted alternately into the collected ulnar bone and radius bone (Fig 4B). The collected cancellous bone and the BMP were transplanted at both ends of the fractured radius and around the ulnar bone fragments (Fig 4C). The muscles, subcutaneous tissue and skin were routinely sutured.

Postoperative management and radiographic evaluation

A Robert Johnson bandage was applied for two weeks and then replaced every three days to check for skin healing and edema. Tramadol (2 mg/kg) and cefazolin (22 mg/kg) were administered intravenously for 3 days as pain controls and antibiotics, respectively. Subsequently, cephalexin 22 mg/kg (25 mg/kg, q12h, Cephalexin cap. Ildong Pharm, Korea), famotidine 0.5 mg/kg (0.5 mg/kg, q12h, Gaster, Donga ST, Korea), tramadol 2 mg/kg and streptokinase 0.5T were prescribed as oral drugs for 5 days. After discharge, the dog was presented once every three days to check the condition and to undergo laser treatment to control pain and inflammation. The activity of the dog was restricted with no weight bearing allowed on day 1 as there was BMP and autogenous cancellous bone around the transplanted ulnar (Fig 5A).

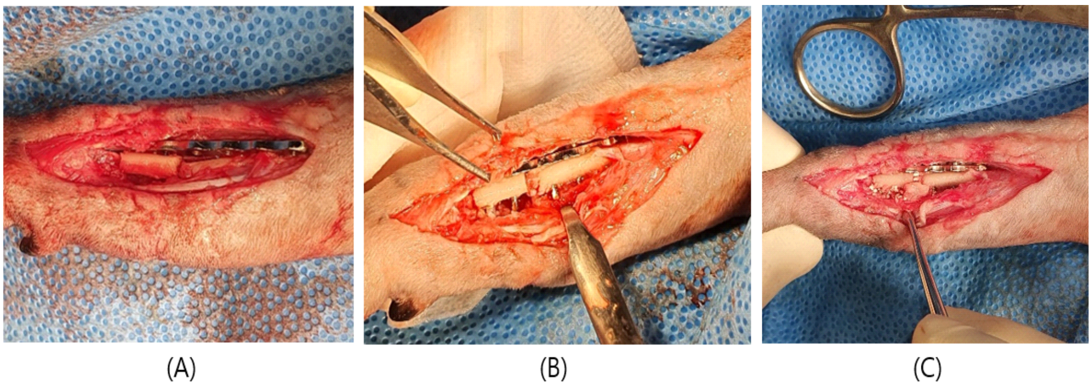
Slight weight bearing was allowed on postoperative day 65. On postoperative day 65, the callus was more abundant than before, the autologous ulnar bone fragment was fused with the existing radius and the implant was stable (Fig 5B). On postoperative day 142, the callus at the fracture end had invaded the ulnar bone fragments grafted in the fracture gap and was much thicker than before the initial presentation. Slight lameness was still observed upon walking and trotting (Fig 5C). On postoperative day 233, the transplanted ulnar bone was stable, with further increased radiopacity at both ends on the ventral side of the plate (Fig 5D). There was no longer any lameness upon walking.

RESULTS AND DISCUSSION

The mobile skin of dogs and cats lends to large pedicles or free grafts; therefore, several strategies exist for closing wounds on the trunk and extremities. In dogs and cats, reconstructive techniques used for repairing skin defects using skin fold advancement flaps have been described (Hunt *et al*. 2001). Skin necrosis is common after reconstruction with axial flaps (Field *et al.,* 2015).

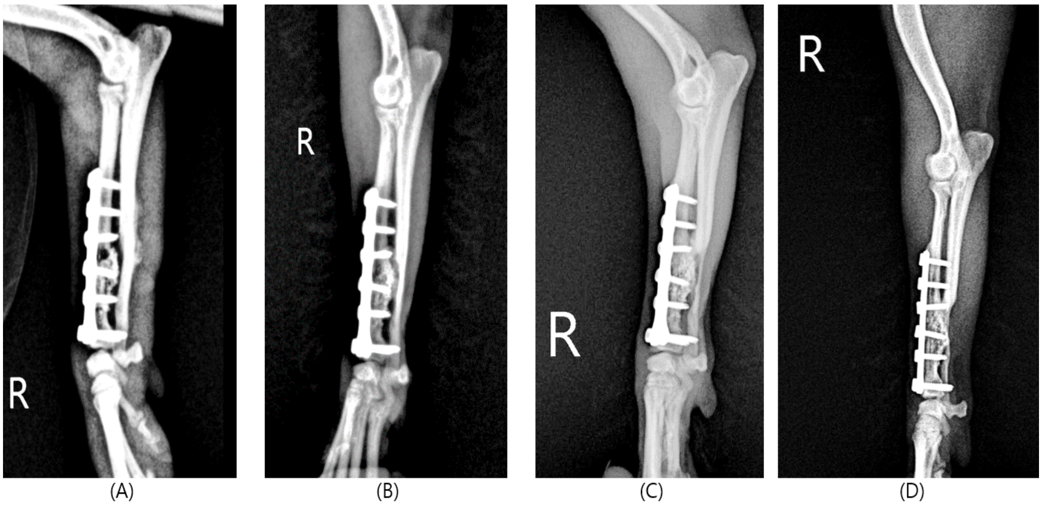
In secondary intent healing, the process of epithelialization involves the migration of epithelial cells from the epithelial edge across the wound surface (Pastar *et al.,* 2014). The application of sugar to contaminated wounds has a good effect (Mathews and Binnington, 2002). It has been suggested that the increase in osmolarity caused by the use of sugar causes a decrease in free water available for bacterial replication, which inhibits bacterial growth and stimulates the influx of macrophages and lymphatic fluid, which promotes granulation tissue formation and epithelialization (Wells and Gottried, 2010).

In dogs, the iliac crest, proximal humerus and proximal tibia are considered the most plentiful sources of autologous cancellous bone (Penwick *et al*. 1991). BMPs enhance the osteo-inductivity of autologous bone grafts and stimulate osteoblast proliferation and the combination of BMPs and cancellous bone grafting may improve bone healing (Bharadwaz and Jayasuriya, 2021). The use of the coccyx



A. A T-shaped plate was used to determine the length and location of screw insertion. B. Proximal radius bone fragments and the transplanted ulnar bone were positioned with a 1.5 mm screw. C. A mixture of cancellous bone collected from the nonaffected humerus and BMP was transplanted around the ulnar bone graft.

Fig 4: The operative process of transplanting a ulnar bone in the radius bone defect.



(A) On day 1, there was an interfragmentary space in the grafted radius, with cancellous bone and BMP surrounding it. (B) On day 65, the callus at the end of the fracture had fused with the autologous ulnar bone fragments and the fracture ends were connected to the existing radius. (C) On day 142, the callus from the fracture ends had invaded the ulnar bone fragments grafted in the fracture gap. (D) On day 233, the radiographs revealed the fracture ends of the radius in proper alignment and the bone plate in position. It was confirmed that the formed callus was connected to the ulnar bone, which increased the bone density.

Fig 5: Sequential radiographs (lateral view) of the right radius and ulna.

as an autogenous bone graft has proven to be an excellent option for the treatment of femoral fracture nonunion. In addition to proper mechanical fixation, various adjunctive methods, including BMPs, may be used for increasing the engraftment of autogenous bone (Cho *et al.,* 2023).

CONCLUSION

Despite some limitations, using autologous ulnar grafts has proven to be an excellent option for replacement material in cases of radial bone loss. In addition to proper mechanical fixation, various supplementary methods, such as BMP and autogenous cancellous bone, can be useful for enhancing the engraftment rate of autologous bone. This is a report of an autologous ulna implanted into a dog with radial bone loss, where the grafted bone healed successfully and eventually allowed the patient to regain mobility. These results also support clinical evidence that fragmented ulnar bone fragments are not rejected as foreign bodies. However, further histologic and histochemical studies may be needed to determine their role in osteoinduction and osteogenesis.

ACKNOWLEDGEMENT

The research was supported by Convergence Research Group project (grant NO. CRC21021-300) of the National Research Council of Science and Technology, Republic of Korea.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Bharadwaz, A., Jayasuriya, A.C. (2021). Osteogenic differentiation cues of the bone morphogenetic protein-9 (BMP-9) and its recent advances in bone tissue regeneration. Mat. Sci. Eng. C-Mater. 120: 111748.

Cho, K., Lee, K., Kang, K., Kim, M. (2023). Treatment of a large defect induced by atrophic nonunion of femoral fracture in a dog with autogenous coccygeal bone Grafting. Vet. Sci. 10(6): 388.

Crowley, J.D., Hosgood, G., Appelgrein, C. (2020). Seed skin grafts for reconstruction of distal limb defects in 15 dogs. Journal of Small Animal Practice. 61(9): 561-567.

Durrani, U.F., Mahmood, A.K., Imran, M. (2023). Effects of autologous and homologous platelet rich plasma on full thickness autologous skin graft in dogs. Indian Journal of Animal Research. 10.18805/IJAR.BF-1606.

Field, E.J., Kelly, G., Pleuvry, D., Demetriou, J., Baines, S.J. (2015). Indications, outcome and complications with axial pattern skin flaps in dogs and cats: 73 cases. J. Small Anim Pract. 56(12): 698-706.

Frölke, J.P.M., Patka, P. (2007). Definition and classification of fracture non-unions. 38(2): 19-22.

Hunt, G.B., Tisdall, P.L.C., Liptak, J.M. *et al.* (2001). Skin-fold advancement flaps for closing large proximal limb and trunk defects in dogs and cats. Vet Surg. 30: 440-448.

Johnston, S., Tobias, K. (2012). Veterinary Surgery: Small Animal Expert Consult, 2nd ed.; Saunders: Philadelphia, PA, USA, 676-684, 719: 783-794.

Jain, R., Shukla, B.P., Shukla, S., Chhabra, D., Karmore S.K., Shrivastava, N. (2023). Evaluation of Autologous Bone Marrow Concentrate along with Hydroxyapatite-collagen for management of long bone fracture in canines. Indian Journal of Animal Research. 57(12): 1678-1685. doi: 10.18805/IJAR.B-4519.

Mathews, K.A., Binnington, A.G. (2002). Wound management using sugar. Comp Cont Educ Pract Vet. 24: 41-50.

Miller, C.W., Fowler, J.D., Bowen, C.V.A., *et al.* (1991). Experimental and clinical free cutaneous transfers in the dog. Microsurgery. 12:113-117.

Pastar, I., Stojadinovic, O., Yin, N.C., *et al.* (2014). Epithelialization in wound healing: a comprehensive review. Advances in Wound Care. 3(7): 445-464.

Penwick, R.C., Mosier, D.A., Clark, D.M. (1991). Healing of canine autogenous cancellous bone graft donor sites. Veterinary Surgery. 20(4): 229-234.

Phillips, I.R. (1979). Survey of bone-fractures in the dog and cat. J. Small Anim Pract. 20: 661-674.

Repellin, R.L., Pitt, K.A., Lu, M., Welker, J., Noland, E.L., Stanley, B.J. (2021). The effects of a proprietary Manuka honey and essential oil hydrogel on the healing of acute full-thickness wounds in dogs, Vet Surg. 50: 1634-43.

Rashmi, Rekhapathak, Tamilmahan P., Amarpal, Aithal H.P., Kinjavdekar P., Pawde A.M., Sivanarayanan T.B., Jayalekshmi Shanthi (2020). Evaluation of Acellular Bovine Cancellous Bone Matrix Seeded with Foetal Rabbit Osteoblasts for Segmental Bone Defects in Rabbits . Indian Journal of Animal Research. 55(4): 439-444. doi: 10.18805/ijar.B-3976.

Sheller, M.R., Crowther, R.S., Kinney, J.H., Yang, J., Jorio S.D., Breunig, T., Carney, D.H., Ryaby, J.T. (2004). Repair of rabbit segmental defects with the thrombin peptide, TP508. J. Orthop Res. 22(5): 1094-1099.

Wells, S., Gottfied, S.D. (2010). Utilization of the scrotum as a full thickness skin graft in a dog. Can Vet J. 51(11): 1269-73.