



Enhanced Fracture Repair with Supercutaneous Plating and Biological Adjuncts: A Paradigm Shift in Open Fracture Management

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ABSTRACT

Open fractures present significant challenges to healing, with the primary objective being meticulous wound management, reduction of bacterial contamination and promotion of healthy granulation tissue. Simultaneously, achieving optimal fracture stabilization through rigid fixation is essential to create a stable environment conducive to complete and complication-free bone healing. A five-year-old male Chippiparai cross-breed dog weighing 17 kg presented with Grade IV non-weight-bearing lameness of the left forelimb following an automobile accident. Orthopaedic examination revealed Type IIIA open, mid-shaft fracture of the left radius and ulna. The wound was initially managed with Negative Pressure Wound Therapy for five days, followed by surgical stabilization using supercutaneous plating with a 3.5 mm locking compression plate. Autologous platelet-rich plasma and nanohydroxyapatite were applied to enhance bone healing. The wound healed satisfactorily and the animal achieved complete weight-bearing by day 28. On post-operative day 60, radiographic assessment demonstrated cortico-medullary union and an uneventful recovery were noticed.

Key words: Autologous platelet-rich plasma, Nanohydroxyapatite, Negative pressure wound therapy, Open fracture, Super cutaneous plating.

Management of open fractures are challenging due to the extensive damage to soft tissue, increased risk of infection, compromised blood supply and the possibility of delayed union or non-union. Open fractures of long bones in dogs are commonly associated with high-velocity trauma, including automobile accidents (68.6%), bite injuries (24.3%), collisions (4.3%) and fall from height (2.9%) (Millard and Weng, 2014). Type I fractures carry a 0-5% risk of non-union, Type II fractures 1-14% and Type III fractures 2-37%. If left untreated, these fractures may ultimately necessitate amputation of the affected limb (Harley *et al.*, 2002).

The treatment protocol traditionally adopts a staged approach, wherein meticulous wound care and control against infection take precedence, followed by definitive surgical stabilization of the fracture, accomplished most commonly with external skeletal fixation techniques (Ness, 2006). The biological, anatomical and mechanical characteristics of the open fracture indicate a delayed healing time, making it imperative that the selected fixation method offers rigid stability, capable of withstanding physiological stresses and preserving alignment throughout the prolonged healing period. The key objectives of managing such open fractures include preventing infections, effective wound management, ensuring fracture union and restoring normal ambulatory function (Zalavras, 2017). For effective wound management, Negative Pressure Wound Therapy (NPWT) enhances blood flow to the wound and peri-wound area, reduces oedema, removes exudates, stimulates granulation tissue formation and lowers infection rates. It reduces the number of dressings and optimizes the wound bed for surgical closure or second-intention healing

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(Stanley, 2017). Synthetic bone graft substitutes like nano-hydroxyapatite offer excellent biocompatibility and osteo-conductivity, supporting neovascularization and bone healing (Appleford *et al.*, 2009; Preethi *et al.*, 2021).

External skeletal fixation is widely utilized and versatile surgical technique for managing open fractures in small animals. The use of locking implants was an essential prerequisite for adopting the technique of supercutaneous plating as they function through a rigid beam construct, eliminating the need for compression between the plate and bone while still providing stable fixation.

Platelet rich plasma (PRP) is an abundant source of autologous growth factors and under optimized conditions, it activates the osseous regeneration process, accelerates bone healing and minimizes complications like delayed/non-union (Souza *et al.*, 2011).

This case underscores the importance of promoting a definitive defined bone healing in open fractures by integrating NPWT for wound management and for osteosynthesis, application of PRP as osteo-inductive source and nanohydroxyapatite as osteoconductive scaffolds with the stabilization of fracture by super cutaneous plating technique (Qiu *et al.*, 2014).

A five-year-old intact Chippiparai cross-breed male dog, weighing 17 Kg was presented to the Madras Veterinary College Small Animal Orthopaedic Out Patient unit with the history of non-weight bearing lameness (grade IV) of left forelimb following an automobile accident 48 hours later to the report for treatment. Clinical examination revealed all the vital parameters were within the normal limits. In the haemato-biochemical investigation, leucocytosis with neutrophilia on the day of presentation and a return to the normalcy on day 7 was noticed. Orthopaedic examination revealed type III A open fracture of mid shaft left radius and ulna at the medial aspect Wound assessment was carried out on days 0, 3, 7, 14 and 28 based on the colour, odour and exudate and the observations were recorded (Wilson, 2012). Wound planimetry was performed to calculate the percentage of wound contraction relative to the original wound size, following the method described by Schallberger *et al.* (2008).

Sample from wound was collected for antibiotic sensitivity which showed growth of *Escherichia coli* sensitive to antibiotic cefotaxime. Radiographic examination revealed transverse diaphyseal left radius and ulna fracture with caudo-lateral displacement. The treatment was planned to perform negative pressure wound therapy and plate osteosynthesis by 3.5 mm Locking Compression Plate (LCP) by super cutaneous plating technique in conjunction with regenerative therapy.

Negative pressure wound therapy was applied for five days with sub atmospheric pressure of -125 mmHg with the foam-based system continuously for two to three hours, two to three times a day, with intervals of three to four hours as described by Demaria *et al.* (2011). Fig 1. Prior to surgery, autologous platelet-rich plasma (PRP) was prepared using the double centrifugation method. A total 10 mL of whole blood was collected in a vial containing 3.8% sodium citrate and the first centrifugation was performed at 2800 RPM for 20 minutes resulting supernatant was collected and subjected to a second centrifugation at 1300 RPM for 15 minutes. The final sediment, representing the PRP, was collected and was activated with 10% calcium gluconate prior to application at the fracture site (Perazzi *et al.*, 2013) (Fig 2).

Food and water were withheld for 12 and 6 hours respectively before surgery. The open fracture wound was lavaged with lactated ringer's (RL) solution and the site was prepared aseptically, covering the wound with RL moistened gauze and the extremities were bandaged.

The affected dogs were premedicated with Inj. Butorphanol @ 0.2 mg/kg I/V, Inj. Diazepam @ 0.2 mg/kg I/V

and antibiotic Inj. Cefotaxime @ 25 mg/kg I/V. General anaesthesia was induced with Inj. Propofol @ 3 mg/kg body weight I/V and was maintained with 1.5-2.5% isoflurane with oxygen. The animal was positioned in right lateral recumbency and the left forelimb was prepped for the surgical procedure.

Through the open fracture segments on the medial aspect, a 2 mm K wire was inserted as IMP in retrograde fashion in ulna and a 12 hole, 3.5mm LCP was applied on the lateral aspect of the radius as super cutaneous plating technique with 10 mm gap between the plate and screw with four screws each in proximal and distal fracture segments (Fig 3).

Commercially available 0.5cc of nano-hydroxyapatite and autologous PRP agent were engrafted at the fracture



Fig 1: Performing negative pressure wound therapy.



Fig 2: PRP Gel after activation with 10% calcium gluconate.



Fig 3: Osteosynthesis using 12 hole LCP by supercutaneous plating technique.

site on the medial aspect and no attempt was made to close the wound and were treated with a proprietary sterile saline-impregnated dressing. Modified Robert Jones's bandage was applied and Inj. Cefotaxime @ 25 mg/kg BID for 7 days, Inj. Meloxicam @ 0.2 mg/kg for three days were administered intravenously and periodical dressing was performed at regular intervals.

Culture and sensitivity testing in the present case revealed the growth of *Escherichia coli*, which was sensitive to the antibiotic cefotaxime. Similar findings have been reported by Akatvipat and Somrup (2018), who identified *Staphylococcus* spp., *E. coli*, *Pseudomonas* spp. and *Streptococcus* spp. as the most common bacterial isolates in dogs with open fractures. Supporting this, Singh *et al.* (2021) documented that *Staphylococcus* spp. accounted for the majority of bacterial isolates in canine wounds (76.47%), followed by cases with no bacterial growth (17.65%) and *E. coli* (5.88%).

In this study NPWT has shown to reduce bacterial load and wound discharge while promoting epithelialization. On the day of presentation, the wound appeared red in colour and remained so following negative pressure wound therapy and there was no foul odour and a moderate amount of exudate was observed. The NPWT dressings and bandages were changed every three days. Colour of the exudate aspirated was mainly red to brown and nature of the wound exudate was serosanguinous. Volume of exudate aspirated ranged from 10 to 15 ml per day for the first three days and gradually decreased to 0-5 ml per day in the subsequent days. These outcomes align with the findings of Demaria *et al.* (2011), who reported that NPWT facilitated the rapid development of smooth granulation tissue within three days, reduced serous or serosanguinous exudate and decreased peri-wound erythema in canine open wounds. NPWT induces two distinct types of tissue deformation: macro-deformation, which involves overall wound contraction and micro-deformation, characterized by microscopic interactions between the tissue surface and the dressing material, both contributing to enhanced wound healing (Borgquist *et al.*, 2010).

Wound bed contraction percentages were 25.31%, 60.91% and 100% on days 7, 14 and 28, respectively. Regarding wound healing progression: on day 0, the wound was contaminated; by day 7, a granulation bed had formed; by day 12, partial epithelialization was observed; by day 21, both epithelialization and contraction were evident and by day 28, complete wound healing was achieved (Fig 4). Gill *et al.* (2011) demonstrated that the application of NPWT generates micromechanical forces within the wound environment, promoting the healing process. This mechanical deformation initiates a signalling cascade that alters ion concentrations, increases cell membrane permeability and stimulates the release of secondary messengers. These events activate various molecular pathways, ultimately enhancing the mitotic activity of elongated cells and accelerating tissue repair.

Postoperative radiographic assessment showed adequate cortical contact of the fractured fragments with normal alignment and angulation. The plates and screws were of the proper length, position and size, resulting in proper immobilization. On the immediate postoperative day, the fracture margins were noticed unclear in the radiographs due to the engraftment of the fracture site with autologous PRP and nanohydroxyapatite. On day 7, signs of periosteal bridging were observed and the nanohydroxyapatite graft material remained visible near the fracture site. However, by day 14, there was limited progression in fracture healing, characterized by minimal periosteal bridging and persistent fracture lines.

By day 28, a moderate bridging callus with uniform density and smooth borders was observed and the fracture line was barely discernible. On day 45, further progression toward healing was noted, with proceeding callus formation on the caudal aspect and a visible radiolucent fracture line. By day 60, the fracture site was filled with dense callus and complete cortical and medullary continuity was established. On day 90, radiographic evaluation confirmed complete fracture union (Fig 5). These observations were in consistent with the findings by Sandness *et al.* (2023); Reshma *et al.* (2022) and Jain *et al.* (2023) and in contrast



Fig 4: (a) Contaminated open fracture wound - Day 0; (b) Granulation bed formation - Day 7; (c) Partial wound epithelialisation-Day 14; (d) Wound epithelialisation and contraction - Day 21; (e) Complete wound contraction - Day 28.

to the findings of Singla *et al.* (2020), who noted complete union by day 120.

A 3.5 mm locking compression plate (LCP) was applied as a super cutaneous implant on the lateral aspect of the limb, providing stable fixation and effective immobilization of the fracture site. Its lateral placement prevented interference with the contralateral limb and its low-profile design was well tolerated by the dog. This configuration also allowed convenient access to the medial aspect for wound management and was easier to manage postoperatively compared to an external skeletal fixator. The plate was removed after complete fracture healing at 120 days consistent with the observations of Nicetto and Longo (2019) and Shin-Ho *et al.*, (2025). Supercutaneous plating shares with other minimally invasive osteosynthesis techniques is the avoidance of fracture gap exposure, thereby minimizing soft tissue trauma. Consequently, the extraosseous blood supply is preserved, facilitating early secondary bone healing (Qiu *et al.*, 2014).

Application of nanohydroxyapatite at the fracture site was facilitated by its powder form, which formed a paste when combined with autologous PRP which aligns with Ghosh *et al.* (2008) and Roberts and Rosenbaum (2012). Grafting nanohydroxyapatite in powder form was manageable, as it adhered well to the fracture site with PRP due to hydrophilic property and further remained to be stable in position. Complete integration and resorption of nanohydroxyapatite was achieved by 28 days post-application. Erbe *et al.* (2001) documented

that bone formation initiated within three weeks after application of hydroxyapatite subsequent examination after one year, revealed that the newly formed bone and hydroxyapatite had undergone remodelling, integrating seamlessly into bone tissue, indistinguishable from normal bone upon radiological and histological examination.

The autologous PRP demonstrated a three- to four-fold increase in platelet concentration, enhancing its regenerative potential, which was in accordance with the findings of Jee *et al.* (2016) and likely facilitated enhanced bone formation in this study owing to its proven osteoinductive properties which in accordance with Kim *et al.* (2001) and Weibrich *et al.* (2004) who observed significant bone regeneration for the fracture treatment. Marx (2004) and Everts *et al.* (2006) stated that following the activation of platelets with calcium gluconate, the growth factors released from α - granules accelerates the osseous regeneration. Which in contrary to Chaput *et al.* (2007), suggesting that PRP did not play a major role in bone ingrowth at the bone-implant interface.

Animal exhibited improved weight-bearing lameness by day 7 and complete weight-bearing by day 28 was achieved. A notable reduction in pain score was recorded by day 14, with complete resolution of pain (score 0) achieved by day 28. Only challenge faced during the postoperative period was ensuring the cleanliness of the screw tracts and safeguarding the external plate, which required consistent bandaging to protect the implant until healing.

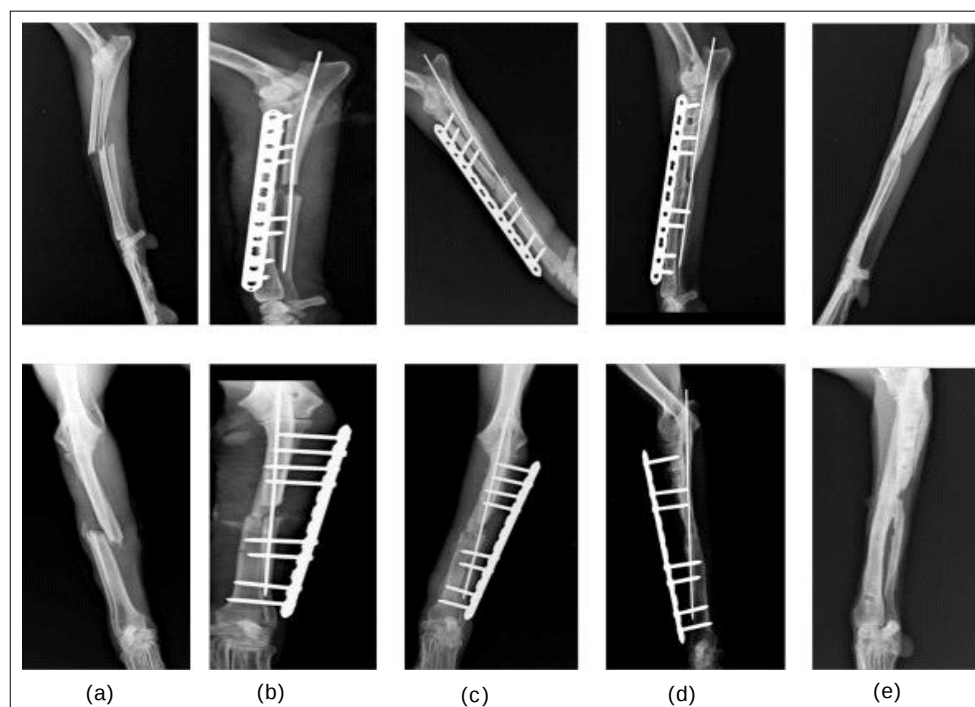


Fig 5: (a) Transverse diaphyseal left radius and ulna fracture with caudo-lateral displacement; (b) Immediate Postoperative x-ray showing normal alignment and angulation; (c) Callus advancement with visible fracture line - Day 45; (d) Complete bone healing by Day 90; (e) Post implant removal.

CONCLUSION

Negative Pressure Wound Therapy proved effective in managing open fractures by promoting smooth, non-exuberant granulation tissue, while osteosynthesis with Supercutaneous plating provided rigid, stable stabilization. Additionally, the adjunctive application of nanohydroxyapatite and autologous platelet-rich plasma facilitated early osteogenesis, accelerated fracture healing and resulted in superior functional outcomes.

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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

The authors declare that there are no conflicts of interest regarding the publication of this article. Nofunding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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