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Use of supracutaneous bone plating for management of radius/ulna and tibia/fibula fractures in dogs

AMIT KUMAR[1], ASHMEET KAUR[1], SUKHPREET SINGH[2], S P TYAGI[1], ADARSH KUMAR[1] and AKSHAY KUMAR[1]

CSK Himachal Pradesh Krishi Viswavidyalya, Palampur, Himachal Pradesh 176 062 India

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ABSTRACT

The study was done with the objective to utilize supracutaneous bone plating as a mean of minimally invasive osteosynthesis for management of radius/ulna and tibia/fibula fractures in dogs. Nine cases of long bone fracture (2 radius/ulna and 7 tibia/fibula fracture) in dogs having body weight 8-20 kg and age 4 months to 2 years were repaired with supracutaneous bone plating (minimally invasive plate osteosynthesis) under general anaesthesia after a thorough physical, orthopaedic, neurological and radiographic examinations. Intra-operatively, 3.5 mm, locking head-limited contact-dynamic compression plate (LH-LC-DCP) was used in locking mode with insertion of two self-tapping locking head cortical screws of 3.5 mm (of varying length) in each proximal as well as distal fracture. The bone plate was applied on the medial surface of radius and tibia. Postoperative radiographs were taken to assess the status of fracture reduction and fixation which was good in all the cases. Regular follow-ups showed good fracture reduction as well as fixation with no changes in implant position. Loosening of screws was observed in single case with no other complication in any of the cases. All the implants were removed on or before 68th day after surgery under sedation. All the animals showed good weight bearing with near to normal limb function on final day of the reappraisal. The supracutaneous bone constructs provided good reduction and fixation at fracture site similar as external skeletal fixators not compromising on axial and torsional stiffness.

Keywords: Biological osteosynthesis, Dogs, Fractures, Supracutaneous bone plating

The concept of stable-rigid osteosynthesis of fracture developed by AO-ASIF was subjected to basic changes recently, with regard to the treatment strategy of multi-fragmental extra-articular fractures. Biological osteosynthesis is rather a new concept in the fracture management. Biological osteosynthesis is not a technique but a concept of rational handling of traumatized bone fragments and surrounding tissues during fracture fixation so as to minimally expose the internal tissues including fracture haematoma to external environment. It implies the indirect (closed) reduction and 'bridge-like' (elastic) fixation, without intervening on fracture area and additionally, with maximally preserved vascularization of intermediate fragments. Biological osteosynthesis in long bone fractures can be achieved by various fixation/ managemental techniques like external coaptation, external skeletal fixation and MIPO (minimal invasive plate osteosynthesis; subperiosteal/subcutaneous and supracutaneous bone plating).

Supracutaneous bone plating technique is further modification of the Type-1 linear external fixators in which the fractures were stabilized by application of the plate above the skin surface with minimal invasive approach. Supracutaneous bone plating technique was described for the treatment of open fractures, non-unions, septic arthritis and distraction osteogenesis (Kerkhoffs *et al.* 2003, Kloen 2009, Woon 2010, Tulner *et al.* 2012, He X *et al.* 2014, Qiu 2014). The supracutaneous bone plating has several advantages over the convectional bone plating and MIPO like minimal invasive approach, avoidance of aggressive dissection and it also protects the fracture haematoma whereas it is more stable configuration than linear external fixators because of its locking screws. Many veterinary workers successfully managed the fracture in animals (dogs, cats and goats) by supracutaneous bone plating with successful outcomes (Klos 1995, Nicetto and Longo 2017, Nicetto and Longo 2019).

MATERIALS AND METHODS

The study was conducted at the Department of Veterinary Surgery and Radiology, Dr G C Negi College of Veterinary and Animal Sciences, CSKHPKV, Palampur, India. In this study, 2 cases of radius/ulna and 7 cases of tibia/fibula fractures were managed by supracutaneous bone plating.

Anamnesis/signalment, basic clinical examination,

Present address: [1]Dr G C Negi College of Veterinary and Animal Sciences, CSK Himachal Pradesh Krishi Viswavidyalya, Palampur, Himachal Pradesh. [2]Veterinary Officer, Department of Animal Husbandry, Punjab. ✉Corresponding author email: sukhivets@gmail.com

haemato-biochemical examination and orthopaedic examination (inflammation at fracture site, pain at fracture site, crepitus, status of weight bearing) were thoroughly recorded in all the 9 cases. Different preoperative and postoperative observations like pain and inflammation were analysed and recorded on a scale of 0-3 as reported by Sakshi (2019) and Singh (2021). The two orthogonal radiographic projections were recorded in all the cases to access the site and type of fracture. In most of the cases, there was inflammation at the fracture site hence Robert-Jone's compression bandage was applied for at least 1-2 days to the fractured limb to decrease inflammation.

The 3.5 mm LH-LC-DCP was applied on the slightly cranio-medially side of the radius and medial side of the tibia for fracture management. The holes for placement of bone-plate were successfully drilled with the help of 2.5 mm Steinmann pin which did not engage the surrounding skin and soft tissue. Then the bone cortex was tapped with the help of 3.5 mm tap. After this, another plate was placed over the surgical site and the LH-LC-DCP was placed over it, so that the LH-LC-DCP (plate to be used as supracutaneous bone plate) does not touch the skin. Then the depth of hole was measured with the help of screw gauge and locking screw of suitable size was placed through the threaded portion of the plate. Minimum 2 screws were placed on each side of fracture line. Similarly, other plate screws were placed after application of at least of two screws in each fragment proximally and distally, the bone plate was removed. After the completion of procedure, the screw insertion site was dressed with the mupirocin ointment and the gap between the supracutaneous plate and skin was filled with soft padding. Additionally, Robert's-Jones compression bandage was applied in every case to provide some extra stability.

Status of weight bearing was recorded on implant fixation day (IFD) and final reappraisal day (FRD); on the scale of 0 to 5 as: 0-test limb not touching the ground; 1-Toe of test limb touching the ground occasionally; 2-Toe of test limb touching the ground frequently; 3-The paw of test limb touching the ground occasionally; 4-The paw of test limb touching the ground frequently and 5-The paw of test limb touching the ground regularly. Net weight-bearing score (max. 10) was calculated by adding individual score of standing and walking phases (max. 5 in each) for a particular patient (Sakshi 2019, Singh 2021).

Post-operatively routine clinical, haemato-biochemical, orthopaedic and radiological examinations as described in pre-operative observations part above were done at the time of reappraisal of the patient. Additionally, the surgical site was examined for its gross appearance and healing status. The muscle atrophy in the affected limb was noted down on the final day of reappraisal and compared with contralateral limb. It was recorded on a scale of 0–4; where 0 means no atrophy and 4 means high muscular atrophy. After radiographic healing of fractures in all of cases, the bone plate was removed under sedation.

RESULTS AND DISCUSSION

All of the 9 cases of dogs in which the radius/ulna and tibia/fibula fractures were fixed/repaired by supracutaneous bone plating were presented for postoperative follow-up.

The extent of manipulation and soft tissue damage in supracutaneous bone paling was minimum i.e. 1.0±0.0 (low). The soft tissue trauma in the supracutaneous plating technique was due to avoidance of the opening/exposure of the fracture site (Kerkhoffs *et al.* 2003, Kloen 2009, Woon 2010, Tulner *et al.* 2012, He X *et al.* 2014, Qiu 2014). The score of technical difficulty was moderate (2.0±0.0) because of relatively new technique and that's why it was a challenge for a surgeon to perform this technique. Many surgeons (Kloen 2009, Qiu 2014) also face initial difficult implant application in first few cases to the new technique.

Status of fracture reduction varied in each of case and it ranged from fair to good (2-3) with mean score of 2.44±0.17. In all the cases, the biological reduction was achieved rather than anatomical reduction. Whereas status

Supacutaneous bone plate in tibia

Supacutaneous bone plate in radius

Fig. 1. Postoperative photographs of fractures fixed by supacutaneous bone plate.

Table 1. Epidemiology of the radius/ulna and tibia/fibula fractures managed by supracutaneous bone plating

AO/AISF	Age	Sex	BW (kg)	Breed	Cause of fracture	Size of implant used
22A3	9 months	M	17	Husky	Automobile accident	7-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 30, 30 mm/ Distal screw- 32, 32 mm
42A2	2 years	M	8	Non-descript	Unknown	7-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 28, 32 mm/ Distal screw- 30, 30 mm
42A3	6 months	F	10	Non-descript	Automobile accident	8-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 30, 30 mm/ Distal screw- 28, 28 mm
42A3	1 year	M	12	Non-descript	Fight with other dog	8-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 34, 34 mm/ Distal screw- 32, 32 mm
22A3	11 months	M	15	Non-descript	Fall from height	6-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 28, 30 mm/ Distal screw- 30, 32 mm
42A2	5 months	F	10	Non-descript	Automobile accident	6-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 28, 28 mm/ Distal screw- 28, 30 mm
42A2	6 months	M	14	Non-descript	Fall from height	8-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 28, 30 mm/ Distal screw- 28, 30 mm
42A3	4 months	F	20	Non-descript	Automobile accident	8-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 30, 28 mm/ Distal screw- 28, 30 mm
42A3	4 months	F	20	Non-descript	Automobile accident	8-hole 3.5 mm LH-LC-DCP in supracutaneous manner Proximal screw- 32, 32 mm/ Distal screw- 30, 30 mm

of fracture fixation was good in all cases with mean score of 3.0±0.0. Fracture reduction was good in the supracutaneous bone plating due to use of the locking screws, head of the screws hold the LH-LCC-DCP in firm way and the threaded portion/shaft of the screw hold the cis and trans cortex of the bone in efficient manner. The supracutaneous bone plate reconstructs also provided a stable fixation to long bone fracture similar to external skeletal fixators (Ang *et al*. 2017). Unilateral external skeletal fixator and locking plates applied in supracutaneous manner have same biomechanical principles, they work as monoliteral fixators (Cronier *et al.* 2010, Petazzoni 2010). The supracutaneous plating approach with locking screws, especially in subcutaneous bones, such as the tibia or the distal radius, preserve the inherent features of stability due to its locking nature (locked screw and locking plate, LH-LC-DCP) and flexibility (long-spanning of the fracture) of a locking implant (Petazzoni 2010, Woon *et al.* 2010).

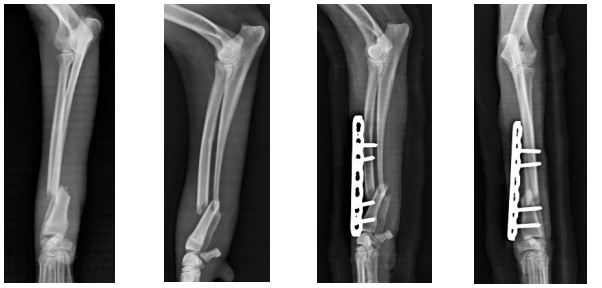
Inflammation score at FRD was zero in all of the cases and its mean value was recorded as 0.0±0.0 whereas it was recorded as 1.78±0.15 on the IFD. The mean score of pain on fracture site was 0.0±0.0 on FRD which was reasonably much lower than pain on fracture site on IFD recorded as 2.22±0.15. Mild amount of muscular atrophy was found in 4 cases. The mean score of muscle atrophy was recorded as 0.44±0.17. The mild amount of muscular atrophy was due to disuse of the limb (Singh 2021).

On the subsequent reappraisals, the dogs showed partial to full weight bearing on the fractured limb with normal gait. Implant (Supracutaneous plate) was well tolerated by the dogs in all of the cases. There was no inflammation or exudation at the screw insertion site. During the reappraisals, the skin under the plate was cleaned with antiseptic solution and antiseptic dressing at the site of screw insertion was done with mupirocin ointment (Singh 2021).

The mean weight-bearing score at FRD was 10.0±0.0 which means full weight-bearing during standing as well as during walking phase. All the animal showed normal gait during walking phase. The weight-bearing score greatly improved from the weight-bearing score at IFD which was 0.55±0.24. Weight-bearing score increases with the time as the fracture healing was in progress. The dogs showed full weight-bearing between 21st-68th days post-operative in different cases under study (Singh 2021).

The dogs and cats in which the radius/ulna and tibia/fibula fractures were repaired by supracutaneous bone plating showed full bearing on the implant removal day which varies from 45-120 day after complete healing of the fracture (Nicetto and Longo 2017, Nicetto and Longo 2019).

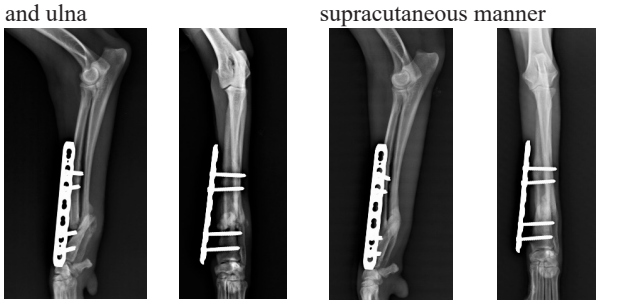
Immediate post-operative radiographs showed fair-good anatomical alignment and apposition of the fracture segments after the fracture fixation in all the dogs under study. Biological reduction (biological osteosynthesis) was achieved in all bones repaired by supracutaneous plating



Medio-lateral projection | Cranio-caudal projection | Medio-lateral projection | Cranio-caudal projection

Closed complete diaphyseal simple fracture of both radius and ulna

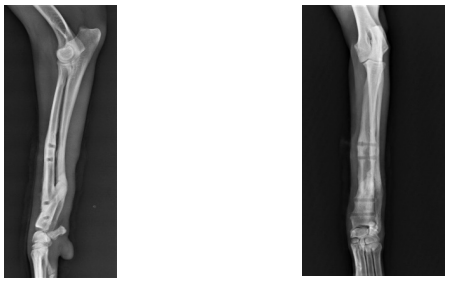
Fracture repaired by 7-hole 3.5 mm LH-LC-DCP applied in supracutaneous manner



Medio-lateral projection | Cranio-caudal projection | Medio-lateral projection | Cranio-caudal projection

On 24th post-operative day, fracture healing in progress, evident of formation of bridging callus at the fracture ends

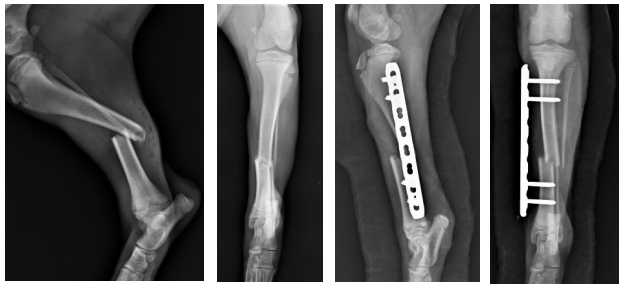
On 61st post-operative day, fracture healing completed with formation of large amount of callus at the fracture ends, fracture line not visible



Medio-lateral projection | Cranio-caudal projection

Immediate post implant removal radiographs: Callus not disturbed after removal of bone plate. Fracture healing completed and callus remodelling in advanced stage.

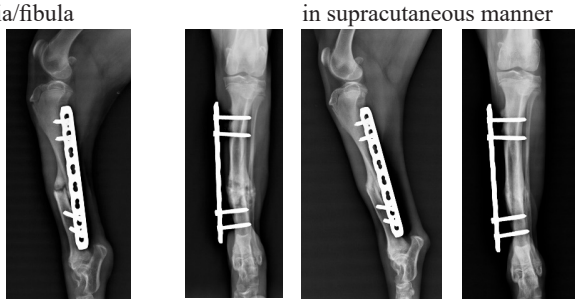
Fig. 2. Radiographs of Case no. 1.



Medio-lateral projection | Caudo-cranial projection | Medio-lateral projection | Caudo-cranial projection

Closed complete diaphyseal simple transverse fracture of tibia/fibula

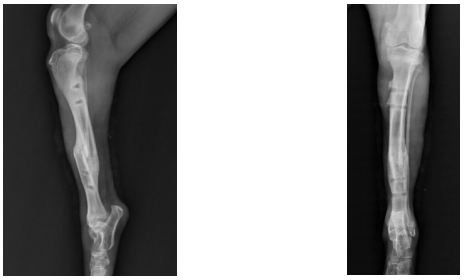
Fracture repaired by 8 hole 3.5 mm LH-LC-DCP applied in supracutaneous manner



Medio-lateral projection | Caudo-cranial projection | Medio-lateral projection | Caudo-cranial projection

On 21st post-operative day, fracture healing in progress, evident of formation of bridging callus at the fracture ends

On 37th post-operative day, fracture healing completed with formation of large amount of callus at the fracture ends, fracture line not visible



Medio-lateral projection | Caudo-cranial projection

Immediate post implant removal radiographs: Callus not disturbed after removal of bone plate. Fracture healing completed and callus remodelling in advanced stage.

Fig. 3. Radiographs of Case no. 3.

instead of anatomical reduction. All of screws engaged the cis as well as trans cortex of the fractured bone and provide good fracture fixation. Fracture healed by secondary bone healing with visible moderate to large amount of callus formation (Bridging callus formation at the fracture site) in most of the cases. No postoperative complication was recorded in any of the case. After the fracture fixation there was gap between the reduced fracture ends that's why the fracture healed by gap healing. Formation of callus at the fracture site describes the elastic nature of supracutaneous bone plating.

Supracutaneous bone plating techniques is based upon concept of minimally invasive osteosynthesis which minimize soft tissue trauma by indirect reduction of fracture as well as avoidance of the exposure to the fracture site which preserve the fracture haematoma as well as extraossess blood supply results/yields in early healing of the fracture (Mizuno *et al.* 1990, Palmer 1999). The radius/ulna and tibia/fibula fractures repaired by supracutaneous bone plating healed by formation of visible amount of callus at the fracture site between 45-120 days, evident of preservation of extraosseous blood supply at the fracture site and elastic fixation of the fracture (Nicetto and Longo 2017, Nicetto and Longo 2019). Bone healing with external

Table 2. Final radiographic observations and clinical outcome in dogs with humerus fracture repaired by intramedullary pinning

Radiographic observations			Final clinical outcome
Size of callus	Outcome (days)	Position of implant	
Moderate	Fracture healing completed (61)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (68)	Implant at its position, no loosening of plate and screws observed	Excellent
Large	Fracture healing completed (37)	Implant at its position, no loosening of plate and screws observed	Excellent
Large	Fracture healing completed (39)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (21)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (30)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (36)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (46)	Implant at its position, no loosening of plate and screws observed	Excellent
Moderate	Fracture healing completed (30)	Implant at its position, no loosening of plate and screws observed	Excellent

fixators may be direct, indirect, or somewhere between these extremes, depending on fracture type, mechanical environment afforded by external fixators, and degree of bone reconstruction (Tobias 1990).

In all the cases, the supracutaneous bone plate was removed after complete healing of the fracture. There was no implant related complication in either of the case (Table 2). The supracutaneous bone plate was tolerated well by dogs in all of the cases. The supracutaneous bone plate was removed under sedation with the use of general anaesthesia. After the removal of supracutaneous bone plate, the left-over screw holes were dressed with mupirocin ointment. Supracutaneous bone plates in dogs and cats were easily removed after complete healing of fracture (45-120 days) without use of general anaesthesia. The advantages of supracutaneous plating over the ORIF technique was the easier and faster removal of the implant with any further skin incision or skin portal (Nicetto and Longo 2017, Nicetto and Longo 2019).

Supracutaneous bone plating is modified form of plate used as an external fixator based upon concept of minimally invasive osteosynthesis as it reduces soft tissue trauma by indirect reduction of fracture as well as avoidance of the exposure to the fracture site and preserve the fracture haematoma as well as extraosseous blood supply resulting in early healing of the fracture. Fracture repaired by supracutaneous bone plating heal by formation of callus at fracture site (secondary bone healing). Fracture reduction was good in the supracutaneous bone plating due to use of the locking screws, head of the screws hold the LH-LCC-DCP in firm way and the threaded portion/ shaft of the screw hold the cis and trans cortex of the bone in efficient manner. The supracutaneous bone constructs provided good reduction and fixation at fracture site similar as external skeletal fixators not compromising on axial and torsional stiffness.

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