

## INTRAMEDULLARY IMPLANT FIXATION FOR MANAGEMENT OF DIAPHYSEAL FRACTURES OF HUMERUS IN DOGS

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### ABSTRACT

The study included 6 different types of humerus shaft fractures managed by end-threaded intramedullary positive profile screw ended self-tapping pin. End-threaded Steinmann pin provided good fracture reduction as well as fracture fixation in humerus shaft fracture due to its better engagement of cancellous part of the distal segment of the fractures by its threaded portion. The fracture healed by secondary bone healing with visible moderate to large amount of callus formation and proximal migration of end threaded pin was observed in one case. All the dogs showed full weight bearing between 15<sup>th</sup>-62<sup>nd</sup> days post-operation.

**Keywords:** Dogs, End-threaded intramedullary, Fracture healing, Fracture repair, Humerus shaft fracture, Self-tapping pin

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Humerus fracture repair in dogs is often considered more challenging due to its anatomy and presence of muscular attachments along the entire length and on all surfaces of the bone, which often makes surgical approaches to humeral fractures more difficult and invasive (Johnston and Tobias, 2018). Most of humerus fractures involve the middle and distal one-third of the bone (Harari *et al.*, 1986). Due to anatomical topography of the humerus bone (closer to the body), the humerus fracture cannot be managed by simpler methods of closed reduction and external coaptation such as casts or splints. Therefore, more invasive internal methods of fracture management like intramedullary pinning, intramedullary interlocking nailing, bone plating and screws etc. are commonly used for management of humerus shaft fractures. Out of these managemental techniques, intramedullary pinning is the simplest and most feasible method. In the present study, the humerus shaft fractures were managed by end-threaded intramedullary positive profile screw ended self-tapping pin. The distal threaded part of end-threaded pin engaged the distal part of fracture and resist pin migration, pin breakage and all load acting on bone, i.e. compression, tension, bending and rotation.

### MATERIALS AND METHODS

In this study, 6 different type of humerus shaft fractures were managed by end-threaded intramedullary positive profile screw ended self-tapping pin (along with cerclage wiring in 2 cases). The age of the dogs with diaphyseal fracture of humerus ranged from 3 month to 5 years and weight varied from 5 kg to 21 kgs (Table 1). In

case no. 2, there was proximal migration of Steinmann pin after 6<sup>th</sup> day of fixation of fracture, then revision surgery was done to fix the fracture by End threaded pin.

Anamnesis/signalment, basic clinical examination, 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 6 cases. The radiographic examination (cranio-caudal and medio-lateral projections) was done to diagnose the type and site of humerus fracture (Figs. 1-3). The diameter of the end threaded pin used for fracture repair were estimated from the preoperative radiographs as approximately about 70 per cent of the diameter of the medullary cavity of humerus at its narrowest point.

The humerus shaft fractures were repaired by intramedullary pinning by open reduction and internal fixation technique (ORIF). Adequate exposure of humerus shaft was achieved following standard cranio-lateral incision in all the cases (Brinker 1957). The Steinmann as well as end-threaded intramedullary positive profile screw ended self-tapping pin was inserted in retrograde manner (Channana, 2014 and DeCamp *et al.*, 2016).

Different preoperative and postoperative observations like pain and inflammation were analysed and recorded on a scale of 0–3. The number increased with severity of pain, inflammation and vice-versa. 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

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**Table 1**  
**Epidemiology of the humerus shaft fractures**

CaseNo.	AO/AISF	Age	Sex	BW (kgs)	Breed	Cause of fracture	Size of implant used
1.	12A2	5 years	M	18	Non-Descript	Automobile accident	* End threaded Steinmann pin (6.5-4.5 mm)
2.	12A3	5 months	M	5	Non-Descript	Automobile accident	Simple Steinmann pin 4 mm revised surgery * End threaded Steinmann pin (4.5-3.5 mm)
3.	12A3	3 years	M	20.8	Labra	Abusive/Gun shot	* End threaded Steinmann pin (6.5-4.5 mm)
4.	12A2	3 months	M	8	German Shepard	Unknowntrauma	* End threaded Steinmann pin (5.5-4 mm)+ 1 full cerclage wiring (20 G)
5.	12A3	1 month	M	2.6	Non-Descript	Mischief	* End threaded Steinmann pin (4.5-3.5 mm)
6.	12B2	4 years	M	21	Non-Descript	Fall from height	* End threaded Steinmann pin (6.5-4.5 mm)+ 1 full cerclage wiring (20 G)

\*First digit, in the end threaded Steinmann pin denote the diameter of the threaded portion (positive profile) and the second part denotes the pitch diameter.

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.

During fracture fixation various intraoperative observations like duration of surgery (min.), extent of manipulation/soft tissue damage, degree of technical difficulty, status of fracture reduction and fixation, intraoperative complications and any other remarkable observations were also recorded. Extent of manipulation/soft tissue damage and degree of technical difficulty were recorded on scale of 1–3; in which 1 means slight, 2 means moderate and 3 means high extent of manipulation/soft tissue damage and degree of technical difficulty. Whereas, the status of fracture reduction and status of fracture fixation were recorded on scale of 1–4; where 1 means poor and 4 means excellent reduction and fixation.

Post-operatively, routine clinical, haemato-biochemical, orthopaedic and radiological examinations as described in pre-operative observations 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.

### RESULTS AND DISCUSSION

Out of 6 cases of dogs in which the humerus fractures were fixed with intramedullary pinning technique, 4 dogs were presented for postoperative follow-up. Case no. 2, 4,

**Table 2**

**Various intra-operative observations in dogs with humerus fracture repaired by intramedullary pinning**

Case no.	Extent of manipulation and soft tissue damage	Degree of technical difficulty	Status of fracture reduction	Status of fracture fixation
1	2	2	4	4
2	2	2	3	3
3	2	2	4	4
4	2	2	4	3
5	1	2	3	3
6	3	2	3	3
Mean ± S.E.	2.0±0.26	2.0±0.0	3.5±0.22	3.33±0.21

**Table 3**

**Miscellaneous clinical and orthopaedic observations in dogs with humerus fracture repaired by intramedullary pinning (Post-operative)**

Case no.	FRD (Days)	Inflammation		Pain		Muscle atrophy on FRD
		IFD	FRD	IFD	FRD	
2	38 days*	2	0	1	0	0
4	24 days	3	0	2	0	0
5	50 days	2	0	2	0	0
6	62 days	3	0	3	0	0
Mean ± S.E.	43.5 ± 8.13 days	2.5 ± 0.29	0.0 ± 0.0	2.0 ± 0.4	0.0 ± 0.0	0.0 ± 0.0

\*FRD (Final Reappraisal Day) and compared with the score at the IFD (Implant Fixation Day)

5 and 6 came for reappraisal, therefore only these four cases were included further in results and discussion.

The extent of manipulation and soft tissue damage

ranged from 1-3 (low-high) with mean  $2.0 \pm 0.26$  (moderate) and the degree of technical difficulty was  $2.0 \pm 0.0$  (moderate). Status of fracture reduction and fixation however, was recorded between good to excellent with mean score of  $3.5 \pm 0.22$  and  $3.33 \pm 0.21$ , respectively (Table 2). Similar type of findings were observed by Chanana (2014) who reported that the fixation of humerus fracture by end threaded pin provided good fracture reduction as well as fracture fixation due to better engagement of cancellous part of the distal segment of the fracture by its threaded portion; with moderate soft tissue damage and technical difficulty.

**Table 4**

**Weight-bearing score of dogs**

Case no.	Weight-bearing status (IFD)			Weight-bearing status (FRD)		
	Standing	Walking	Total	Standing	Walking	Total
	2	1	1	2	5	5
4	1	1	2	5	5	10
5	0	0	0	5	5	10
6	1	0	1	5	5	10
Mean $\pm$ S.E.	0.75 $\pm$ 0.25	0.5 $\pm$ 0.29	1.25 $\pm$ 0.48	5.0 $\pm$ 0.0	5.0 $\pm$ 0.0	10.0 $\pm$ 0.0

**Table 5**

**Final radiographic observations and clinical outcome in dogs with humerus fracture repaired by intramedullary pinning**

Case no.	Radiographic Observations			Final clinical outcome
	Size of callus	Outcome (days)	Position of implant	
2	Moderate	Fracture healing completed (38)	Steinmann pin migrated proximally; No migration of end threaded Steinmann pin	Excellent
4	Large	Fracture healing completed (24)	Proximal migration of end threaded Steinmann pin	Excellent
5	Moderate	Fracture healing completed (50)	No migration of end threaded Steinmann pin	Excellent
6	Large	Fracture healing completed (62)	No migration of end threaded Steinmann pin	Excellent

Mean inflammation score at FRD was zero ( $0.0 \pm 0.0$ ) whereas, it was recorded as  $2.5 \pm 0.29$  on the IFD. The mean score of pain on fracture site was also  $0.0 \pm 0.0$  on FRD which was  $2.0 \pm 0.4$  on IFD. No muscular atrophy was found in any of the case on FRD hence its mean score was recorded as  $0.0 \pm 0.0$ . (Table 3). Chanana (2014) also reported that there was no muscular atrophy in any cases that were repaired by end threaded pin.

The mean weight-bearing score at FRD was  $10.0 \pm 0.0$  which means full weight-bearing during standing as well as during walking phase. All the animals showed normal gait during walking phase (Table 4). The weight-bearing score greatly improved from the weight-bearing score at IFD ( $1.25 \pm 0.48$ ). Weight-bearing score increased with the time as the fracture healing was in progress. The dogs showed full weight-bearing between 15<sup>th</sup> - 62<sup>nd</sup> days post-operative in different animals.

Ozsoy (2004) reported that cat showed full bearing within 20 to 30 days (mean 25 days) after fixation of humerus shaft fractures by full-threaded trocar-pointed Steinmann pins (negative profile). Altunatmaz *et al.* (2012) reported full weight-bearing after 20 days of surgery in dogs (n=15) with humerus fracture repaired by

full threaded modified Steinmann pin without any post-operative complication. These findings were similar with those of Chanana (2014); in which the dogs showed partial weight-bearing on 10<sup>th</sup> -14<sup>th</sup> day post-operative and full weight-bearing on the affected limb on 21<sup>st</sup> - 42<sup>nd</sup> day post-operative with normal limb function.

In all of the cases, fracture repaired by end threaded Steinmann pin (5 fresh cases+1 revisional surgery), immediate post-operative radiographs showed good anatomical alignment and apposition of the fracture segments after the fracture fixation (Fig. 1-3). The threaded portion of the end threaded Steinmann pin engaged the distal segment of the fracture in efficient manner and it provided good-excellent fracture reduction as well as fixation. None of the post-operative radiographs showed the involvement of the elbow joint by the tip of the end threaded Steinmann pin (Table 5).

In all the cases, fracture healed by secondary bone healing with visible moderate to large amount of callus formation (Bridging callus formation at the fracture site). Only in one case, there was proximal migration of end threaded pin, in other three cases there was no pin migration (Fig. 1-3). Ozsoy (2004) and Venkataiah (2008)



Medio-lateral projection Cranio-caudal projection  
 Closed complete diaphyseal simple oblique fracture  
 Fracture repaired by end threaded Steinmann pin (5.5-4 mm) and 1 full cerclage wiring (20 G)



Medio-lateral projection Cranio-caudal projection  
 On 24<sup>th</sup> post-operative day fracture healing completed, cortical union nearly attained and large amount of callus was formed at the fracture site. Proximal migration of end threaded Steinmann pin  
 Immediate post implant removal radiographs: Callus not disturbed after removal of implant. Fracture healing completed

Fig. 1. Radiographs of case no. 4



Medio-lateral projection Cranio-caudal projection  
 Closed complete diaphyseal simple transverse fracture  
 Fracture repaired by end threaded Steinmann pin (4.5-3.5 mm)



Medio-lateral projection Cranio-caudal projection  
 On 21<sup>st</sup> post-operative day, bridging callus formed at the fracture site, fracture line clearly visible  
 On 50<sup>th</sup> post-operative day, fracture healing completed with obliteration of fracture line, cortical union attained, moderate amount of callus was formed and remodelling of callus was in advance stage

Fig. 2. Radiographs of case no. 5



Medio-lateral projection Cranio-caudal projection  
 Closed complete diaphyseal wedge fracture  
 Fracture repaired by end threaded Steinmann pin (6.5-4.5 mm) and 1 full cerclage wiring (20 G)



Medio-lateral projection Cranio-caudal projection  
 On 62<sup>nd</sup> post-operative day, large amount of callus formed at the fracture site. Fracture healing completed with the formation of bridging callus. There was large amount of uneven periosteal reaction on the lateral and caudal side of the proximal fracture segment. Bridging callus was also formed along the wedge.  
 Immediate post implant removal radiographs: Callus not disturbed after removal of implant. Fracture healing completed.

Fig. 3. Radiographs of case no. 6

reported that all the humerus fractures repaired by intramedullary pinning healed by bridging callus formation with minimum to moderate amount of periosteal reaction. Chanana (2014) reported that radiographs taken on day 21<sup>st</sup>-30<sup>th</sup> day showed stable implant without any axial rotational or compression at the fracture site and presence of periosteal reaction at the fracture site was evident of fracture healing in humerus fractures repaired by end threaded Steinmann pin.

Sakshi (2019) and Swathi (2019) observed that telescoping of fracture segments and proximal migration of end threaded pin were common type of complications during the post-operative period in which the long bone fractures were repaired by positive profile end threaded Steinmann pin. Ozsoy (2004), Altunatmaz *et al.* (2012) and Chanana (2014) reported that threaded pin provide better stability than the simple Steinmann pin.

To conclude, end-threaded intramedullary positive profile screw ended self-tapping pin was efficient in repairing of humerus shaft fracture because the distal threaded part of end threaded pin engaged the distal segment of fracture and resist pin migration, pin breakage and all load acting on bone, i.e. compression, tension, bending, rotation leading to early fracture healing and ambulation of the limb.

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