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Evaluation of bar square mesh for the management of compound fracture of metacarpal and metatarsal bones in bovines

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Abstract
The present clinical study was carried out to evaluate the clinical, haematological, biochemical, Radiographic findings and the economy of treatment after application of bar square mesh for the management of compound fracture of distal long bones in bovines. Based on clinical and radiographic examinations, patients were randomly distributed irrespective of sex and age suitable for application of bar square mesh (n=6) for the study. In the present study, six clinical cases in bovines with compound fracture of distal long bones were stabilized with welded stainless-steel wire mesh. Anamnesis, signalment, clinical and physical evaluation, haematological, biochemical and radiographic evaluation was carried out preoperatively in all the cases. During the study, the species, the age of animals, body weight of animals, gender, etiology of fractures, limb and bone involved, age of fracture and location of fracture site varied significantly without any specific trend. Weight bearing on affected limb, healing of open wound at fracture site, range of motion of joints in affected limb, haemato-biochemical findings, radiographic findings and complications were noticed postoperatively. The cost of materials used in bar square mesh method was found to be lesser than the cost involved in other external coaptation methods. Based on the present study, conclusions drawn were; bar square method had good efficacy in the treatment of compound fractures of distal long bones in bovines and was more economical. The haematological and biochemical parameters were showing no systemic adverse effect with the use of this method.

Keywords: Bar square mash, compound fracture, Metacarpal. Metatarsal

Introduction
A fracture is a dissolution of bony continuity with or without displacement of the fragments which is characterized by soft tissue damage of varying degrees, torn blood vessels, bruised muscles, lacerated periosteum and contused nerves (Tulleners, 1996) [35]. Trauma is the most frequent aetiology of fractures caused by another cow while sleeping (Gahlot, 2000) [15] or during transportation (Ferguson *et al*., 1990, Steiner *et al*., 1993) [12, 30] or as a result of traffic accidents (Aithal *et al*., 2007) [1], sports injuries, and other activities. The metacarpus and metatarsus III-IV (MTC/T III-IV) represent the bones most commonly fractured in cattle (Ferguson, 1982) [13] and are more common in calves than adults (Mulon, 2017) [25]. Fracture management focuses mainly on restoration of function and physical integrity with the minimum deformity of bone (Mohiuddin *et al*., 2018) [23]. When there is an open wound communicating with the fracture site, have a poor to grave prognosis because of contamination of the fracture site and the resultant negative effects on bone healing (Jean and Anderson, 2014) [20]. Decision making regarding fixation of long bone fractures must include consideration of the cost of the treatment, likelihood of successful outcome, perceived potential economic or genetic value of the animal, and the location and type of fracture. (Pentecost *et al*. 2016) [26]. The common treatments include use of splints, plaster of Paris, wire suture, combination of wire suture and bone pinning or bone plating casting, external fixator (Mohiuddin *et al*., 2018) [23]. Casts and splints are used separately or in combination in all types and sizes of ruminants as a successful, effective and economical method for fracture repair (Baird and Adams, 2014) [7]. Bar square mesh technique involves use of stainless-steel wires of adequate strength and thickness, welded at even spacing. It involves moulding of welded stainless steel wire mesh according to the shape of the limb and then tightening with the help of hose clamps with appropriate padding over limb. The aim of this study was to evaluate the bar square mesh for the management of compound fractures of metacarpal and metatarsal bones in bovines and to calculate the cost involved in this method of treatment.

Materials and Methods

The study was conducted in the department of Veterinary Clinical Complex, College of Veterinary Sciences, LUVAS, Hisar. Six bovine cases irrespective of species, age, and sex with a history of compound fracture of metacarpal and metatarsal bones were used for this study. All the animals of the present study underwent signalment, anamnesis, clinical examination, physical examination, haemato-biochemical examinations and radiographic examinations.

Complete physical examination of the animals was done on the day of presentation. Physiological parameters including rectal temperature (ºC), heart rate (beats per minute), and respiratory rate (breaths per minute) were recorded pre-operatively and post-operatively at 20th day, 40th day and 60th day. Weight bearing with affected limb was recorded pre-operatively and post-operatively at 20th day, 40th day and 60th day whereas general health condition of the animals was recorded pre-operatively.

Radiographic examination was conducted Medio-laterally or latero-medially and antero-posteriorly of metacarpal and metatarsal bones in all the animals to evaluate the type and location of fracture. Radiographs were taken preoperatively and postoperatively at 20th day, 40th day and 60th day.

Estimation of hematological parameters *viz*., haemoglobin (gm/dl), packed cell volume (%), total erythrocyte count (x10^{6} /µl), total leucocyte count (x10^{3} /µl), differential leucocyte count and total platelet count (x10^{3} /µl) was done preoperatively and post-operatively at 20th day, 40th day and 60th day. In plasma biochemical parameters aspartate aminotransferase (AST) (IU/L), alanine aminotransferase (ALT) (IU/L), alkaline phosphatase (IU/L), blood urea nitrogen (BUN) (mg/dl), creatinine (mg/dl), total protein (g/dl), albumin (g/dl), globulin (g/dl), albumin: globulin ratio, calcium (mg/dl), phosphorus (mg/dl), calcium: phosphorus, magnesium (mg/dl), sodium (mEq/L), potassium (mEq/L) and chloride (mEq/L) were estimated pre-operatively and post-operatively at 20th, 40th day and 60th day.

Method of application of bar square mesh in compound metacarpal and metatarsal fractures in bovine

The animal was casted on comfortable bedding with the wound side up. Hairs around the open wound were clipped or shaved and generously cleaned with normal saline. The piece of thick cotton string (approximately 75cm) was tied just above the hoof in the form of a loop for traction. Zinc oxide powder was applied to the limb especially under the dewclaws, and bony protuberances like accessory carpal for reducing the moisture content over the site. The cotton rolls were applied around the limb from the coffin joint to the mid radius region in metacarpal and to the mid tibia in metatarsal bone respectively without covering the wound site by placing the hand over the wound. Cotton bandages were applied tightly over the rolled cotton and in 8 shape fashion around the wound site. Stainless steel welded wire mesh was molded in a circular fashion according to the shape of the limb. It includes the proximal carpal joint in metacarpal fracture or tarsal joint in metatarsal fracture and distal fetlock joint. Molded wire mesh was put around the affected limb over the tight bandage and tightened by initially placing 2 adjustable pipe hose clamps at proximal and distal ends of the mesh. Daily dressing of the wound through the mesh was advised to the owner of the animal. In postoperative treatment, analgesic (inj. Meloxicam @ 0.5mg/kg, IM, OD) was advised for 3 days in all bovines. Antibiotics (inj. Ceftriaxone @ 10mg/kg, IM OD and inj. Gentamicin sulphate @ 5mg/kg, IM, BID) were prescribed for 7 days. The owner was advised to keep the movement of the bovine restricted until removal of wire mesh and not to take the animal to nearby water bodies.

All data values were expressed as mean ± standard error of parameter value (Mean ± SE). P-value of less than 0.05 was considered as statistically significant.

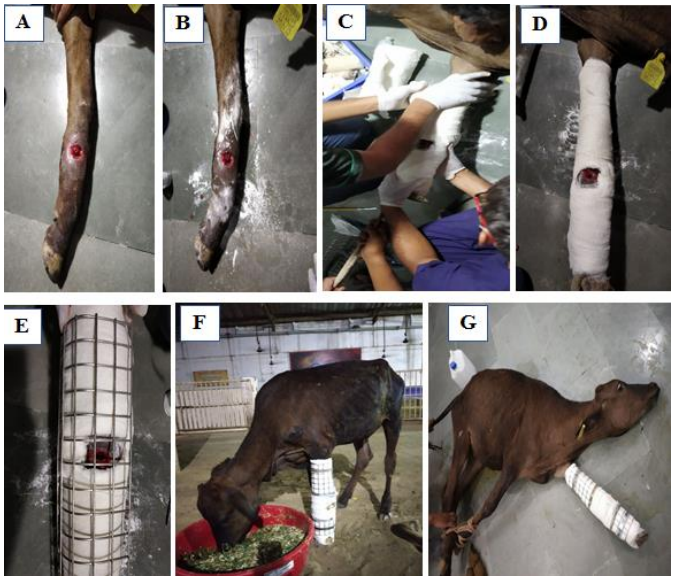

Fig 1: Photographs showing the procedure for stainless steel bar square mesh application in compound metacarpal fracture in cattle. Casting of animal with the wound side up and aseptic preparation of wound (A), application of zinc oxide or any antibiotic powder (B), thick cotton rolling and simple bandages application with leaving of window at wound site (C and D), application of welded stainless steel wire mesh around the limb (E), tightening of wire mesh with adjustable pipe hose clamps by using screw driver (F), window availability for antiseptic dressing of wound (G).

Results

Out of six animals, four were cattle and two were buffaloes. Male cattle were 50% followed by 33% female buffaloes and 17% female cattle respectively. 50% animals were within age group 6-12 months followed by 33% having age less than 6 months and 17% were above 12 months. The main etiology of fracture was automobile accident in five cases followed by slipping on sticky surface in one animal. Right and left forelimbs were equally affected in two cases each whereas right and left hind limbs were affected in one case each. Metacarpal and metatarsal bones were affected in 67% and 33% of cases respectively. Three animals were having body weight between 50-100kg, two were having body weight less than 50kg and one animal was above 100 kg. Four animals were having age of fracture less than 3 days, followed by 3-6 days in one case and more than 12 days in one case. maximum number of animals were having fracture at proximal diaphysis (50%) followed by distal diaphysis (33%) and mid diaphysis (17%).

No significant variation was observed in the mean values of physiological vital parameters of rectal temperature (ºC), heart rate (beats per minute) and respiratory rate (breaths per minute) when compared at different time intervals and remained near to the base value throughout the study interval.

Significant difference was present in the mean values of weight bearing score while walking when compared at different time intervals, from zero at pre-operative to approximately four at 60th post-operative day indicating

improvement in weight bearing from carrying the limb off the ground surface at pre-operative to touching of the sole on every step along with complete weight bearing at 60th postoperative day.

Absence of swelling to mild swelling was present in animals at the time of presentation. Mean value of lameness score in six animals preoperatively was 5 indicating that the animals were showing severe lameness whereas the mean value at 60th postoperative day was approximately 1 indicating normal animals without showing any lameness. The average time of complete healing of open wound in buffalo was 60 days whereas in cattle it was 75 days.

The mean value of haemoglobin in six animals was less preoperatively and showed gradual increment reaching normal or near normal values by 60th post-operative day. Leukocytosis with neutrophilia was noticed preoperatively in these animals. However, the mean value of total leucocyte count and neutrophils returned to normal at 40th and 60th post-operative days. The mean values of alkaline phosphatase increased at 20th post-operative day in comparison to mean values at pre-operative day and returned to normal at 60th post-operative day. There was mild hypocalcemia at 20th post-operative day in comparison to mean values at pre-operative day and returned to normal at 60th post-operative day. The rest of haemato-biochemical values remained within the normal range both pre and postoperatively.

The follow-up radiographs taken 20 days postoperatively revealed intact fracture fragments and the mesh was holding the proximal and distal fragments firmly without any displacement. Post-operative radiographs taken at 40th day revealed the apparent bridging of fracture line. 60 days post-operative radiography revealed the exuberant callus formation with no distinction of fracture line

Minor complications of superficial skin wounds due to over tightening of hose clamps were noticed. No other complications were noticed in these animals after removal of bar square mesh. The final outcome was excellent in one case (n=1; 16.67%), good in four cases (n=4; 66.66%) and fair in one case (n=1; 16.67%). The total cost of materials used per animal was found to be Rs.590.

Fig 2: Photographs showing the pre-operative radiograph at the time of presentation (A), immediate post-operative radiograph showing proper alignment of fracture fragments (B), 20th day post-operative radiograph showing initiation of early callus formation in the form of periosteal reaction (C), 40th day radiograph showing the apparent bridging of fracture line (D), 60th day post-operative radiograph showing exuberant callus formation with no distinction of fracture line (E).

Table 1: Showing haemato-biochemical parameters pre and postoperatively

Blood parameter	Pre-operative	20th day	40th day	60th day
Haemoglobin (Gm/dl)	$7.6^{A} \pm 0.91$	$8.18^{AB} \pm 0.79$	$8.85^{B} \pm 0.64$	$9.73^{B} \pm 0.44$
Total erythrocyte count ($x10^{6}$/µl)	$5.22^{A} \pm 0.42$	$5.96^{AB} \pm 0.4$	$6.14^{B} \pm 0.43$	$6.31^{AB} \pm 0.56$
Total leucocyte count ($x10^{3}$/µl)	$12.97^{B} \pm 1.3$	$11.43^{B} \pm 0.5$	$9.17^{AB} \pm 1.71$	$8.52^{A} \pm 0.85$
Packed cell volume (%)	$24.45^{A} \pm 3.16$	$27.07^{AB} \pm 3.26$	$27.47^{AB} \pm 2.75$	$27.68^{B} \pm 2.6$
Total platelet count ($x10^{3}$ /µl)	317.67 ± 67.75	402.33 ± 77.32	307.5 ± 35.96	434 ± 78.74
Lymphocyte count (%)	$42^{A} \pm 4.34$	$43^{A} \pm 3.6$	$49.17^{A} \pm 2.73$	$61.67^{B} \pm 2.65$
Neutrophil count (%)	$53.33^{B} \pm 4.6$	$53^{B} \pm 3.38$	$46.67^{B} \pm 3.15$	$34.5^{A} \pm 2.09$
Monocyte count (%)	4.67 ± 0.84	4 ± 0.77	4.17 ± 0.7	3.83 ± 0.95
Alanine aminotransferase (IU/L)	25.7 ± 4.76	20.88 ± 3.23	24.85 ± 3.77	26.27 ± 4.12

Aspartate aminotransferase (IU/L)	75.48 ± 11.83	62.42 ± 9.28	68.93 ± 8.24	73.77 ± 6.73
Blood urea nitrogen (mg/dl)	22.23 ± 4.34	24.98 ± 3.05	22.68 ± 3.44	25.17 ± 4.29
Creatinine (mg/dl)	0.61 ± 0.06	0.67 ± 0.05	0.6 ± 0.08	0.7 ± 0.07
Alkaline phosphatase (IU/L)	92.12^{AB} ± 9.2	108.95^{BC} ± 7.48	104.1^{B} ± 5.56	96.37^{A} ± 7.18
Calcium (mg/dl)	6.6^{BCD} ± 0.74	5.69^{A} ± 0.64	6.12^{BC} ± 0.6	7.19^{CD} ± 0.76
Phosphorus (mg/dl)	4.21^{AB} ± 0.39	4.06^{A} ± 0.4	3.87^{A} ± 0.34	5.05^{B} ± 0.3
Calcium: phosphorus	1.6±0.16	1.47±0.19	1.62±0.17	1.45±0.18
Total plasma proteins (g/dl)	4.52^{B}±0.34	4.19^{B}±0.38	4.56^{AB}±0.58	5.26^{A}±0.49
Plasma albumin (g/dl)	2.67^{ABC} ± 0.26	2.44^{AB} ± 0.20	2.38^{A} ± 0.24	2.92^{C} ± 0.21
Globulin (g/dl)	1.85^{AB}±0.16	1.75^{A}±0.33	2.18^{AB}±0.38	2.34^{B}±0.42
Albumin: globulin	1.49±0.18	1.62±0.29	1.18±0.12	1.55±0.37
Sodium (mEq/L)	125.02^{A}±4.68	131.55^{AB}±2.26	130.55^{A}±0.83	135.10^{B}±1.65
Chloride (mEq/L)	99.80±2.87	105.30±1.25	104.50±0.97	106.15±0.59
Potassium (mEq/L)	3.53±0.33	3.52±0.16	3.70±0.23	3.83±0.21
Magnesium (mg/dl)	2.14±0.19	2.16±0.28	2.11±0.15	2.13±0.24

Means with different superscripts (A, B, C, D) vary significantly ($p< 0.05$) within group.

Discussion

Higher incidence of fractures in cattle in comparison to buffaloes have also been reported by Yadav *et al.* (2018) [38]. The observation of this study was similar to the findings that reported metacarpal fractures were having more percentage than metatarsal fractures in cattle (Tulleners, (1986a); [37] Steiner *et al.* (1993a) [31]; Tulleners, (1996) [35] and Arican *et al.* (2014) [5]. Arican *et al.* (2014) [5], Belge *et al.* (2016) [8] and Akin (2017) [3] reported that male cattle population have more metacarpal fractures due to traction during dystocia. Tambe (2010) [32] and Alam *et al.* (2014) [4] also reported that the fracture occurred mainly due to road accidents in most of animals.

Tembhurne *et al*. (2010) [34] reported that the physiological parameters were within normal range in all animals treated with the use of horn peg. Kumar *et al*. (1999) [21] in calves, Gabriel *et al*. (2014) [14] and Gupta (2015) [18] in goats, Aithal *et al*. (1998) [2], Tembhurne *et al*. (2010) [34] and Rajhans (2013) [28] in dogs who also reported non-significant difference in the values of haemoglobin, total erythrocyte count and packed cell volume and the values fluctuated within normal physiological limit. Gabriel *et al.* (2014) [14] and Gupta (2015) [18] in goats, De' Souza (2012), Rajhans (2013) [28] and Singh (2015) in canines reported slight increase in total leucocyte count and neutrophil count post-operatively followed by a decrease, after which it fluctuated within normal range. Ginsberg, A.L. (2002) [17] stated that the bone disease cannot account for even mild AST or ALT elevation. Meller *et al.* (1984) [22] also stated that the main events following a fracture are an acute reaction—characterized by significantly increased serum ALP activity and hypocalcemia. Calciolari *et al.* (2021) [9] reported that during bone repair in rabbit, the albumin average displayed slight variations at each time period, however, this was not statistically significant. Indrowiyono *et al.* (2021) [19] reported that serum biochemical results were relatively within normal limits without any indication of differences in values between the closed and open type of fracture cases.

20 days post-operative radiographs revealed intact fracture fragments and evidence of periosteal reaction at the fracture site. These findings were similar to the radiographic findings by Gill and Tyagi (1972) [16]; and Chaudhary (1982) [10]. In group I, follow-up radiographs taken at 40th post-operative day revealed the apparent bridging of fracture line similar to the findings of Ayaz, 2000. 60 days post-operative radiographs revealed extensive callus formation and obliteration of fracture line was evident in all cases. These findings were similar to the findings of Morgan, 1972 [24]; Tulleners, 1986 [35]; Tamilmahan *et al.* 2017 [33] and Prabhakar *et al.* 2012 [27].

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