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External Fixation using Acrylic versus Epoxy as a Connecting bar for Repair of Compound Fracture in Goat

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ABSTRACT

The study was conducted on 10 goats, aged between 10 months to 5 years, brought to T.V.C.C, Jabalpur for the treatment of compound fracture in metacarpal and tibia. The animals were selected irrespective of their age, sex, breed and body weight. The animals were randomly divided into two equal groups. In group I, external skeletal fixation using Acrylic as the connecting bar was applied whereas in group II, Epoxy putty was used as the connecting bar. Wound area at fracture site decreased significantly at 30th day as compared to 0 day. The mean radiographic score increased significantly at 30th day and was highest at 60th day. Weight bearing score improved on 15th day and complete weight bearing was observed on 12th to 30th days in all goats. Pin loosening, pin tract drainage and inflammation were observed post-operatively.

Keywords: Goat, External skeletal fixation, Acrylic, Epoxy, Long bone fractures

Fracture is the breach in the continuity of hard tissue. Bone is unique among tissue, in that it heals by regeneration and not by scar formation as is evident in muscle, skin, heart etc. External fixation enables successful treatment of open and closed fractures, limb deformity, non-unions and arthrodesis. External Skeletal Fixation (ESF) is less invasive than internal fixation and allows better access to open wound than internal cooptation (Marcellin-Little, 2003). ESF is associated with shorter duration of surgery and lesser complications (Dudley *et al.,* 1997) and is ideal method of choice for the repair of fractures fixation and can be easily removed after bone healing (Gorse, 1998).

The Acrylic external fixator is economical and technically feasible. In heavier animals, use of acrylic bar on one side of type-II fixator give adequate stability (Julie *et al*., 2007). Acrylic connecting bars are economical and have equivalent or superior mechanical strength when compared to contemporary stainless steel connecting bars (Martinez *et al.,* 1997).

The versatility of the system allows the Epoxy putty to be used in place of clamps, to cover sharp ends of cut pins and many other applications, easy to handle, inexpensive, versatile and has suitable setting time and mechanical properties (Kern and Smith, 1995). The Epoxy putty can be moulded to any shape allowing great flexibility in the direction of pin placement which was particularly useful in stabilizing jaw fractures or multiple metacarpal or metatarsal fractures (Corr, 2005).

MATERIALS AND METHODS

The types of ESF configurations adopted were bilateral uniplanar with either Acrylic or Epoxy connecting bar on both side. Animals were kept off feed for a period of 24 hours and off water for twelve hours before surgery. Anaesthesia was induced by diazepam @ 0.5 mg/kg b.w. I/V followed by ketamine hydrochloride @ 6 mg/kg b.w. I/V till effect. Maintenance of anaesthesia was done by intravenous administration of ketamine hydrochloride as and when required. Surgical site was prepared aseptically before surgery.

The animals were placed in lateral recumbency. The pins

were inserted in a medio-lateral direction. Two transfixation pins were inserted through the proximal and distal fracture fragments. The proximal most and the distal most pins were drilled first by high speed torque drill machine, while the site was being irrigated with normal saline. Pins were drilled through the safe corridors of the respective bone across the two cortices of bone. Following the placement of pins, the proximal and distal pins were connected by the hollow pipe. The pipes were placed 0.75-1.00 inch away and parallel to long axis of bone. This was accomplished by piercing the tube along its width through the free ends of the transfixation pins. Then Acrylic powder and liquid were mixed in 2:1 ratio, it started getting solidified progressively within 30-60 seconds and therefore, it was not suitable for pouring. Hence, the Acrylic mixture was placed into the pipes in semi-solid state. After complete hardening of acrylic, excess parts of the transfixation pins were cut close to the Acrylic bar.

For application of Epoxy connecting bar, hardener and resin base of the Epoxy compound were kneaded until uniform black colour dough was produced. Following mixing of the Epoxy, it remained in a semi-solid state approximately for 25-35 minutes and was placed as connecting bar and it started getting solidified progressively (Fig. 1).

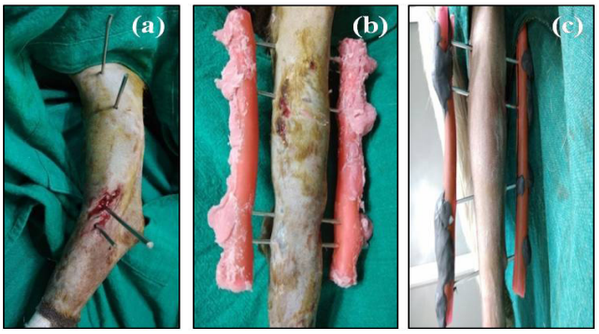

Fig. 1: Photograph showing placement of **(a)** transfixation pins; **(b)** Acrylic connecting bars; **(c)** filling the pipe with Epoxy

In both the groups of animals, inj. amoxycillin sodium and sulbactum sodium combination @ 10 mg/kg b.w. i.m, b.i.d. preoperatively and up to 5th post-operative day was administed. Inj. meloxicam @ 0.1-0.2 mg/kg b.w., i.m, o.d. was also administered for three post-operative days to alleviate pain. Antiseptic dressing was done on 2nd, 4th, 6th, 8th and 10th post-operative day using 5% povidone iodine solution.

RESULTS AND DISCUSSION

During the study period, etiology of long bones fracture revealed that automobile accident (80.00%) was the most common cause of fracture followed by falling from height (20.00%). Similar findings were also reported by Kushwaha *et al.* (2011). Fractures were more commonly seen in male (70.00%) goats when compared to female (30.00%) animals. Dandekar (2007) also made similar observations.

The mean values of hardening time of connecting bars for group I and group II were 11.20±0.86 minutes and 53.40±5.33 minute respectively. The mean value of hardening time in group II was four times higher than in group I. Similar findings were also reported by Ozak *et al.* (2009) and Basith *et al.* (2018). The Acrylic gets hard rapidly due its chemical composition.

All the animals in the present study tolerated the external skeletal fixator assembly well. The swelling and discharge from the pin insertion site was observed during the first three post-operative days and resolved by the end of the first post-operative week. The pin tracts were found dry during the entire post-operative observation period in all the animals.

The ESF were removed from the animals between 43rd and 68th post-operative days with mean time of 60.90±2.22 days. Following cutting of the transfixation pins during removal of the external skeletal fixators, most of the pins were found to be loose in all the animals (Basith *et al.,* 2017). Following disassembly of the fixators, slight bleeding and discharges were noticed for 1 to 2 days. This discharge resolved in three days due to routine antiseptic dressing of these wounds.

The mean values of weight of connecting bars for group I and group II were found 117.00±13.19 gms and 262.00±21.54 gms respectively. The mean value of weight of connecting bars in group II was significantly higher than group I. These findings were in accordance with the findings of Basith (2015), who conducted clinical studies on Acrylic and Epoxy external skeletal fixation system in goat and sheep. He concluded that weight of Epoxy was significantly higher than the Acrylic. The Acrylic is lighter than Epoxy due to its polymer quality.

Rectal temperature was observed significantly lower at 24 hour post- operatively in both the groups as compared

to zero hour. These findings were in accordance with the findings of Gupta (2015) and Kumar (2016) in goats, who reported fluctuation of body temperature within normal physiological limit at different post-operative intervals. The post-operative decrease in rectal temperature may be attributed to effect of pre-anaesthetics and analgesics.

A significant exudation was observed on 5th day in both the groups. The exudation decreased significantly on 10th day onwards and was nil at 15th day, in both the groups. The size of the wound was reduced to minimum in both the groups on 14th day.

The radiographic score in group I increased significantly at 15th, 30th and 60th day indicative of initial periosteal proliferation and organized periosteal proliferation. The mean radiographic score was non-significantly higher in group I than group Il at 60th day. This was indicative of exuberant osseous callus in evolution with or without presence of radiolucent line at gap between the fracture fragments. These findings are consistent with Rao *et al.* (2017) who observed progressive bone healing on 15th day (Fig. 2).

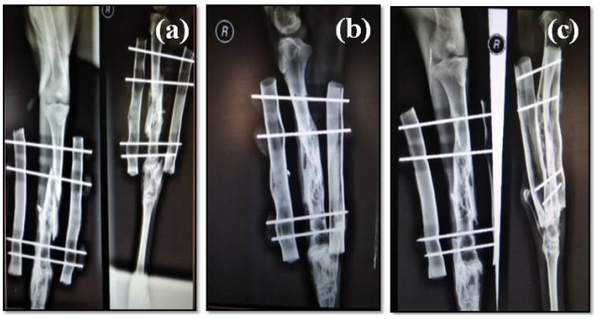

Fig. 2: Radiograph showing fracture healing following the application of Acrylic fixator at **(a)** 15th day; **(b)** 30th day; **(c)** 60th day

Callus formation was evident from 21st post-operative day. Periosteal and endostoeal callus at the fracture site was observed on 30th day. Post-operative radiographs showed that fracture line disappeared and showing restitution of cortico-medullary continuity by 45th to 60th post-operative days in external fixation (Fig. 3).

The mean weight bearing score (while standing) was recorded to be significantly higher at 7th, 15th, 30th day in group I, as compared to group II.

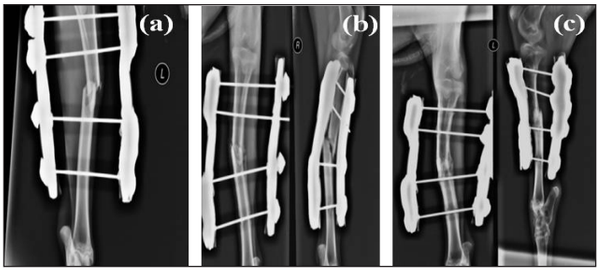

Fig. 3: Radiograph showing fracture healing following the application of Epoxy fixator **(a)** at 15th day; **(b)** at 30th day; **(c)** 45th day

Complete weight bearing was observed at 30th day in both the groups. In both the groups mean weight bearing score decreased significantly at 45th and 60th day. These findings were in accordance with the findings of Basith *et al.* (2018) who also recorded full weight bearing around 30 days (Table 1).

Table 1: Mean values of weight bearing score at different time intervals in group I and II

Groups	Days	While standing	While walking	While running
Group I	0	$0.00^{c}\pm0.00$	$0.00^{d}\pm0.00$	$0.00^{c}\pm0.00$
	7	$1.00^{b}\pm0.00$	$1.00^{c}\pm0.00$	$0.80^{b}\pm0.20$
	15	$1.80^{a}\pm0.20$	$3.40^{b}\pm0.24$	$3.60^{a}\pm0.24$
	30	$2.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$
	45	$1.80^{a}\pm0.24$	$3.60^{ab}\pm0.24$	$3.60^{a}\pm0.24$
	60	$1.60^{a}\pm0.13$	$3.40^{b}\pm0.24$	$3.40^{a}\pm0.40$
Group II	0	$0.00^{c}\pm0.00$	$0.00^{b}\pm0.00$	$0.00^{c}\pm0.00$
	7	$0.00^{c}\pm0.00$	$0.00^{b}\pm0.00$	$0.00^{c}\pm0.00$
	15	$1.20^{b}\pm0.20$	$2.60^{a}\pm0.40$	$2.60^{b}\pm0.40$
	30	$2.00^{a}\pm0.20$	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$
	45	$1.60^{ab}\pm0.24$	$3.00^{a}\pm0.31$	$3.40^{ab}\pm0.40$

Values within treatment groups with different superscript varied significantly ($p<0.05$).

The mean weight bearing score (while walking) was recorded to be significantly higher at 7th, 15th and 30th day in group I, as compared to group II. Complete weight bearing was observed at 30th day in both the groups. In both the groups, mean weight bearing score decreased significantly at 45th and 60th day. These findings were in accordance with the findings of Basith *et al.* (2017) who also recorded full weight bearing around 36 days.

The mean weight bearing score (while running) was recorded to be significantly higher at 7th, 15th and 30th day in group I, as compared to group II. Complete weight bearing was observed at 30th day in both the groups. In both the groups, mean weight bearing score decreased significantly at 45th and 60th day. These findings were in accordance with the findings of Singh (2015) in canines, who too reported complete weight bearing while running as shown by the animals while standing. The decrease in weight bearing may be attributed to callus formation at fracture site and osteolytic changes around pin tract resulting pain on movement. Good weight bearing was observed after fixator removal (Fig. 4, 5).

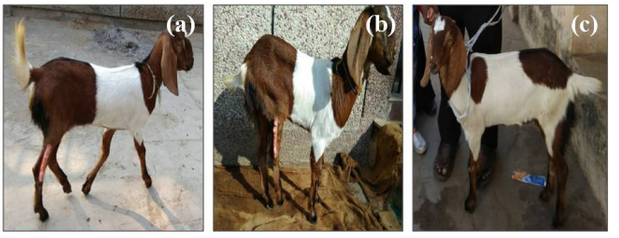

Fig. 4: Good weight bearing was achieved **(a)** after 15th day of surgery; **(b)** 45th day of surgery; **(c)** removal of Acrylic connecting bar

Fig. 5: Good weight bearing was achieved **(a)** after 15th day of surgery; **(b)** 45th day of surgery; **(c)** removal of Epoxy connecting bar

Complications

During the study period, pin loosening was observed as most common complication of external skeletal fixation in all the cases. In few cases, delayed union and malunion was observed. These findings were in accordance with the findings of Joy and Venugopal (2014) who conducted a study on management of metatarsal fracture using external skeletal fixation system in goat. The reported complications of ESF included pin loosening, mal union, delayed union and non-union and pin tract drainage.

CONCLUSION

Customised external fixation system using Acrylic and Epoxy were able to immobilize the compound fracture in goats. Acrylic connecting bars were lighter in weight and required less time for hardening. However, those were costlier than Epoxy. Based on radiographic score and weight bearing score, Acrylic was better than Epoxy as connecting bar material for repair of compound fracture in goats.

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