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Clinical Evaluation of Bioglass for Long Bone Fracture Repair in Dog

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ABSTRACT

Background: Six dogs irrespective of age, breed and sex affected with long bone fractures were subjected to clinical evaluation. **Methods:** Locking compression bone plating was done for stabilization of fracture and bio glass putty was used as gap filler in interfragmentary spaces. The clinical, radiographic, hemato-biochemical evaluation was done pre-operatively and post-operatively at periodic intervals.

Result: The study concluded that bio glass could be used as space filler for repair of long bone fractures in conjugation with primary stabilization with locking compression plate.

Key words: Bio glass putty, Locking compression plating, Long bone fractures.

INTRODUCTION

Bone grafting procedures are undergoing a major shift from autologous and allogeneic bone grafts to synthetic bone graft substitutes. Bioactive glasses are synthetic silica-based bioactive materials with bone-bonding properties (Hench, 2006). Bioactive glasses have a very unique composition, as this resorbable material contains high amounts of calcium, phosphateand silicon species. Soluble silicon has notably demonstrated its role in the up-regulation of collagen synthesis, osteoblastic metabolism, promotion of osteo-inductive gene expressionand therefore faster bone formation (Guth *et al.,* 2005).

MATERIALS AND METHODS

The present study was conducted on six dogs having long bone fractures, suitable for bone plating presented to Bai Sakarbai Dinshaw Petit Hospital for Animals (BSDPHA) affiliated with Mumbai Veterinary College, Parel, Mumbai during the year 2022-23 (Table 1) (Fig 1). The clinical, radiographic, hemato-biochemical evaluation was carried out pre-operatively. The surgical correction was done with internal fixation by locking compression plate and the bio glass putty was used as synthetic bone graft in interfragmentary spaces (Fig 2). The clinical examination was carried out on 14th, 30th and 60th day post-operatively. The radiographic evaluation to access bone healing was done on 15th, 30th and 60th day post-operatively (Fig.3). Hemato-biochemical evaluation was done pre-operatively and on 30th day post-operatively. The Mann-Whitney test was used for statistical data analysis.

RESULTS AND DISCUSSION

The present study was conducted on six cases of long bone fracture presented to BSPCA Hospital, Parel. Preoperative, intraoperative, postoperative findings regarding hemato-biochemical parameters, weight bearing on operated limb, functional limb usage and gait were noted.

Pre-operative evaluation

Most of the animals were young fell below age group of 12-18months (n=5) (Table 1). Young dogs were more prevalent as they were under development, with low-density bones in osteogenesis phase, which can be fragile even for injuries of lower intensities (Minar *et al.,* 2013) and also the young ones are more active and are not learned to cope up with hazards unlike their older counterparts (Aithal *et al.,* 1999 and Eyerefe and Oyetayo, 2016).

Males (66.66%) (Table 1), in search of females in heat get exposed to accidents or to be involved in fights with other males (Kumar *et al.,* 2007and Libardoni *et al.,* 2016).

Most of the animal breeds included in the present study were non-descript (n=5, 83.33%) breeds (Table 1). More number of non-descriptive breed dogs which are usually let loose to roam outside freely and thus more likely to succumb

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to road accidents (Maala and Celo, 1975), Similar results were observed by (Jain *et al.,* 2018) and (Sran *et al.,* 2016) who reported highest occurrence of fracture in non-descript dogs. Most of the animals included in the study had history of automobile accidents (83.33%), one being fallen from height (16.66%) (Table 1). (Aithal *et al.,* 1999); (Harasen, 2003). (Ali 2013), (Singh *et al.,* 2015), (Eyerefe and Oyetayo, 2016), also recorded high incidence of fractures due to automobile accidents.

In present study hind limbs (83.33%) found to be more affected than fore limbs (16.66%) (Table 1). In automobile accidents, animals were likely to be hit from behind, as the animals were slow to react from their hind quarters, might be the cause of more fracture in hind limb (Harasan, 2003). Similarly the incidence was found in pelvic limbs (63.69%) followed by pectoral limbs (38.22%) (Kumar *et al.,* 2007and Aithal *et al.,* 1999).

Lack of guidance by the local practitioners and the treatment given by quacks at the field level might have led to the delayed presentation of cases (n=4) (Table 1). Similar observations were also made by (Singh, 2015) who reported that the socio-economic status, carelessness of the owner and treatment by the nearby veterinarians had contributed to the delayed presentation of cases. The animals included

Table 1: Anamnesis of cases.

Case No.	Age (Year)	Gender	Breed	Etiology	Bone affected	Duration of illness (days)	Swelling	Skin condition
1	1	M	German Shepherd	Automobile accident	Femur, Right side	4	Severe	Bruised
2	1.5	F	Non-descript	Automobile accident	Tibia fibula, Right side	30	Absent	Normal
3	2	F	Non-descript	Automobile accident	Tibia fibula, Right side	30	Absent	Normal
4	1.5	M	Non-descript	Automobile accident	Tibia fibula, Right side	7	Moderate	Normal
5	2	M	Non-descript	Automobile accident	Tibia fibula, Right side	20	Absent	Normal
6	1.5	M	Non-descript	Automobile accident	Radius ulna, Left side	40	Moderate	Normal

Table 2: Data regarding ease of reduction, stability of implant fracture gap and“amount of bio glass putty applied case wise.

Type of fracture	Ease of reduction	Stability of implant	Fracture gap (mm)	Amount of bio glass putty applied(ml)
Spiral	Difficult	Good	6	6
Spiral	Easy	Excellent	2	2
Transverse	Easy	Excellent	3	3
Spiral	Difficult	Good	5	5
Oblique	Easy	Excellent	2	2
Oblique	Easy	Excellent	3	3
	Mean ± SE= 3.5±0.66	Mean ± SE= 3±0.6		

Table 3: Data of various parameters studied case wise.

Case no.	ROM Score	Time required	Post operative in days	Mentation functional limb usage	Mucous membrane	Health condition
Case 1	3	20	Good	Alert	Normal	Good
Case 2	4	22	Good	Active	Normal	Excellent
Case 3	5	25	Excellent	Active	Normal	Good
Case 4	5	30	Excellent	Alert	Pale	Fair
Case 5	4	25	Excellent	Alert	Normal	Good
Case 6	4	20	Excellent	Active	Normal	Good
Mean SE	4.16±0.30	23.66±1.55				

in the present study were evaluated based on mention, mucous membrane and health condition into excellent, good, fair, poor (Table no.3).

All of the animals included in the study had non weight bearing lameness on affected limb at the time of presentation. All the animals underwent physical examination to examine skin condition and extent of swelling at fracture site (Table 1). Orthopedic examination was carried out to evaluate bone and joint involvement. Amongst all cases studied the tibia fibula (66.66%) found to be mostly affected followed by radius ulna (16.66%) and femur (16.66%) (Table 1). Amongst the total cases studied, no joint involvement in any of the cases noted Similar observations were also made by (Varshneya, 2011). Animals tend to either carry the affected limb or simply touch the toe on the ground due to the pain associated with the inflammation and injury to the surrounding soft tissue from the movement of the fracture fragments. Non weight bearing and varying degree of limb swelling are observed in patients with diaphyseal fractures, (Fossum, 2007).

Two radiographs *viz*. cranio-caudal view and medio-lateral view were taken preoperatively to evaluate status of bone fracture, number of fracture fragments, direction of fracture fragments, diameter of medullary cavity, length of fracture fragments to predict the size of bone plate and screw, similar findings were given by (Langley- Hobbs, 2003).

Intraoperative findings

Fracture gap and Amount of bio glass putty applied at fracture site

The gap between fracture fragments after anatomical reduction and internal fixation was recorded and analyzed. The fracture gap ranged between 2-6 mm, mean average being 3.5±0.66 mm (Table 2).

Table 4: Data regarding the bone formation score and bone union scores observed in present study.

	0^{h} day		15th day		30th day		60th day	
	BFS	BUS	BFS	BUS	BFS	BUS	BFS	BUS
Case 1	0	0	3	2	4	2	3	4
Case 2	0	0	2	2	3	4	4	4
Case 3	0	0	3	2	4	4	4	4
Case 4	0	0	3	2	4	4	4	4
Case 5	0	0	3	2	4	4	4	4
Case 6	0	0	2	2	2	4	4	4
Mean±SE	0±0.00	0±0.00	2.66±0.37	2±0.00	3.5±0.73	3.66±0.61	3.83±0.22	4±0.00
P value	0.002							

Fig 1: Radiographic evaluation of the cases with two views of cases included.

Table 5: Weight bearing scores while standing and walking

Case no.	0th day		14th day		30th day		60th day	
	Standing	Walking	Standing	Walking	Standing	Walking	Standing	Walking
1	0	0	1	2	2	3	3	4
2	0	0	2	3	3	4	3	4
3	0	0	2	2	3	3	3	4
4	0	0	2	3	3	4	3	4
5	0	0	2	3	3	4	3	4
6	0	0	2	3	3	4	3	4
MeanSE	0.00±0.00	0.00±0.00	1.83±0.16	2.66±0.22	2.83±0.16	3.66±0.22	3.00±0.00	4.00±0.00
P-value	0.001							

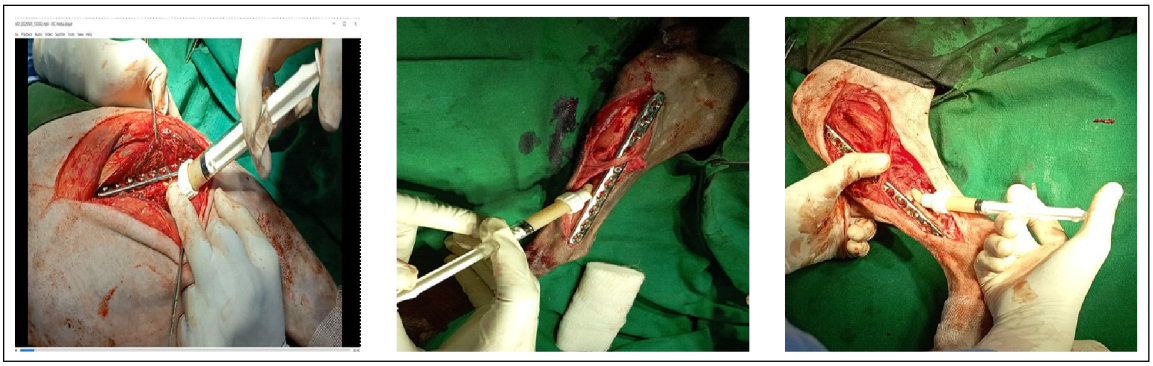


Fig 2: Application of bio glass putty at interfragmentary spaces after internal fixation.

The bio glass putty was applied at fracture site under aseptic and sterile conditions. The amount of bio glass putty applied ranged from 2-5ml (Table no.2). The amount required was more in oblique overriding fractures. (Valimaki *et al.,* 2005) stated that, the bioactive glasses result in significant intramedullary new bone formation and high local bone turnover. (Guth *et al.,* 2011) reported that the soluble silicon has notably demonstrated its role in the up-regulation of collagen synthesis, osteoblastic metabolism, promotion of osteo-inductive gene expressionand therefore faster bone formation.

Postoperative evaluation

Range of motion of the joints

On the 60th day post operatively, the operated animals were examined to evaluate the range of motion of the proximal and distal joints to the affected bone. Scores were given as described by (McCartney *et al.,* 2010) (Table 3). Stiffness of the stifle joint reducing the range of motion after intramedullary pinning have been reported as a result of direct damage to the joint due to pin penetration during the operation or its migration in the later stage.

Time required to attain normal gait

Minimal exposure of fractured fragments together with gentle manipulation of bone fragments during surgery led to early weight bearing (Table no.3). The mean time required to attain normal gait in group I was 23.66±1.55 days, (Bhalerao, 2010) recorded period to attain normal gaits as 22±0.672 days, (Coutinho, 2012) reported it as 32.12±6.32 days

Post operative clinical examination

The postoperatively animals were evaluated for weight bearing on 7th, 14th ,30th, 60th day as per system given by (Sahu *et al.,*2017). Weight bearing while standing was graded on score (0-3) and weight bearing while walking graded on score (0-4).

The better weight bearing while standing and walking was observed in cases was may be due to the osteo-inductive properties and compatibility of bio glass bone cement (Table 4) (Fig 4). These findings were in correlate with findings of (Singh *et al.,* 2015and Kumar *et al.,*, 2007) who also reported a gradual increase in weight bearing with partial weight bearing from 7th day onwards and complete weight bearing from 6th week interval.

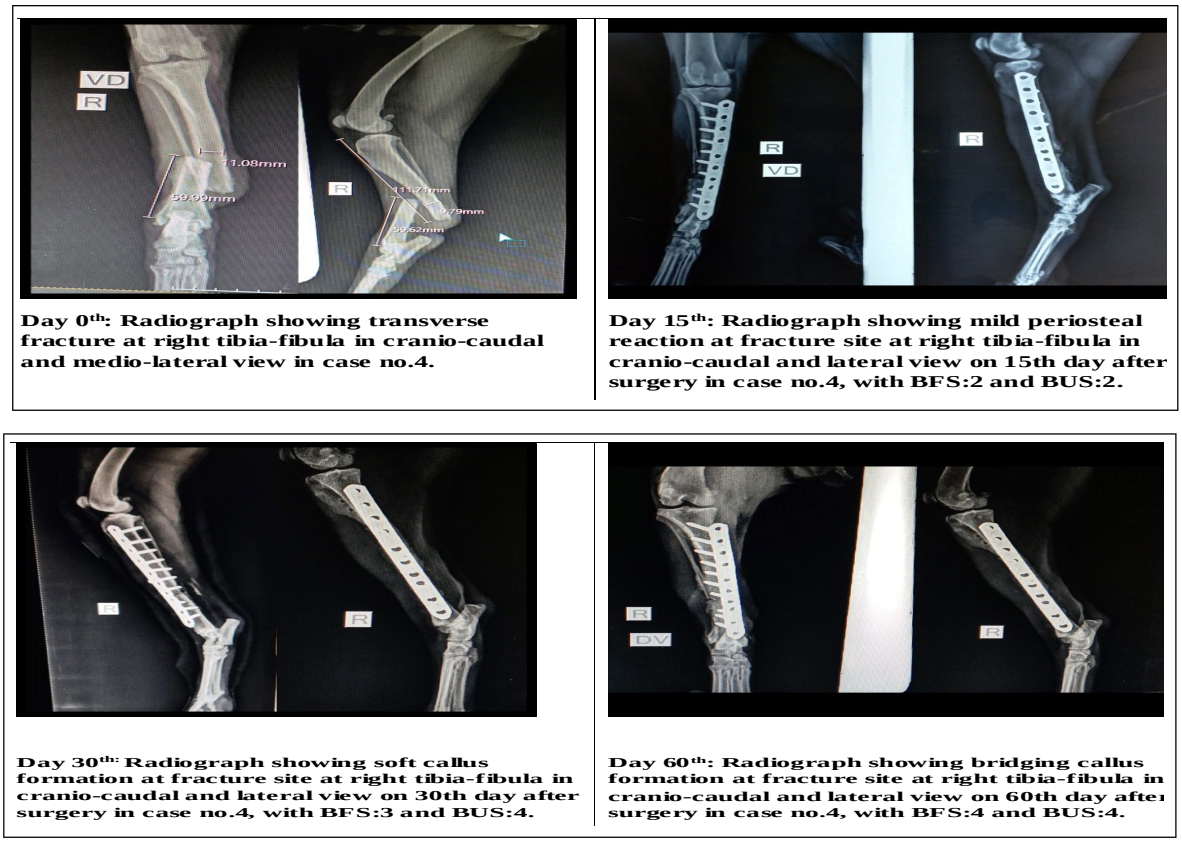
Post operative functional limb usage

The postoperative functional limb usage based on the degree of lameness was evaluated and graded based on the system given by (Fox *et al.,* 1995) on 60th day (Fig 5). Better functional limb usage observed due to osteo-stimulative property of bio glass bone cement and its components *viz*. Calcium phosphate, Hydroxyapatiteand Tricalcium phosphate which are osteoconductive in nature (Table no.3). (Mathew, 2019) in their study reported the comparison between two groups, the functional limb usage was found good in three cases (50%) and poor in three cases

(50%) of group I whereas excellent functional limb usage was evident in two cases (33.33%), good in three cases (50%) and poor in one case (16.66%o) of group II. (Larsson, 2006) reported that, better functional limb usage, attributed to the augmentation of the fractures with polymethylmethacrylate bone cement that provided more stability with reduced overall movement, less distal displacement and less varus angulation when compared with fractures fixed with metal devices alone.

Post operative radiographic examination

The radiographic examination was performed immediately after the surgery, on 15th day, 30th day, 60th day postoperatively to assess the position of implants, fracture fragments and callus formation. The bone formation score (BFS) and the bone union score (BUS) were given on the system given by (Lane and Sandhu, 1987) . The system given by (Hammer *et al.,* 1985) was used to score stage of union (SOU) (Table 5).



Day 0th: Radiograph showing transverse fracture at right tibia-fibula in cranio-caudal and medio-lateral view in case no.4.

Day 15th: Radiograph showing mild periosteal reaction at fracture site at right tibia-fibula in cranio-caudal and lateral view on 15th day after surgery in case no.4, with BFS:2 and BUS:2.

Day 30th: Radiograph showing soft callus formation at fracture site at right tibia-fibula in cranio-caudal and lateral view on 30th day after surgery in case no.4, with BFS:3 and BUS:4.

Day 60th: Radiograph showing bridging callus formation at fracture site at right tibia-fibula in cranio-caudal and lateral view on 60th day after surgery in case no.4, with BFS:4 and BUS:4.

Fig 3: Radiographic evaluation of fracture healing at periodic intervals

7th day 14th day 30th day 60th day

Fig 4: Evaluation of weight bearing status while standing and walking at periodic intervals in case no.4

Fig 5: Evaluation of functional limb usage on 60th day post-operatively.

Bone formation and bone union scores were found to be better, which might be attributed to the osteo-stimulative and osteoconductive properties of bio glass bone cement, leading to early migration of mesenchymal cells resulting in to callus and bone formation. (Schwandt and Montavon, 2005) reported that complete bridging and callus remodeling was observed at 53 days after surgery. (Haaland *et al.,* 2009) found that mean healing time using LCP in dogs in appendicular fractures was 7 weeks. (Egol *et al.,* 2004) opined that in the absence of anatomic reduction and interfragmentary compression, locked plating constructs rely on secondary bone healing which was induced by interfragmentary motion in millimeter range. The bone union was achieved at and around day 30th-60th post-operatively.

Complications

(McLaughlin, 1999) described the complications following bone plating such as loosening of plate, breakage of screws, delay in fracture healing, non-union, infection, osteopenia and rarely implant induced osteosarcoma.

In present study no as such complications were noted due to, proper sterilization of surgical site and asepsis followed during surgical procedure, most of wounds healed by first intentionand also due to early presentation of the case where there was less soft tissue damage and also due to washing of wound with diluted amikacin in normal saline (1 ml+500 ml) prior to suturing of the wound reduced infection at fracture site. (Bhalerao, 2010) observed a wide range of activity of amikacin against gram positive and gram-negative bacterial infections in orthopedic surgeries. It was also observed independently in the studies by, (Coutin ho, 2012).

CONCLUSION

The following conclusions were drawn based on present study:

1. Bio glass bone cement group showed early weight bearing, better functional limb usage of operated limband less time required to attain normal gait.
2. Bio glass bone cement group showed good bone formation scores and bone union scores.
3. Bio glass bone cement group showed better range of motion of joints scores.
4. Based upon all the clinical and radiological parameters studied, it has been observed that, the bio glass bone cement is better substitute for fracture repair of long bones.

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Conflict of interest

All authors declared that there is no conflict of interest.

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