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REVIEW ARTICLE

BONE PLATING FOR FRACTURE REPAIR IN GOATS

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ABSTRACT

Fractures have been described as the most common orthopedic problem in goats. Fractures in goats are commonly immobilized by using non-invasive external immobilization techniques such as splints, plaster of paris, fibre glass cast and various external fixation devices due to their economic and conservative nature. However, these methods have various demerits like mal-union, delayed union and non union, large callus formation, weakening of tendons, muscle atrophy and pressure sores, delayed weight bearing, interference with radiographic evaluation, slippage of plasters, softening of plaster cast and wetting of cast due to faulty management which ultimately leads to increase in expenses because of reapplication. The continually-evolving understanding of bone biology and the analysis of clinical complications have led to a modified approach to internal fixation. Biological osteosynthesis with bone plates is one of the most stable fixation techniques for neutralizing all the forces that commonly act on the fracture like compression, tension, shear, torsion and rotation. Bone plating improves the function of surrounding joints, decreases muscle atrophy by allowing early activity and provides an avenue for anatomic reduction of fracture, thus preventing "fracture disease". Evaluation of different implant materials has thrown some light on the development of different bone plates for fracture repair in goats. Various studies have been carried out in goats for fracture repair of long bones using different bone plates prepared from bovine horn, nylon, teflon, stainless steel, horn, xenogenous bone, polypropylene mesh impregnated poly methyl methacrylate plate, dynamic compression plate, veterinary cuttable plate, LC- DCP and locking plates. Further research studies may improve the techniques of application and development of newer biomaterials will help to adopt the most appropriate treatment, thus maximizing benefits and minimizing complications.

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INTRODUCTION

Fractures have been described as the most common orthopaedic problem in goats (Singh and Nigam, 1981). Rearing of goats is economic to farmers due to their docile nature and habit of browsing in free ranges during which they during which they meet with automobile accidents, attack by dogs and maliciously get hit by stones or sticks. Because of their provoking nature, they attempt impossible jumps resulting in severe unpredictable forces on bone, leading to complex and comminuted fractures (Aithal and Singh, 1999). Kumar (2000) reported history of injury and sudden onset of symptoms in most of the fracture cases. Firoozabadi *et al.* (2008); Singh *et al.* (2008) and Reilly *et al.* (2012) recorded the major clinical signs exhibited by animals with fracture as loss of function of the affected limb, abnormal mobility at the fracture site, deformity due to displacement of fractured fragments, pain and crepitus on palpation, local swelling, overlying soft tissue trauma, as the major symptoms of fracture. Affected animals showed altered deviation from their normal posture and position. Loss of function was mainly exhibited by inability of the animal to bear weight on the affected limb.

Pain was usually absent in pathological fractures. Hulse and Johnson (1997); Langley-Hobbs (2003) and Kumar *et al.* (2007) stated that for adequate evaluation of affected bone, minimum two radiographs should be taken at 90 degree angle to each other (medio-lateral and cranio-caudal. He also advised inclusion of proximal and distal joints to bone of interest for evaluation the fracture. They opined that comparison between affected and normal limb radiographs may help in appropriate diagnosis. Fractures in animals have always remained as the most severe and complicated pathologies posing challenges to the veterinarian. Adequate reduction and strong fracture fixation, being the key elements of a successful fracture repair, should be achieved with the most appropriate technique for the animal concerned. For a successful fracture repair, every attempt should be made to preserve the healing potential of the bone and to direct minimal callus formation through a mechanical setting most appropriate to the case concerned. Rigid fixation is important to ensure early weight bearing and quick fracture healing through minimal callus formation (Tralman *et al.*, 2008). Fractures in goats are commonly immobilised by using non-invasive external immobilisation techniques such as splints, plaster of Paris, fibre glass cast and various external fixation devices due to their economic and conservative nature. However, these methods have various demerits like malunion, delayed union and non union (Singh *et al.,* 1984), large callus formation, weakening of tendons, muscle atrophy and pressure sores (Mbuiki and Byagagaire, 1984), delayed weight bearing, interference with radiographic evaluation, slippage of plasters, softening of plaster cast and wetting of cast due to faulty management which ultimately leads to increase in expenses because of reapplication. Orthopaedics is an ever evolving science. The continually-evolving understanding of bone biology and the analysis of clinical complications have led to a modified approach to internal fixation. The ultimate goal of the orthopaedic surgeon is to restore function through undisturbed bone healing, preservation of soft tissues, which allows safe and expeditious rehabilitation of the patient. Biological osteosynthesis with bone plates is one of the most stable fixation techniques for veterinary orthopaedic surgeons as opined by Tan and Balogh, (2009) and Sirin *et al.* (2013). Since the first instance of internal fixation with bone plates and screws carried out by Hansmann in 1886 and in later stage integration of this principle with operative result of Lambotte's work, continuous developments in implant designs and materials, the principles of application have led to advancement in fracture fixation. Bone plating provides the most stable form of fracture fixation with neutralising all the forces that commonly act on the fracture like compression, tension, shear, torsion and rotation. Bone plating improves the function of surrounding joints, decreases muscle atrophy by allowing early activity and provides an avenue for anatomic reduction of fracture, thus preventing "fracture disease" (Allgower and Speigel, 1979).

Various studies have been carried out in goats for fracture repair of long bones using different bone plates. Singh *et al.* (1987) studied the efficacy of bone plate prepared from bovine horn for treatment of femoral fracture in goats and found it suitable implant for immobilization of fracture segments without any signs of osteopenia and abnormal reaction. They concluded that horn plate was strong enough to hold fracture fragment in alignment till complete fracture healing without any adverse effect or reaction. Shivaprakash and Singh (2003) evaluated bone plates made up of various materials such as nylon, teflon, stainless steel, horn and xenogenous bone for repair of femoral fracture in Black Bengal goats. They opined that the fabrication of implant material (industrial grade nylon and Teflon sheets) into bone plates didnot pose any problem as they can be easily cut for shaping into bone plate using limited facilities in very less time. The preparation of horn plates and xenogenic bone plates took more time in cutting and grinding the horn and bones. Fabrication was relatively tedious and time consuming. Further they reported that the alignment of fracture fragments using nylon and teflon plates was very easy and was comparable to stainless plates. However it was less satisfactory with horn plates as they could not be contoured to the shape of the bone after tightening of screws which resulted in elevation of the plate. Satisfactory reduction and alignment with xenogenic bone plate was possible in most of the animals and was not achieved in few animals. The reduction and alignment was easy and quick with stainless steel plates. Functional restoration of fractured limb in animals treated with nylon plates and stainless steel plates was much faster than the animals treated with other implant materials. Slight delay in the functional restoration in animals plated with Teflon and horn plates could be due to a little movement at the fracture site allowed by them resulting in pain and lameness. Clinical union was observed in animals treated with nylon and stainless steel plates as early as day 35 and the animals were able to run without any evidence of lameness by day 60. This early functional weight bearing could be due to better reduction and alignment given at the time of surgery and subsequent improved stability with the absence of pain. Even in later stage the functional weight bearing in animals plated with teflon, horn and xenogenic bone plates was inferior to nylon and steel plated animals. They opined that the delay in weight bearing in the animals treated with xenogenic bone plates may be due to resorption of the plate at later stages allowing slight movement at the fracture site. The radiographic evaluation of fracture healing in both the views was easier in all groups except stainless steel plates as all the other materials were radiolucent. The stainless steel plates obliterated the fracture area in medio-lateral view but provided better assessment in anterio-posterior view. Also the type of callus seen radiographically in animals of all the groups was 'external callus' although greater variation was encountered in the extent of callus. In most of the animals treated with nylon and stainless steel plates, the external bridging callus was smaller compared to other groups. They opined that total suppression of external callus was not observed in stainless plate and nylon plates as they might have not achieved total compression and absolute stability in certain areas of bone. The large callus formation seen in animals treated with horn, teflon and xenogenic bone plates is suggestive of poor fixation of plates in some cases. The reestablishment of medullary canal at the fracture site was seen as early as day 90 in animals treated with nylon and stainless steel plates and also in few animals treated with xenogeneic bone plates suggested the ability of these implant materials in providing adequate stability leading to early union and remodelling. They opined that the delay in reestablishment of medullary canal in most of the animals treated with horn and teflon plates might be attributed to the rate of remodelling. They concluded that careful fabrication of the raw materials, selection of proper sized plates and screws, correct placement of the device in achieving fracture reduction and alignment, strict asepsis and proper post operative care are important in achieving the success and to get uniform results.

Gupta (*2015*) studied *fracture healing* using biphasic calcium phosphate with *dynamic compression plate (*DCP) in *goats* and found it suitable for fracture fixation of long bones. He observed that 2.7 mm system was suitable for goats weighing less than 10 kg and 3.5mm system for goats weighing between 10-20 kg and opined that longer length of the implant provided more stable internal fixation in case of comminuted or multiple fractures. Dharmendra (2016) used DCP with various bone substitutes for fracture repair in goats and found complete weight bearing in goats started after 30 days. Diajode (2018) evaluated fracture healing in goats using Veterinary cuttable plate (VCP) and polypropylene mesh impregnated poly methyl methacrylate plate for long bone fracture repair in goats. The study showed good weight bearing by day 30 in both the groups. He opined that the VCP provided slightly better stability at fracture site compared to polypropylene mesh impregnated PMMA plates. However the PMMA plates require slightly more time compare to VCP for stable fixation. Initiation of periosteal callus was noted at the fracture line at 15^{th} post-operative day. On 30^{th} day, bridging callus was noticed filling the gap of fracture with slight cortical union with visible fracture line. On 60^{th} day, radiographic evaluation revealed complete union with radio dense callus between fractured fragments of bones. VCP came to existence on the basis of elastic plate osteosynthesis technique for treatment of femoral diaphyseal fractures in juvenile dogs. VCP can be used in fractures of long bones. As the name suggests cuttable, the length of VCP is fitted to the broken bone by cutting and the rigidity was achieved by sandwiching two plates together (Bruise and Prieur, 1989) in some cases. These plates are implant of choice for stable fixation in case of bone with thin cortex having diaphyseal fractures. These plates are malleable and can be bent according to contour of bone and are economical comparable to other plates. Poly methylemethacrylate (PMMA), commonly known as 'acrylic cement' has been increased used for orthopaedic operations and was first introduced by Charnley (1960). It has the property to get moulded into fixed design implants or can be polymerised at the time of surgery for tailor made implant applications which has recently increased its importance in orthopaedic surgery as internal fixation device. PMMA has promising results with respect to decreasing osteomyelitis when combined with antibiotic (Yuvraj *et al*., 2007). PMMA material is easily available and more economic compare to other external coaptation technique used as internal fixation for early weight bearing. Locked plating is a more recent technique available for fracture fixation and understanding the principles and limitations is essential to maximise its effectiveness. Locked plating technology is continuously evolving since its introduction into fracture repair just over twenty years. For the first time in 1998, Prof. Dr. Micheal Wagner used threaded screws in combination with standard screws.

A refined understanding of bone healing biology, the role of tissue vascularity and gap strain and the biomechanics of fracture fixation in fracture healing have led to a significant evolution in plating techniques which has contributed to the development of the concept of bridging plate osteosynthesis and use of locked plate technology. Locked plates were developed in response to a need for adequate fracture stabilization in cases of poor bone quality, mechanically weaker metaphyseal bone or bone affected by osteoporosis, osteomalacia or comminution where standard bicortical screws were unable to gain sufficient purchase for maintanence of the plate-bone relationship. Da-cheng *et al,* (2010) compared LC-DCP and Locking plates in goats and recommended the use of locking plate as it minimises impairment of blood supply to cortical bone due to significantly smaller bone contact area than LC-DCP, thus leading to early healing of fracture.

The Locking compression plate (LCP) features a uniquely designed combination hole that accepts standard bone screws as well as locking screws and allows the plate to be used as a conventional plate (compression), a locking plate (internal fixator principle) or as a combination of both principles. The LCP is a fixed angle construct that does not rely on friction at the plate-bone and screw-bone interfaces. Rather, the system relies on friction at the threaded screw-plate interface. The underside of the plate has scalloped undercut, which creates a uniform area moment of inertia to minimize stress concentration at the plate hole, as well as mitigate disruption of extra osseous blood supply. LCP has brought the use of locking plate technology into routine fracture care (Frigg, 2001). Clinical use of LCP began in March 2000 and it was first used in Veterinary medicine in 2005. Locking plates function as "internal fixator" with multiple anchor points. They have a locking mechanism between the screw heads and the plate holes thereby producing a very sturdy mono-block effect, with all screws forcing at the same time. This interface creates a fixed angle, single beam construct which provides axial and angular stability, eliminates screw toggle (Egol *et al.,* 2004), increases their load carrying capacity, minimises the compressive forces between the bone and plate and avoids bone implant contact there by preserving the periosteal biology (Toro *et al.,* 2015). Since they cause less disruption of the soft tissues, do not exert pressure on the periosteal and endosteal blood supply and they do not hinder fracture healing, indirectly by a good callus formation (Bhandari *et al.*, 2002; Gauiter and Sommer, 2003; Wagner *et al.*, 2004 and Greiwe and Archdeacon, 2007). The techniques for rigid fracture fixation are always invasive which demand stringent postoperative care. Thus, they are often associated with complications such as osteomyelitis (Semevolos *et al*., 2008) affecting the productivity and delaying return to normal function. Non-cooperation from the patient during post operative treatment, hygienic conditions in the premises and climatic conditions influence the wound healing. Attempts to control wound and bone infection with broad spectrum antibiotic injections and local dressing with betadine solution resulted in healing of local wound but the bone infection could not be completely eliminated (Shivaprakash and Singh, 2003). In a nut shell, evaluation of different implant materials has thrown some light on the development of different bone plates for fracture repair in goats. Further research studies may improve the techniques of application and development of newer biomaterials will help to adopt the most appropriate treatment, thus maximising benefits and minimising complications.

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