

Standard Surgical Technique for Applying Rod Through Plate (RTP) Internal Fixator – An Experimental Study in Sheep

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Summary

The standard surgical technique for applying a rod through plate (RTP) internal fixator to treat long bone fractures was carried out. The experiments were performed in 4 male Estonian Blackhead sheep. Previously, a RTP fixator for small animal fracture repair has been tested experimentally in rabbits and also on clinical cases in dogs. To reduce complications such as screw loosening and rod displacement, modification to the original fixator was made: one locking screw on each rod was added to fix the rod to the plate. In this study the healing process of tibial osteotomies using the modified RTP fixator was evaluated in sheep. Sheep were used as experimental animals because body weight and bone structure is similar to small animals.

Introduction

To treat fractures of long bones of small animals both conservative and operative methods are used (Brinker *et al.*, 1991). Although numerous options are available for fracture treatment, surgical intervention is very often the method of choice, where for the internal fixation, various plates or intramedullary nails are used (Tarr & Wiss, 1986; Uthoff *et al.*, 2006). By combining these two methods, i.e. plate fixation and intramedullary nailing, additional stability can be achieved, especially in conjunction with the resistance to rotational forces. In this study a new fixator, where support plates are combined with intramedullary rods, has been tested for treatment of long bone diaphyseal fractures. The combined new rod through plate (RTP) internal fixator has two patents – European Patent No 1682008 (authors Andrianov V, Lenzner A, Haviko T, 30.05.07) and Estonian Republic patent No 04899. Our RTP fixator is derived from the original meth-

od developed by Seppo (1979), but by combining (Fig.1) extramedullary and intramedullary elements of osteosynthesis, is a new fixator, which expands the treatment possibilities for the internal fixation of bone fractures. The main elements of the fixator are extramedullary plates and two curved rods, which are located intramedullary and exert dynamic pressure on the bone cortex in three points proximally and distally from the fracture site. Rods are fixed to the supporting plate with bone screws.

The purpose of this study is to describe the operative technique for applying our modified RTP in experimental animals for use as a standard clinical

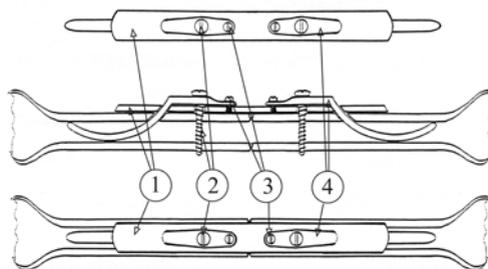


Figure 1. 1 support plate; 2 bone screws; 3 locking screws; 4 curved rods.

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method in diaphyseal bone fracture treatment in small animals. This type of fixator has been tested on rabbits for the treatment of femoral osteotomies and also clinically on dogs for the treatment of tibial and femoral fractures (Andrianov *et al*, 2007).

Materials and Methods

The experiments were performed on 4 male Estonian Blackhead sheep. All sheep were from Karula farm (Estonia) and were four months old. Permission (No. 75, 16 March 2007) for the present study was given by the Estonian National Board of Animal Experiments in accordance with the European Communities Directive (86/609/EEC). The mean body weight of the sheep was 35 (\pm 5.0) kg. The animals were kept in the animal house at 20 \pm 2°C under a 12-h/12-h light/dark cycle (lights on at 0700 hours). The animals had free access to food and tap water.

Medication

Surgery was performed under inhalation anesthesia, which was premedicated by atropine 1 mg/ml (Atropine sulfate, Verofarm, Russia) 3 ml i/m and induced by Medetomidine hydrochloride 1 mg/ml (Dorbene®, Laboratorios Syva, Spain) 0.5 ml i/v. All animals were intubated and anesthesia was maintained with a mixture of isoflurane 2% (Forane®, Abbott Laboratories Ltd, England) and pure oxygen with a flow of 11 ml/kg/min (Riebold *et al*, 1995). A Komesaroff (Medical Developments, Melbourne, Australia) inhalation anesthesia device was used. Lactated Ringers solution (Ringer-Lactat, B.Braun Melsungen AG, Germany) 11 ml/kg/h was administrated intravenously during the anesthesia. At the end of the operation, for antibiotic prophylaxis procainpenicillin 300 mg/ml (Norcilin®, Norbrook Laboratories Ltd., North Ireland) 5 ml i/m was administered on the first and second postoperative day. Carprofen 50 mg/ml (Rimadyl®, Vericore Ltd., Dundee, Scotland) 2 mg/kg according to body weight s/c once a day was administered as analgesic for the two postoperative days.

Preparation for surgery

The left tibia was radiographed in mediolateral and craniocaudal projections by *Medlink URS Veterinary Portable X-ray SP-VET-4.0* (SEDECAL, Spain) (Fig 8/1). The f.f.d. (focal spot-film distance) was 100 cm and the exposure data were 50 kVp and 10.0 mAs. Radiographic screen *AGFA CR MD 4.0 General Plate* (AGFA-Gevaert, Germany) was used and images were loaded to computer by *AGFA ADC Solo Digitizer* (AGFA-Gevaert, Germany). The size of the plate and rods were chosen according to the bone size on a craniocaudal radiograph. The plate was accurately contoured to the shape of the bone. Curved rods had to correspond with the diameter of the medullary canal and to extend in maximal distance from the osteotomy site proximally and distally according to the radiograph. Intramedullary rods are curved and have to be in contact with the cortex at three points: at the end of the rod, at the centre of the rod arc, and at the point of rod and plate union. Before surgery, hair was clipped from the region of the jugular vein, the cephalic antebrachial vein and from the centre of the left femur to the centre of the metatarsus. Blood samples from the jugular vein were taken for biochemistry (and immunological analysis). Intravenous cannula was placed to cephalic vein.

Operative procedure

The animal was placed on right lateral recumbency (Fig. 2). Operation field was disinfected with 75° ethanol (Chemisept-G, Chemi-Pharm, Tallinn, Es-



Figure 2. Position of the animal on the table.

tonia) followed by covering with towels to get an aseptic working area (Fig. 3).

A skin incision about 12 cm in length was made in the middle third of the tibia at the lateral side. Fasciae were identified and cut in line with the skin incision.



Figure 3. Covered operation field.

The intermuscular septum between *M. extensor digiti quarti proprius* and *M. flexor digitorum profundus* (May, 1964) was identified and separated by blunt dissection. The peroneal nerve was identified and protected (Dyce *et al*, 1987).

Self-retaining retractors were used to maintain the exposure to the tibia. With a periosteal elevator, muscle attachments were freed from bone to about one third of the diameter of the bone and all the length of the skin incision (Fig. 4).

The plate was applied to the lateral side of the tibia and held in position by bone holding forceps. The plate was conformed to the bone contour, if neces-



Figure 4. Access to the tibia.

sary, using plate benders. The forceps holding the plate and the bone were placed in the centre of the plate. In this position they did not hinder the following manipulations.

Starting proximally, a 4 mm hole was drilled through near the cortex of the bone at approximately 45° to its longitudinal axis. The channel for the rod in the plate served as a guide ensuring the correct angle and position of the 4 mm hole (Fig. 5).



Figure 5. Drilling 4 mm hole at 45 degrees to the long axis of the tibia.

The rod was inserted through the hole into the medullary cavity holding the tail of the rod with forceps. If necessary the arc of the rod was changed according to the need not to apply too much pressure to the cortex of the bone. After the insertion of the rod, the distance between the tail of the rod and the plate should be about 2-3 mm. At the same time the holes for the cortical screws in the plate and in the rod's tail were aligned. For correct alignment of the holes, 2 mm Kirschner wire was used through both holes and the wire was moved in the required direction until both holes were perfectly aligned (Fig. 6).

A cortical screw was inserted through rod and plate holes to the bone. Screws were inserted according to the AO standard technique (Brinker *et al*, 1984). Using a 2.5 mm drill bit, holes through both cortices were drilled. The length of the hole was measured, both cortices tapped and an appropriately sized 3.5 mm screw was inserted. Tensioning the screw pushed the rod's tail to the plate and gave tension to the bone cortices from the medullary canal. The

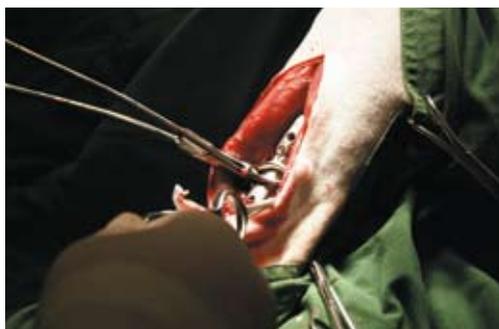


Figure 6. Plate on the bone with proximal intramedullary rod in its position.

same procedure was performed distally.

For osteotomy the fixator was removed and osteotomy was performed perpendicular to the long axis of the bone. A Gigli wire saw was used for osteotomy, which was centered midway between the screw holes.

The fixator was placed back on the osteotomised bone using the same locations. In our modification of the RTP fixator, there are two additional screws for fixation of the rods to the plate.

Cortical screws were first inserted but not tightened. The next step was placement of the locking screws followed by the tightening cortical screws (Fig. 7). Wound was closed in layer: the deep fascia using continuous suture and the subcutaneous tissue and skin layer by layer using absorbent material (Sa-



Figure 7. Fixator installed without distal locking screw.

fil®1, Braun, Germany). After the closure Chlortetracycline spray 1 ml/20 mg (Pederipra Spray, Laboratorios Hipra, Spain) was applied to the wound. No bandages on the operated leg were used.

The first postoperative radiographic examination of the operated leg was undertaken immediately after the surgery in the craniocaudal direction to describe the location of the fixator on the bone (Fig. 8/2). Follow-up examinations were performed after 2, 4, 6, 8 and 10 weeks (Fig. 8/3-7)

Free movement of the animals was allowed directly after the recovery from anesthesia. To grant similar handling of all operated animals all surgical procedures were performed by the same surgeon and one assistant. Average operation time was 1 hour and 40 minutes. After eight weeks from the beginning of the experiment fixators were removed. Removal of the implant took about 20 minutes. Clinical monitoring time of the animals after fixator removal was 2 weeks to ensure the absence of any possible complication.

The animals were euthanized after the follow-up time of ten weeks. Euthanasia was carried out after sedation with 20 mg/ml Xylazin hydrochloride 0.08-0.75 ml/100 kg according to the body weight i/v (Xsylan®), Vetoquinol AG, Bern, Switzerland) by i/v administration of T61® (Embutamid 200 mg + Mebezoniumiodid 50 mg + Tetracain hydrochloride 5 mg, Intervet S.A., EU) 5 ml/50 kg.

Results

No complications after the surgery of the experimental animals were detected. Postoperative swelling of the operated leg was minimal and no clinical problems were noted. On postoperative radiographs, the osteotomy line was clearly visible, two weeks after the operation radiolucent periosteal callus formation was seen on radiographs and after four weeks a wider radiodense callus formation was noted. After six weeks the osteotomy line was still visible, but disappeared on eight-week radiographs (Fig. 8). No implant loosening was noted during the experiment. Animals started to use the operated leg on the third day after the operation except one sheep, who

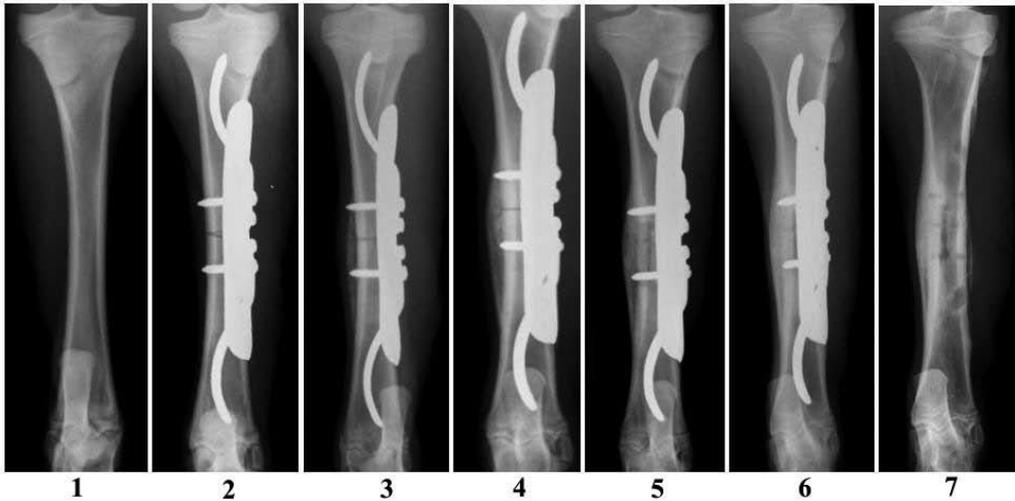


Figure 8. Radiographs of the left tibia. 1 – left tibia before surgery; 2 – radiograph after surgery, wk „0”; 3 – wk 2; 4 – wk 4; 5 – wk 6; 6 – wk 8; 7 – wk 10.

started to load weight on the treated limb on the seventh day.

Discussion

Although there are numerous methods for fracture fixation in small animals, operative methods are usually preferred. The choice of operative technique depends on the location and type of the fracture, but the purpose of the fixation is always stability of the fragments to allow quick consolidation of the fracture and more importantly to restore the function of the leg. The RTP fixator has been designed for internal fracture treatment in small animal surgery. The fixator was previously tested on femurs of rabbits (*Andrianov et al, 2007*). Rabbits are relatively inexpensive and widely used experimental animals. Leporine long tubular bones are big enough for internal fixation without the use of microinstruments (*Huber et al, 2006*). On the other hand tubular bones of rabbits have fragile structure with a thin cortical layer (*Crigel & Balligand, 2002*), which complicates experimenting with RTP. According to our experience the bone structure of small ruminants is more similar to the small animal bones and that was the reason to use sheep in this experiment. The sec-

ond reason was the much bigger body weight compared to rabbits and more active movement of sheep giving the more loading to the fixator.

The tibia was chosen because approach to the bone is easy and radiographic examination is technically simple. The skin of the sheep is very thin and on the medial side there is not enough soft tissue to cover the fixator but on the lateral side we could hide the fixator under the soft tissues, while on the medial side it is simple to take bone biopsies during the healing process, if necessary.

This experiment is a part of the larger project, where bone healing is compared after applying either RTP fixator or the plate fixator. The plate fixator is also applied to the lateral surface of the bone (*Tralman et al, 2008*). In this experiment the RTP fixator is modified with the addition of two locking screws to fix intramedullary rods to the plate. Cortical screws can get loose and cause loosening of the rod and instability at the fracture site (*Andrianov et al, 2003*). Locking screws are inserted through holes in the rods and fixed to the plate, which has threaded holes in it. Locking screws are short enough not to penetrate the surface of plates contacting the bone. This type of construct should maintain stability at

the fracture site even in case of cortical screw loosening. Transcortical screws penetrate through cortex medially after tightening and the ends of these screws serve as landmarks for bone biopsy.

Conclusions

The clinical and radiological findings in this experimental study in sheep show that successful consolidation and rigidity after long bone osteotomies can be achieved by the use of a RTP fixator

This novel type of fixator can be recommended to be applicable also in clinical cases of companion animal diaphyseal fractures. The technique for RTP fixator placement is simple and does not require special instrumentation.

Acknowledgements

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