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Original article

Treatment of comminuted tibial shaft fractures in four dogs with the use of interlocking nail connected with type I external fixator

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Abstract

The treatment of comminuted tibial shaft fractures in canine patients is burdened by significant risk which involves bone healing complications, such as delayed bone union. Complications may result from iatrogenic damage to blood vessels during fracture stabilization. To minimize this risk, treatment methods increasingly often rely on the concept of biological osteosynthesis. One of such methods involves the treatment of fractures with the use of new hybrid fixator consisted of an interlocking nail connected with type I external fixator. Connection of the nail with external fixator has been recently developed to maximize treatment efficiency. This manner of stabilization increases bone-fixator construct strength on forces acting in the place of fracture. It also enables fracture fixation with minimal damage of the blood supply of bone fragments. This article describes surgical procedure of stabilization of comminuted tibial bone fractures in four dogs by the use of interlocking nail connected with external fixator type I, discusses and evaluates the results of clinical treatment with the involvement of the said fixator. To control bone consolidation process the radiograms were taken in 6 and 8 week of healing.

In all cases, the reviewed methods of clinical treatment were successful in producing bone union after eight week of healing. During the whole period of observations no complication was observed. In all cases the intramedullary nail were left in the medullary canal after the healing process was finished. The fixator supported quick restoration of limb function after treatment.

Key words: interlocking nail, external fixator, biological osteosynthesis, tibia, fracture, dog.

Introduction

Tibial fractures occur very frequently, and they account for around 20% of all long bone fractures (Unger et al. 1990, Seaman and Simpson 2004). Nearly 73% of tibial fractures affect the tibial shaft (Zaal and Hazewinkel 1996). The concept of biological osteosynthesis is increasingly applied to engineer new methods for the treatment of tibial fractures. Such methods are reputed to be minimally invasive and highly effective. One of such techniques involves the stabilization of fractures with the use of external fixators and interlocking nails (Pettit 1992, Patil et al. 2008, Piórek et al. 2012). A hybrid fixator incorporating an interlocking nail and an external fixator has been recently developed to maximize treatment

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efficiency. The proposed construct was subjected to a series of in vitro biomechanical tests (Bernarde et al. 2001, Radke et al. 2006, Goett et al. 2007), but the number of in vivo experiments remains low (Moses et al. 2002). The aim of this study was to evaluate the effectiveness of the discussed fixator in clinical treatment of tibial fractures. The paper describes the technique of stabilization tibial bone comminuted fractures in dogs by the use of interlocking nail connected with the type I external fixator and the course of treatment until the achievement of the bone union.

Materials and Methods

In 2011 comminuted fractures of the tibial bone were treated in four canine patients with the involvement of an interlocking nail incorporated into a type I external fixator. In all cases the fracture resulted from road accidents. Two patients were mixed-breed, male dogs, aged 2 and 3.5 years, with body weight of 25 kg and 32 kg, respectively, one Boxer (female), 4 years old, 31 kg of body weight and one German Shepherd, male, 4 years old, 36 kg of body weight. Radiograms revealed in all patients comminuted tibial fractures with accompanying fractures of the fibula (Fig. 1).

Fig. 1. Comminuted fracture of the tibial shaft with an accompanying fibular fracture.

Approximately 30 minutes prior to surgery the patients were administered an antibiotic – amoxicillin, 15 mg/kg SC (Betamox, Scanvet). The dogs were premedicated with a combination of atropine 0.02 mg/kg IM, medetomidine 0.01 mg/kg IM (Domitor, Orion Pharma) and butorphanol 0.1 mg/kg IM (Butomidor, Richter Pharma). The affected limb was shaved to the talus and an aseptic surgical field was prepared in accordance with stringent requirements. General anesthesia was induced by a combination of ketamine 5 mg/kg (Vetaketam, Vet-agro) and diazepam 0.5 mg/kg (Relanium, Polfa) whose proportions were modified subject to the produced sedative effect. The patients were positioned in dorsal recumbency and slightly rotated in the direction of the operated limb. A skin incision with a length of 0.5 cm was made on the medial side of the intermediate patellar ligament above the tibial tuberosity. A surgical awl was inserted through the access to the tibial plateau to open the medullary cavity of the tibia. The patency of the medullary cavity was restored with a trocar. An interlocking nail was inserted into an opening in the bone into the proximal fragment of the fractured bone. The above procedure facilitated maximum bending of the knee joint. After the nail had been inserted into the proximal fragment of the bone the fracture was reduced and the nail was inserted towards the distal end of the bone. A successive incision was made at the fracture site on the medial side of the tibia to visually control the stabilization process. The nail was inserted in an antegrade fashion. In the first patient, bone fragments were additionally secured with several loops of orthopedic wire. At the next stage the nail was fitted into the medullary canal and it was locked relative to the main fragments of the tibia using Schanz pins. A guide was attached to the nail to ensure that pins are correctly aligned with the nail's transverse openings. The pins were placed in a cannulated guide, skin incisions were made at the place of contact with the cannulas and implants were inserted with the use of a low-speed drill. At the last stage of the procedure skin wounds were sutured using non-absorbable monofilament material (Monosof 2-0). Implants protruding above the skin were connected with clamps to the aluminum frame of the external fixator. The fixator was assembled and the pins were cut to length.

Immediately after surgery and on the following day the patients were administered analgesic treatment consisting of metamizole at 10 mg/kg (Biovetalgin, Biovet) and tramadol at 5 mg/kg IM (Tramal,

Table 1. Results.

Breed	Weight	Age	Sex	Time of surgical procedure	The moment of start weight bearing after surgery	Radiological bone consolidation in 6 week	Radiological bone consolidation in 8 week	Add information
I Mixed-breed	25 kg	2 years	male	39 min	1st day	++++	++++	Addition cerclage
II Mixed-breed	32 kg	3,5 years	male	48 min	2nd day	++++	++++	serous discharge on the seventh week
III Boxer	31 kg	4 years	female	58 min	3rd day	+++	++++	serous discharge on the seventh week
IV German--Shepherd	36 kg	4 years	male	43 min	2nd day	++++	++++	none

+++ – bridging calus betwen 3 cortices (on radiographs in 2 projections) – good bone consolidation
++++ – bridging calus betwen 4 cortices (on radiographs in 2 projections) – very good bone consolidation

Fig. 2. Pictures taken after surgery (a) and after six weeks of treatment (b).

Grunenthal). Wound dressings in the area of bone implants were changed every week, and the wounds were rinsed with 1% aqueous solution of chlorhexidine gluconate.

Results

The procedure of stabilizing tibial fractures in all cases was completed in 39 to 58 minutes. Functional weight bearing began between the first (n=1) and second (n=3) day after surgery (Table 1). The presence of external elements of the fixator on the medial side of the leg was well tolerated in all patients. The results of clinical tests were within the norm. On the seventh week of treatment serous discharge was observed at the site of the Schanz pin in two patients. The mobility of joints in the treated limb did not deteriorate in comparison with the range of motion observed in the opposing leg.

In the sixth week of treatment limb fractures were subjected to radiological tests which revealed clear bridging of fractured bone fragments (Fig. 2). Radiological examinations performed in the eighth week of treatment showed complete clinical union of the affected bones. The external fixator frame and Schanz pins were removed in all patients. Intramedullary nails were not removed due to their deep position.

Discussion

The discussed method of open fracture reduction with minimal surgical access, referred to as the "open but do not touch" technique (Aron et al. 1995), is consistent with the concept of biological osteosynthesis which emphasizes the importance of blood flow to the fractured bone (Perren 2002, Horstman et al. 2004). To minimize the loss of soft tissue a very small incision is made during surgical fixation to view the fracture site and correctly position the pins (McLaughlin 1999, Palmer 1999, Horstman et al. 2004). This approach significantly reduces the risk of iatrogenic damage to blood vessels at the fracture site, it promotes blood flow to the fractured bone (Lansdowne et al. 2007) and minimizes the risk of infection (Wyrsch et al. 1996, Im and Tae 2005). In own research this manner was sufficient for visualization of the medullary canal of distal main bone fragment and correct placement of the interlocking nail inside of it.

The external stabilizer was placed on the medial side of the leg which is characterized by a smaller share of soft tissue (Johnson and DeCamp 1999). This location minimized the risk of serous discharge appearing at the site of pin fixation (Adamiak and Piórek 2009), however in spite of it in two dogs on the seventh week of treatment minimal amount of serous discharge appeared in the site of inserting the Schanz pins.

Early weight bearing in all treated dogs should be consider as a beneficial effect to the course of treatment. Weight bearing increases stability at the fracture site and the above is achieved by incorporating an interlocking nail with an external fixator. According to Lu, early weight bearing after surgery involving a braid fixation system reduces micro-motions at the fracture site (Lu et al. 2009). Micro-motions are caused by instability which is difficult to eliminate in fixation systems that rely on standard interlocking nails (von Pfeil et al. 2005, Dejardin et al. 2006). The work of Kaspar (Kaspar et al. 2005) seems to corroborate the above findings. Functional weight bearing accelerates bone healing and it strengthens newly formed callus tissue (Sarmiento et al. 1977, O'Sullivan et al. 1994). The results reported by Kline suggest that the use of a type I external fixator without an interlocking nail does not eliminate the described condition. According to Kline, the absence of weight bearing directly after surgery can have a long-term effect on newly formed callus tissue and it can significantly prolong bone union (Klein et al. 2004). It should be noted, however, that weight bearing without sufficient stabilization of bone fragments could delay the healing process (Augat et al. 1997).

In our study joint rigidity was not observed in the treated limbs. In a study analyzing the stabilization of femoral fractions with an interlocking nail and an external fixator, Durall reported stifle joint rigidity in five dogs from a non-dynamized group starting in the fifth week of treatment. In the cited experiment, static fixation was replaced by dynamized treatment where in the fourth week of treatment the frame of the external stabilizer was removed and bone implants were inserted into the fracture site in an antegrade fashion. The above technique prevented stifle joint rigidity in the treated limb. According to the authors, joint rigidity was probably caused by fibrosis or adhesion of the quadriceps muscle to surrounding tissue (Durall et al. 2004). The above would explain why similar observations were not made in our study – the site of pin fixation was characterized by a low share of soft tissue. Dynamization speeded up the restoration of limb function which was observed after 5.7 weeks on average, whereas patients from the non-dynamized group required nine weeks to make a full recovery (Durall et al. 2004). In an earlier study investigating the osteosynthesis of canine tibia with the use of interlocking nails destabilization was not shown to have an effect on early restoration of limb function (Georgiadis et al. 1990).

This study validated the high efficiency of the discussed method for the treatment of comminuted tibial fractures in canine patients. Described stabilisator enables treating fracture in biological manner with minimal blood supply disturbances simultaneously ensure a high degree of fixing stability between fractured bone fragments. It promotes early restoration of limb function and shortens the treatment process. Among the advantages of this method a relatively easy manner of montage and short time of stabilisation should be emphasized.

Unfortunately, in all dogs the nail had to be left inside the medullary canal. We need to make further observation about influence on the bone structure of resisted nail in long term.

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