Angiographic study of the canine tibial fracture fixed by bovine bone pins as compared with the Conventional metal pins

Dehghani, S.1; Vafafar, A.2* and Emami, M. J.3

1Department of Clinical Sciences, School of Veterinary Medicine, University of Shiraz, Shiraz, Iran
2Department of Clinical Sciences, College of Veterinary Medicine, Islamic Azad University of Kazeroon, Kazeroon, Iran
3Department of Orthopedic Surgery, Medical School, Shiraz University of Medical Sciences, Shiraz, Iran

*Correspondence: A. Vafafar, Department of Clinical Sciences, College of Veterinary Medicine, Islamic Azad University of Kazeroon, Kazeroon, Iran. E-mail: vafafar@iauk.net

Summary

Tibial fracture is one of the most commonly encountered fractures in small animals that requires particular attention and care. Bone pins were made from bovine long bones treated by 3% hydrogen peroxide and sterilized by ethylene oxide. Ten mixed breed dogs were osteotomized at tibial mid shaft under general anesthesia. In 5 dogs the fractures were immobilized by bone pins and in other 5 dogs they were fixed using the conventional metal pins. 50 days after surgery, 883 mg/kg urographin was injected into the femoral artery and radiography was performed during urographin injection. Angiography of the healthy leg was performed simultaneously as a control study. Analysis of data revealed that there was no significant difference in arterial diameter of popliteal, proximal cranial tibial, distal cranial tibial, caudal tibial, cranial branch of saphenous, caudal branch of saphenous, main saphenous and proneal arteries between two groups. There was, however a significant increase (P<0.05) in the diameter of these arteries between each group as compared with the control study. The number of vessels in callus region was not significantly different between the two groups but it was significantly increased in each group as compared with the control study. By intramedullary pinning, the medullary and metaphyseal blood supply impair. However, periosteal and extraosseous blood supplies are the major sources for callus nutrition. Medullary blood supply generates parallel to intramedullary pins after 10–28 days postoperatively. After this period, extraosseous and periosteal arteries supply the fracture callus predominantly. This study proved that both bovine bone pins and metal pins had similar influences on extraosseous blood supply.

Key words: Angiography, Tibia, Dog, Bovine bone pin, Metal pin

Introduction

Tibial fracture is one of the most commonly encountered fractures in small animals. Healing of tibial fracture, however is difficult and may results in delayed union or nonunion. Blood supply to the fracture site plays a crucial role in bone healing (Brinker et al., 1990). By using intramedullary pin for fixation of the fracture the medullary blood circulation will be ceased, when the pin enters the medullary space. Therefore, the only nourishing source left for the fracture site is then the vessels that originate from the adjacent muscles and soft tissue (Rhineland, 1974). This study is focused on the angiographic differences of extraosseous blood supply if we use bovine bone pin or the conventional metal pin for fixation of tibial fractures.

Materials and Methods

Ten mixed breed dogs weighing 20± 4.3 kg were selected. They were vaccinated against rabies and dewormed. The intramedullary pins were made of bovine long bones and then treated with 3% hydrogen peroxide for 24 hr and dried in air. The bones were sterilized by ethylene oxide for 24 hr, packed in plastic paper packages and stored at room temperature. The dogs were off fed for 12 hr. The anesthesia was induced by 10 mg/kg of 5% sodium thiopental and maintained by 1% halothane.
Medial approach was selected for osteotomy of tibial midshaft in all dogs. The tibial midshaft was cut by an oscillating bone cutter. In five cases, the bovine bone pins were used to fix the fracture by retrograde technique. In other five cases, the conventional metal pins were used to fix the fracture by similar technique. Immediately after operation and every month for 12 months the radiography was performed to monitor the process of bone healing. All of the animals were kept in cage until the end of the study. Fifty days postoperatively, 883 mg/kg of 76% urographin (sodium amidotrizoate, Schring, Germany) was injected in the femoral artery and simultaneously, a lateral and an anteroposterior angiography were performed. In the bovine bone pin group, the healthy contralateral limb was also investigated similarly to make a control study (Figs. 1, 2, 3). Data were analyzed between bovine bone pin group as compared with the control study using paired Student t-test. Moreover, data were analyzed between metal pin group as compared with the control and between the bovine bone pin group as compared with the metal pin group using independent-samples Student t-test. All the animals in this study were treated according to human ethics.

Results

Using a Collis-Vernier, the diameters of several arteries were measured on angiograms. There was no significant difference in arterial diameter of popliteal, proximal cranial tibial, distal cranial tibial, caudal tibial, cranial branch of saphenous, caudal branch of saphenous main saphenous and proneal arteries between the two groups. There was significant increase in popliteal, proximal cranial tibial, distal cranial tibial, caudal tibial, cranial branch of saphenous, caudal branch of saphenoas, main saphenous and proneal diameter between each group as compared with the control study (Table 1). Moreover, the number of vessels and their side branches in cross section of the fracture site in each group were increased significantly as compared with the control study. Nonetheless, there was no significant difference between the two groups (Table 2). After 30–45 days, all dogs showed appropriate weight bearing and clinical intention.

Discussion

In respect to blood supply, tibia is a significant bone amongst all long bones of the mammals. Inadequate soft tissue surrounds tibia and therefore the extraosseous blood supply has a crucial role in nourishing the callus and the fracture healing (Rhinelander, 1974). The blood is supplied from popliteal artery which is a branch of femoral artery. Popliteal artery is divided into cranial and caudal tibial arteries. The nutrient artery in turn is a branch of caudal tibial artery that after penetrating the bone is divided into two medullary branches which are the main blood supplies of tibia. Saphenous artery is divided into two cranial and caudal branches. Proneal artery is originated from caudal branch of saphenous artery (Sisson and Grossman, 1975). Other blood supplies supporting tibia are metaphyseal artery in proximal and distal metaphyses and small periosteal arterioles that nourish its periosteum and the outer one-third of its cortex (Brinker et al., 1990). In tibial fractures and intramedullary pin application, metaphyseal and medullary blood circulations are damaged. Therefore, the periosteal arteries become the major blood supply. Besides, the new vessels originating from the surrounding soft tissue and the attached muscles become important sources of blood for the fracture site and callus (Welch et al., 1997). Among all type of soft tissues, muscles have the most capability in nourishing the callus and fracture site. Subcutaneous fat and skin, to a lesser extent, can play such a role. Because of this blood supply originating from muscles, antibiotics and immune cells can easily penetrate the fracture site (Rhinelander, 1974). The less traumatized the surrounding soft tissue, the more the blood supply, hence a faster healing process and callus formation (West et al., 1996 and Wander et al., 2000). These new extraosseous vessels are formed immediately after onset of fracture and keep
on nourishing the bone until the medullary circulation is reconstructed and continues its supporting until healing is completed. This period is reported to be between 10 and 28 days. However, we did not observe any medullary circulation 50 days postoperatively, only extraosseous circulation was evident by this time.

When metal intramedullary pins are used, after sometime, the medullary vasculature is formed along the space between the pin and endosteum that becomes a nourishing source to the bone (Rhinelander, 1974).

There was a significant increase in neovascularization, arteriole tufts and extraosseus blood vessel network in bone cement and bone graft application on zero through 45 postoperative days. (Abedi et al., 2001).

A diffuse increase in angiographic contrast material was observed in rabbit limbs undergoing distraction osteogenesis. (Decoster et al., 1999).

Fig 1. Lateral normal angiogram of tibial region of the dog (1. popliteal, 2. cranial tibial, 3. caudal tibial, 4. cranial saphenous, 5. caudal saphenous, 6. proneal, 7. saphenous)
Fig 2. Lateral angiographic view of a tibial fracture treated with bovine bone pin (1. popliteal, 2. cranial tibial, 3. caudal tibial, 4. cranial saphenous, 5. caudal saphenous, 6. saphenous)

Fig 3. Lateral angiographic view of a tibial fracture treated with conventional metal pin. (1. popliteal, 2. cranial tibial, 3. caudal tibial, 4. caudal saphenous, 5. saphenous, 6. proneal)
Table 1: Arterial diameter (mm; $\bar{x}$ ±SD) calculated from angiograms of bovine bone pin and conventional metal pin groups as compared with the control group

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Pop</th>
<th>CTP</th>
<th>CT_D</th>
<th>CdT</th>
<th>CS</th>
<th>CdS</th>
<th>S</th>
<th>Pn1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine Bone Pin</td>
<td>5</td>
<td>2.64</td>
<td>2.44</td>
<td>1.92</td>
<td>1.66</td>
<td>1.12</td>
<td>1.82</td>
<td>2.1</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Conventional Metal Pin</td>
<td>5</td>
<td>2.14</td>
<td>1.75</td>
<td>1.75</td>
<td>1.35</td>
<td>1.00</td>
<td>1.6</td>
<td>1.6</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>a, b Control</td>
<td>5</td>
<td>1.3</td>
<td>0.9</td>
<td>0.7</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.11</td>
<td>0.21</td>
<td>0.24</td>
<td>0.09</td>
<td>0.03</td>
<td>0.16</td>
<td>0.46</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Pop = popliteal, CTP = proximal cranial tibial, CT_D = Distal cranial tibial, CdT = Caudal tibial, CS = Cranial branch of saphenous, CdS = Caudal branch of saphenous, S = Saphenous, Pn1 = Proneal

a, b = Different values in the columns are significantly different (P≤0.05)

Table 2: Number of arterial branches at the callus site in the bovine bone pin and conventional metal pin groups as compared with the control group

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control</th>
<th>Conventional metal pin</th>
<th>Bovine bone pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>No. of arterial branches (±SD)</td>
<td>$8±2.5^a$</td>
<td>$15±4.2^b$</td>
<td>$14.4±6.0^b$</td>
</tr>
</tbody>
</table>

a, b = Different values in the row are significantly different (P≤0.05)
References


