BONE LENGTHENING USING CIRCULAR EXTERNAL SKELETAL FIXATOR IN 9 DOGS

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Summary: The aim of this study is to treat long bone defects and extremity shortness in 9 dogs using circular external skeletal fixator and also to present the outcomes of the operations to our colleagues. One case had a bone necrosis and osteomyelitis affected on radius within 7.0 cm; however others had extremity shortness between 2.0 and 6.0 cm affected on radius-ulna or tibia. 2 or 3 rings within 60.0-100.0 mm diameters, and 3 rods were used on circular external skeletal fixator. The distractions at the rate of 0.5 mmX2 times/day were performed following a latent period of 3 days after the corticotomy. Unifocal internal lengthening for case 1 and unifocal external lengthening for the others were performed. Distraction was performed between 20 and 70 days (mean 42 days). It was noted that the circular external skeletal fixator were well-tolerated by all cases. The first usages of their limbs in all cases were on postoperative between 5 and 47 days (mean 19 days). The radiographic follow-up examinations revealed a complete consolidation on postoperative between 39 and 80 days (mean 49 days). The fixators were removed on the postoperative between 40 and 85 days (mean 63 days). The treatment was successful in restoring the appropriate length of the limbs using by circular external skeletal fixator. After removing the fixator, functional and cosmetic results were graded as excellent in 5 cases, good in 2 cases and fair in 2 cases.

Introduction

While Doctor Gavriil Abromovich Ilizarov was working in a small town in the Kurgan Region of Russia, he developed a new method and invented the circular external skeletal fixator (CESF) which are commonly utilized in the field of Orthopaedics and Traumatology (Bianchi-Maiocchi 1991). He created a new vision for the orthopaedics and traumatology research field with his new method and made inventions in the field of soft tissue and bone regeneration. CESF is one of the most distinct external fixation systems that has been developed until now, and it can be used in many different fields (Bianchi-Maiocchi 1991, Bilgili and Olcay 1998, Bilgili et al. 2006, Bilgili et al. 2007, Ilizarov 1989a, Ilizarov 1989b, Ilizarov 1990).

Following a simple osteotomy in 1956, Ilizarov discovered that periosteal and medullary blood supply could be preserved by incremental distractions used to lengthen a bone, thereby eliminating the need for bone grafts (Ilizarov 1989a, Ilizarov 1989b, Ilizarov 1990).

In the field of veterinary orthopedics and traumatology, this method continues to be used commonly on dogs for the treatment of long bone fractures (Bilgili and Olcay 1998, Bilgili 2004, Bilgili et al. 2006, Bilgili et al. 2007, Olcay and Bilgili 1999, Ferretti 1991, Latte 1995, Marcellin-Little 1999, Lewis et al. 1999a), correction of angular deformities (Ferretti 1991, Latte 1995, Lewis et al. 1999b), nonunion (Ferretti 1991, Lesser 1994, Owen 2000), distraction osteogenesis and lengthening of extremities (Ferretti 1991, Lewis et al. 1999a, Bilgili et al. 1999a, Bilgili et al. 2000, Welch and Lewis 1999, White and Kenwright 1991, Erler et al. 1999, Gungor et al. 1997, Elkins et al. 1993, Stallings et al. 1998), arthrodesis (Lewis et al. 1999a) and bone transportation after bone tumor resections (Rovesti et al. 2002) throughout the past ten years.

The purpose of this study was to treat long bone defect and extremity shortness on radius-ulna and tibia with Ilizarov method and CESF in 9 dogs, which obtained between 3.0 -7.0 cm bone lengthening. In addition, it is aimed to present the results of these operations to our

colleagues.

Material and Methods

Anterio-posterior and medio-lateral radiographs were taken from the normal and affected limbs of the subject. The exact location of all orthopaedic problems, appropriate ring diameters, the number of rings to be used, ring types, rod numbers, rod lengths and suitable wire penetration levels were determined from these radiographs for preoperative planning. Vascular, neural and anatomical structures of the radius and ulna were examined from anatomical atlases, and also safe wire penetration levels, directions and suitable ring levels were determined from the images found in literature (Latte 1995, Bilgili et al. 1999b, Piermattei and Johnson 2004, Bilgili et al. 2006). In this study, CESF was made from a human type system (CEF, Tipsan, Turkey). CESF was made up of ETAL-74 (94.5% aluminium, 1.5% magnesium, and 4.5% copper). CESF and the whole set was prepared according to the data obtained from the cases. They were mounted preoperatively and sterilized after the rehearsal.

Anesthesia was induced by intramuscular injection of a combination of xylazine hydrochloride (1.1 mg/kg, Rompun, Bayer, Germany) and ketamine hydroclorure (15 mg/kg, Ketamidor, Richter Pharma AG, Austria), and maintained with inhalation of isoflurane (Abbott, Italy) and oxygen.

In all cases, the attentive pre-operative planning and protection of the periosteal and intramedullary blood supply during the corticotomy were done, as well as regulated rhythmic distractions was performed when a distraction with CESF is considered.

Tension was applied (to wires being on the ½ and 5/8 rings with a magnitude of 30 kg and to wires being on full rings with a magnitude of 60 kg) by using a dynamometric wire tensioner for all cases.

Following a three-day lag period, a period of seventy-day unifocal internal distraction was started. The distraction rate was 1.0 mm per day divided into two equal increments (0.5 mm every 12 hours). The surgical area was protected with a padded bandage for six weeks to accelerate the wound healing.

Owners were advised to dress the wire penetration surfaces with 10% polyvidon-iode solution (Polyod, Eczacibasi, Turkey) or terramycine spray (Terramycin spray, Pfizer, Turkey) twice a day. Bandage was applied to avoid postoperative edema in the paw. Massage and passive exercises on the upper and lower joints of osteotomy line were also recommended for 5 minutes 2 times a day. Moreover, 10 minute of leash walks (twice a day) were advised, and the owners were recomended to stop the physiotherapy after the dog had started to use its operated limb.

The whole postoperative radiographic images were taken at our university radiology department in all cases. In all cases, CESF was removed whenever the new bone tissue on the lengthening area was obtained normal bone density for radiological outcome. In Case 1 which had open fracture, wound and osteomyelitis, the callus was completely healed on postoperative 85th day, and CESF was removed.

The whole cases were checked clinically and radiographically in postoperative period. The upper and lower joints of affected bones (radius or tibia) were examined postoperatively. The motion range of elbow and carpal joints for radius-ulna or the stifle and the hock joints for tibia were not shown any problem. The skin and soft tissue of operation regions on affected bone were not observed any swelling, lesion and inflamation, etc. in all cases after removed CESF.

The functional and cosmetic results of the extremities were evaluated according to the Fox evaluation scale (Fox et al. 1995). Satisfaction in limb use was classified according to the

following: Excellent: Functionally normal; Good: Slight lameness only after extensive exercise; Fair: Slight to moderate lameness but consistent weightbearing; and poor: Non-weightbearing lameness. Cosmetic apperance was classified as follows: Excellent: Similar in apparence to the contralateral, normal limb; Good: Minor difference from the contralateral, normal limb; Fair: Noticeable difference from the contralateral, normal limb; Poor: Marked, disfigured alteration from the contralateral, normal limb, or a normal limb. According to this scales, functional and cosmetic result were graded as "good" in case 1.

Discussion

Fixator stability (Bilgili 2004, Bilgili et al. 2006), adequate blood supply, minimal disruption of soft tissues, proper rate and rhythm of distraction and physiologic use of the limbs directly affect the new bone formation (Elkins et al. 1993, Bilgili et al. 2000, Erler et al. 1999, Stallings et al. 1998, Aronson and Shen 1994, Kurum et al. 2002).

In order to provide the maximum fixator stability, it is important to choose the narrowest ring diameter which is large enough to secure the soft tissues (Bilgili and Olcay 1998, Kurum et al. 2002). Unsupported areas between the rings need to be short, and if necessary more rings should be used. It is also important that applying two or more K-wires for each rings with the angles of 60º - 90º is essential for ring and fracture gap stability (Bilgili and Olcay 1998, Bilgili et al. 2000, Kurum et al. 2002). In this study, all procedures applied in the treatments were correctly performed, hence no complication was observed.

To protect the periosteal and intramedullary blood supply, osteotomy of the intercalary fragment should be carried out delicately. For this purpose, a corticotomy or compactomy as mentioned by Ilizarov (Ilizarov 1989a) or a low energy osteotomy can be preferred. Zembo and colleagues (White and Kenwright 1991) were unable to find any difference between subperiosteal corticotomy and subperiosteal osteotomy with respect to the amount, rate or vascularity of the new bone formation in a canine model. In this study, the subperiosteal osteotomy for protecting periosteum was performed without any complication. In addition, according to the bone problems of cases the bone lengthening was obtained minimum 3.0 cm, maximum 7.0 cm and there is no complication on new bone tissue of distracted area.

A delay or latency period is recommended between osteotomy and the initiaition of distraction to allow early phase of fracture healing to occur (Ilizarov 1989a). In this period, a fibrovascular bridge was formed which serves as a framework for intramembranous ossification under proper conditions of stability and provide controlled distraction and weight bearing. Ilizarov's clinical experiences and experimental observations led him to recommend a delay of 5 to 7 day after surgery (Ilizarov 1989a, Stallings et al. 1998). However, in a recent study dealing with the diaphyseal and metaphyseal osteotomies in the tibia of the dog, it was found that a seven-day latency period caused premature consolidation in metaphyseal osteotomy (Aronson and Shen 1994). In veterinary orthopaedics, the suitable latency period is two to three days for immature (Ferretti 1991) and 5 to 7 days for adult patients (Welch and Lewis 1999). However, the osteotomy area (diaphyseal or metatarseal), metabolic diseases, type of osteotomy (subperiosteal corticotomy or osteotomy) and osteomyelitis may affect the latency period (Lesser 1994, Stallings et al. 1998). In this study, a latency period of 3 days were chosen. After this latent period, the controlled distraction was applied and the radiological outcome was shown that new bone formation was regular on distracted area in all cases.

Rate of distraction refers to the total amount of distraction performed in a 24 h period. Rhythm refers to the number of distraction increments per 24 h period. Optimal regenerative bone formation was obtained with a rate of 1.0 mm per day distracted in equal increments (0.017 mm every 24 min) which is controlled by a mechanical autodistractor (Stallings et al. 1998). In the field of veterinary orthopaedics, the suggested rate is 1.0 mm/day divided into

two or four increments (Ferretti 1991, Latte 1995, Bilgili et al. 2000, Erler et al. 1999, Gungor et al. 1997, Rovesti et al. 2002). In this study, a 0.5 mm X 2 / day rhythmic distraction was performed on all cases in which the outcome for the new bone formation was good.

As the intercalary fragment reaches to its destination and docks with the opposing stationary segment, compression is initiated to facilitate union at the docking site (Stallings et al. 1998). This period is named as the neutralization phase where the newly formed callus calcify and recorticalize. The neutralization phase takes two to four weeks individually (Lesser 1994). In this study, the CESF was removed between 7 and 10 days, following the radiologic consolidation.

During the application of the CESF, wire track drainage can frequently be seen as in other type of external skeletal fixator (Bilgili et al. 2006, Lewis et al. 1999a and 1999b, Bilgili et al. 1999a, Stallings et al. 1998, Gul et al. 2004, Bilgili et al. 2007). In the current study, an antiseptic solution or antibiotic spray on wire tracks was recommended to the patients' owners in every day against to the infection. On the other hand, superficial wire track inflammation were observed in some cases. And in any cases, wire loosening was not shown.

In conclusion, the basis of Ilizarov method depends on protection of periosteal and intramedullary vascular structure during the corticotomy and stimulation of ossification with rhythmic distraction after a short period of interval. The attentive pre-planning of the operations was suggested to the colleagues, protecting the periosteal and intramedullary blood supply, as well as performed regulated rhythmic distractions when a distraction with CESF is considered in all cases.

The treatment was successful in restoring the appropriate length of the limbs using by circular external skeletal fixator. After removing the fixator, functional and cosmetic results were graded as excellent in 5 cases, good in 2 cases and fair in 2 cases.

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