Limb lengthening in three dogs using distraction rates without a latency period
Radius/ulna, tibia, femur

W. T. McCartney
Marie Louise Veterinary Hospital, Baldoyle, Dublin, Republic of Ireland

Introduction

The objective of this report was to raise the issues of the need for a latency period and of distraction rates in limb lengthening. The details of the three cases that were managed by the author using a protocol different from that considered as the norm for limb lengthening in the current literature, are outlined in this report.

More than 10% shortening of a limb will compromise function (1); however another study (2) showed that dogs can tolerate shortening of the femur of up to 20%. Clinically, a dog with a shortened limb may suffer lameness, ulceration, painful joints, and an inability to walk, thus necessitating lengthening surgery (3, 4). Limb deformities are best managed using external fixation as there is less soft tissue trauma and greater possibility for adjustment after osteotomy compared to internal fixation (5). Ilizarov ring fixators have been used successfully in human and veterinary orthopaedics for limb lengthening and for the correction of deformities (1, 6, 7). When dealing with complex deformities, the ring fixator allows the management of tortional, axial and length corrections through post-operative frame adjustment (6). The healing of bone during and following distraction using a ring fixator was shown to be efficient experimentally (8). A latency period following osteotomy, before distraction is started, is considered to be standard procedure and has been shown to produce a more prolific bone healing pattern (9). Rates of distraction from 0.92 mm to 2.72 mm per day have been reported (10).

Materials and methods

The three dogs were referred to the author for corrective surgery between 2004 and 2005.

Case 1 (Table 1) was a four-year-old male Corgi with an antebrachial valgus deformity, secondary to premature closure of the distal ulna growth plate. The dog had a pronounced chronic deformity, 40 degrees lateral deviation and shortening of the radius and ulna approximately 16% or 28 mm of normal length, with a reduced range of motion of the carpus. Case 2 was an 11-month-old male Labrador Retriever with a lameness and awkward gait caused by a shortening of the tibia by 78 mm or approximately 39% of normal length (Fig. 1). Case 3 was a one-year-old female Dobermann with a continuous lameness caused by a shortened femur due to premature closure of the distal femoral growth plate. The femur was approximately 28% or 53 mm shorter than normal and the dog could not stand on the limb (Fig. 2).

In each case, the dog was premedicated with medetomidine and butorphanol. Anaesthesia was induced and maintained with isoflurane. Preoperative cephalixin was administered and maintained for at least seven days after surgery. Butorphanol was administered daily for the first three days postoperatively. Meloxicam administration was started preoperatively and used for pain relief during the time the fixator frames were in place.

Keywords
Limb, lengthening, dog, latency, distraction rates

Materials and methods

The three dogs were referred to the author for corrective surgery between 2004 and 2005.

Case 1 (Table 1) was a four-year-old male Corgi with an antebrachial valgus deformity, secondary to premature closure of the distal ulna growth plate. The dog had a pronounced chronic deformity, 40 degrees lateral deviation and shortening of the radius and ulna approximately 16% or 28 mm of normal length, with a reduced range of motion of the carpus. Case 2 was an 11-month-old male Labrador Retriever with a lameness and awkward gait caused by a shortening of the tibia by 78 mm or approximately 39% of normal length (Fig. 1). Case 3 was a one-year-old female Dobermann with a continuous lameness caused by a shortened femur due to premature closure of the distal femoral growth plate. The femur was approximately 28% or 53 mm shorter than normal and the dog could not stand on the limb (Fig. 2).

In each case, the dog was premedicated with medetomidine and butorphanol. Anaesthesia was induced and maintained with isoflurane. Preoperative cephalixin was administered and maintained for at least seven days after surgery. Butorphanol was administered daily for the first three days postoperatively. Meloxicam administration was started preoperatively and used for pain relief during the time the fixator frames were in place.
Osteotomy was performed using a combination of osteotome and a small oscillating saw. No attempts were made to preserve the periosteum. In Cases 1 and 2, Ilizarov ring fixators were used. All of the wires were tensioned to 90–100 Nm. In Case 3, a dynamic linear external fixator (Veterinary Instrumentation, Sheffield, UK) was used, with positive profile pins at each end of the femur (Fig. 3). Following osteotomy a 2.4 mm threaded intramedullary pin was inserted normograde to align the femur. The threaded bar (4 mm) was left protruding above the proximal clamp and the intramedullary pin was bent over and connected to the threaded bar using polymethylmethacrylate, thus creating a tie in intramedullary pin dynamic unilateral fixator. A latency period was not used before lengthening was started, and all of the cases were treated with a twice daily rhythm of distraction. The limbs were lengthened at a rate of 2 mm per day in Case 1 and 3 mm per day for Cases 2 and 3.

The Ilizarov fixators were removed in Cases 2 and 3 due to implant problems and were replaced with a unilateral fixator and intramedullary pin, respectively, for the final two to three weeks of healing. All of the length measurements were made using the radiographs. Clinical examination was performed in each case at least every two weeks until the external frames were removed and radiographs were taken every three to four weeks, with follow-up examination of four to six months.

### Results

Preoperatively, in each case the limb was significantly abnormal thus causing lameness. Apart from Case 1, which had a carpal valgus deformity with reduced range of motion of the carpus, all the joints in the involved limbs had normal range of motion.

During the first four weeks after surgery in Case 1, there were two complications, as one wire became loose causing discomfort and lameness, and there was significant swelling and discharge at the most proximal wire. The most proximal wire was replaced at six weeks and was redirected away from the previous site as much as possible. The fixation frame was removed after 12 weeks. The normal elbow joint and reduced range of motion of the carpus were unchanged following the lengthening procedure. The final bone lengthening achieved was 27 mm.

In Case 2 there was significant lameness at six weeks due to a broken Ilizarov pin. At this stage the Ilizarov fixator was removed, and, using the two positive profile pins, some of the remaining Ilizarov pins and two additional pins, a unilateral acrylic fixator was applied for two weeks until healing was complete. The final increase in bone length was 78 mm (Figs. 4, 5).

In Case 3, the ‘tie in’ intramedullary pin was removed at four weeks because of local irritation and also because the distal femur was no longer engaged by the pin. At the four week examination, signs of high tension in the soft tissues were noticed, causing bowing of the threaded bar and of the bone. Due to femoral bowing and swelling around the distal pin, which caused discomfort, the frame was removed at six weeks. At this point the femur had not completely healed and there was some instability at the distraction site on palpation, especially in the medio-lateral plane. An intramedullary pin that was introduced normograde allowed the lateral bowing to be corrected and also provided stability for the femur. A final bone

---

### Table 1

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Breed</th>
<th>Bone</th>
<th>% short</th>
<th>Distraction mm/day</th>
<th>Bone Length increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 yrs</td>
<td>M</td>
<td>Corgi</td>
<td>Radius/ulna</td>
<td>16</td>
<td>2</td>
<td>27 mm</td>
</tr>
<tr>
<td>2</td>
<td>11 mths</td>
<td>M</td>
<td>Labrador</td>
<td>Tibia</td>
<td>39</td>
<td>3</td>
<td>78 mm</td>
</tr>
<tr>
<td>3</td>
<td>1 yr</td>
<td>F</td>
<td>Dobermann</td>
<td>Femur</td>
<td>28</td>
<td>3</td>
<td>45 mm</td>
</tr>
</tbody>
</table>

---

**Fig. 1** Preoperative view of shortened and deformed tibia in Case 2.

**Fig. 2** Preoperative view of Case 3 showing shortened femur and closure of distal femoral growth plate.
lengthening of 45 mm was achieved and the
dog was able to reach the ground suffi-
ciently to walk (Fig. 6). Even though the
femur was lengthened by 45 mm, the dis-
tance travelled by the threaded nut along the
bar was in excess of 80 mm. The dog im-
proved significantly compared to the pre-
operative situation but for the first four
months after implant removal it had a re-
duced range of motion of the stifle. How-
ever, the range of motion was found to be
normal at the one year check-up.

In all of the cases the radiographic progres-
sion of healing demonstrated an excellent pat-
tern of osteogenesis. Clinical examinations did
not reveal any discomfort in the limbs, apart
from the local inflammation caused by pin loo-
sening and breaking. The complications of pin
loosening and breakage, and lateral bending of
the bar were caused by the high distraction
rates, but corrective management in each case
prevented these complications from interrupt-
ing the treatment goals.

In summary, as the result of better limb
alignment and increased length, the out-
come in each case was clinically successful,
with all of the dogs using the limb normally
after the removal of the frame.

Discussion

By changing the method of managing cases
needing lengthening the author found that
higher rates of distraction, without a latency
period, were acceptable in a clinical situ-
ation to achieve bone lengthening, in a
shorter time frame than previously used by
the author. The lengthening of the bone by
distraction osteogenesis may theoretically
have no limits, except that the management
and consideration of the soft tissues is as im-
portant as the bone itself. Bone has a great
ability to regenerate due to its lower order in
the tissue differentiation scale, which other
tissues such as peripheral nerves and blood
vessels cannot emulate.

The forelimb case in this study did not
have carpal nor elbow subluxation but had a
reduced range of motion of the carpus, both
before and after correction. In the case
series by Latte (1) the incidence of reduced
range of motion of the carpus is not men-
tioned; however, subluxation of the radio-
carpal joint is described necessitating arth-
rodesis. Latte (1) also mentions the shorten-
ing of the flexor tendons as a problem that
may require transection of the superficial
digital flexor. In the present case, the re-
duced range of motion was for flexion of the
carpus suggesting that restriction of carpal
movement may have been caused by short-
ening of carpal extensor rather than flexor
tendons. None of the joints had a reduced
range of motion following the tibial length-
thening, unlike the carpus and stifle joints
which were affected in the other two cases.

The limb lengthenings achieved in the
tibia and femur cases were significant,
being 78 mm and 45 mm, respectively. Bone formation in distraction osteogenesis is by intramembranous ossification, which has a high capacity to remodel, and may explain the appearance of the regenerate bone as a secondary bone healing pattern rather than the palisading pattern in the final radiograph (Fig. 2). The radiographic progression during healing was consistent with parallel lamellae formation, which is the classical radiographic sign of distraction osteogenesis. Apart from the tension caused at the local cellular level, the other critical factors needed for distraction osteogenesis to proceed are stability at the osteotomy site, sufficient vascularity and a local osteogenic potential (12). In particular, the latter factor would be associated with immature bone as in Cases 2 and 3, and it is the authors' opinion that the use of high distraction rates without a latency period in cases needing significant lengthening are more applicable in this type of bone.

The maintenance of an intramedullary pin throughout the entire lengthening process would be beneficial, a technique which is used in human surgery (11). A hybrid Ilizarov ring fixator for femoral lengthening in humans is available but surgeons must be aware that a delicate balance exists during the lengthening process between the soft tissues and the bone that, if ignored, will lead to valgus deformity and stiffness of the knee (12). The lateral bowing of the femur that occurred in this study was to a certain degree due to the 4 mm bar being too small to resist the forces caused by distraction. The high distraction rates used in this case caused the bar to bend due to the high level of tension developed in the adjacent soft tissues. The other significant complications of pin loosening and pin breakage were also caused by the high rates of distraction (Fig. 2). Evidently the tensile forces created by the distraction exceeded the limit of the implants and perhaps indicates the need for larger diameter implants when using high distraction rates.

A latency period of four days is the accepted practice in human lengthening procedures (7). Latency periods of two days have successfully been used in dogs (13). The delayed distraction of bone compared to immediate distraction could improve the quality and homogeneity of the new bone (14, 15). Furthermore, the delayed distraction leads to a larger callus and greater capillary ingrowth (16). However, in one experimental study, latency periods ranging from 0 to 21 days in dogs had similar results, leading to the conclusion that latency was not required in distraction osteogenesis in dogs (17). Despite this, a latency period is still considered to be required (10, 8). The results of the present report of three clinical cases indicate that a latency period may not be required. The advantage of omitting the latency period is that the time for the patient in the fixator is reduced. Because immature bone has a higher osteogenic potential, the omission of the latency period may be more applicable in young dogs, and this would be a recommended area for further study.

Based on extensive experience in human surgery, the accepted rate of lengthening is 1 mm per day either by 0.5 mm twice a day or 0.25 mm four times a day. If a higher rate than this is used two corticotomy sites are created, and even then the distraction may exceed the limit of the surrounding soft tissues (12). These same rates of distraction were successfully applied to veterinary patients by Ferretti and others (6) and accepted as standard procedure (18). Latte (1) states that a rate of 2 mm per day may lead to cessation of osteogenesis due to ischaemia of medullary blood vessels, and a rate of 0.5 mm per day may produce a premature union.

However, higher rates of distraction of up to 2.72 mm per day were applied in a study by Marcellin-Little and others (10). In the cases reported herein the distraction rate of the femur and tibia were higher than that of 2.72 mm per day, and the radius / ulna case was higher than the accepted rate of 1 mm per day. Despite these higher rates of distraction there were not any detected incidences of cessation of osteogenesis, long-term musculotendinous contracture and paraesthesias.

In human patients, tendinous contracture and paraesthesias due to peripheral nerve stretching can occur that require tenotomy, or capsulotomy, to permit lengthening to continue (12). The reduced range of motion of the stifle following femoral lengthening may indicate some musculotendinous contracture, but this was found to be temporary and did not cause any discomfort. There was a lack of evidence that paraesthesias occurred in these cases. The detection of paraesthesias may be difficult in dogs, but the sequential clinical examinations did not detect any pain which would be expected for that situation. The dogs were weight-bearing on their limbs during the lengthening procedure except when the pins became loose or broke and caused local irritation. None of the three dogs showed any signs of discomfort, apart from that caused locally by the failure of implants. The relatively minor corrective surgery needed to circumvent the complications did not involve any major invasive procedures and in each case only required percutaneous placement of pins.

The significant complications of bar bending and pin loosening and breaking necessitated corrective surgical measures and may deter surgeons from using as high a distraction rate. The results indicate that higher rates of distraction for limb lengthening are possible but further studies are required to examine the high complication rates and how they can be avoided. The issues of paraesthesias, patient discomfort, implant failure, musculotendinous adaptation and joint mobility are all areas for further research and discussion.

Acknowledgements
The author would like to acknowledge the postoperative care provided by the referring veterinary surgeons and also for referral of the cases.

Fig. 6 Ten-week postoperative view of lengthened femur in Case 3.
References


Correspondence to:
William T. McCartney, NVB, BSAS (Orth), PhD, Dip. ECVS, MRCVS
Marie Louise Veterinary Hospital
38 Warrenhouse Road
Baldoyle, Dublin 13
Republic of Ireland
Phone: +353 1832 2843, Fax: +353 1839 6502
E-mail: billymccartney@gmail.com

Vet Comp Orthop Traumatol 5/2008