Original Article

Active tension-extension splints: A novel technique for management of congenital flexural deformities affecting the distal limb in the foal

P. C. Compston* and R. J. Payne
Rossdales Equine Hospital, Newmarket, Suffolk, UK.

Keywords: horse; flexural deformities; congenital; tension-extension splint; foal

Summary

A variety of methods are described for managing distal limb flexural deformities in the foal, including intravenous oxytetracycline and splint or cast use. This case series describes a novel technique that creates an ‘active tension-extension splint’ by wiring the toe into a custom-made fibreglass splint and therefore into active extension. A dorsal fibreglass splint is made by halving a cast that is set around the affected leg with padding underneath it, so that it is sculpted to a more appropriate anatomical shape. Cerclage wire is placed through the toe and the dorsal aspect of the splint, then tightened to pull the limb into active extension. Foals with distal limb flexural deformities that were treated in this way were followed up by examination of hospital records and telephone questionnaire. Records were examined for 13 foals treated between 2004 and 2010. One foal developed septic osteitis of the distal phalanx due to suspected laminar penetration; other post operative complications seen were bandage sores and minor cosmetic scarring. Out of 10 foals where follow-up by questionnaire was available, 8 had complete resolution of their deformity following active tension-extension splinting, one required inferior check ligament desmotomy for complete correction and one had carpal flexural deformities that did not resolve. All that survived to adulthood are sound and have achieved their intended purpose. This previously unpublished technique using a wire through the toe to create an active tension-extension splint has a high success rate for correction of congenital flexural deformities affecting the distal interphalangeal and metacarpo-/metatarsal joint and the carpal joints (McIlwraith 2002; 2006). These deformities usually affect the forelimb and occur at the distal interphalangeal, metacarpo-/metatarsophalangeal joint or the carpal joints (McIlwraith 2006). Foals are often affected in more than one limb or joint (Kidd and Barr 2002). Flexural deformities in the distal limb (e.g. metacarpo-/tarsophalangeal joints, distal interphalangeal joint) carry a more positive prognosis than deformities higher in the limb (e.g. of the carpal joints) (Adams and Santschi 2000).

Introduction

Congenital flexural deformities in the foal are a relatively common problem, with a prevalence of up to 20% reported in some studies (Crowe and Swerczek 1985). The aetiology of these conditions is not clear, with a variety of genetic, infectious and toxicological agents having so far been implicated in the pathogenesis (Kidd and Barr 2002; Auer 2006). These deformities usually affect the forelimb and occur at the distal interphalangeal, metacarpo-/metatarsophalangeal or the carpal joints (McIlwraith 2002; Auer 2006). Foals are often affected in more than one limb or joint (Kidd and Barr 2002). Flexural deformities in the distal limb (e.g. metacarpo-/tarsophalangeal joints, distal interphalangeal joint) carry a more positive prognosis than deformities higher in the limb (e.g. of the carpal joints) (Adams and Santschi 2000).

There are obvious consequences of flexural limb deformities, the most immediate being dystocia in the mare (Greet 2000). Severe deformities may prevent foals from standing and nursing, which presents a significant problem in the neonatal period. This is due to the foal ‘knuckling-over’ when stable weightbearing is prevented because the underlying deformity causes involuntary and spontaneous flexion of the distal limb. Any congenital conformational abnormality has the potential to affect future athletic performance.

Mild cases of congenital flexural deformity where the foal is able to ambulate and does not knuckle-over often resolve spontaneously with exercise (Adams and Santschi 2000; McIlwraith 2002). If spontaneous resolution is not achieved, foals are treated with custom-made splints and...
casts, toe extensions, i.v. oxytetracycline (Madison et al. 1994; Kasper et al. 1995) or a combination thereof (Adams and Santschi 2000; Greet 2000; McIlwraith 2002). In severe cases where more conservative measures are not successful, surgical management by flexor tenotomy or arthrodesis has been described (McIlwraith 2002; Spoormakers et al. 2008).

Different methods of splinting have been previously described. Kidd and Barr (2002) described the use of fibreglass to construct a splint in one foal where the unaffected limb was used as a template and the splint rebandaged daily onto the affected leg under tension so that the leg was eventually pulled into a normal anatomical position. Other methods include splinting with plastic drainage piping (Adams and Santschi 2000) and the use of fibreglass casts (Greet 2000).

This study describes a novel technique to correct distal limb flexural deformities in the foal using an ‘active tension-extension splint’. It also provides follow-up in a case series of foals managed in this way.

Methods

Inclusion criteria

The main criterion for treatment of foals in this study was presence of a distal limb flexural deformity that was severe enough to cause spontaneous knuckling-over of the foot/fetlock when walking (Fig 1).

Technique

Initial bandaging

The foal is sedated and placed on a foam mat in lateral recumbency with the affected leg uppermost. A single thick padding layer (Gamgee tissue) is applied to the limb from the upper metacarpal/metatarsal region to the distal extremity of the toe. This is held in place by a simple conforming bandage (Knit-Firm). The leg is held in a fixed, straightened position by an assistant, with one hand pushing on the dorsal aspect of the distal radius/cranial aspect of stifle and the fingers of the other hand pulling the toe into extension. It is important at this point to ensure that there is no medial-lateral deviation of the limb, especially in young foals with increased joint laxity.

A padding bandage (Soffban) is applied only on the dorsal surface, from the level of the fetlock joint to the toe in a cone shape, in order to recreate an ideal normal dorsal contour of the normal shape of the distal limb (Fig 2); the bandage is sculpted to the correct shape. Rolls of fibreglass casting tape (Vetcast) are applied to the outer layer of this constructed bandage from the level of the proximal cannon to the toe. In a typical foal, 2–3 rolls of 5 inch (12.7 cm) Vetcast will be used.

Constructing the splint

Once the cast has set it is split into dorsal and palmar/plantar halves using a cast saw (Figs 3 and 4). The palmar/plantar half is discarded and the dorsal half shaped at the proximal and distal margins to remove any sharp edges. The extra cone of padding bandage (Soffban) distal to the fetlock on the outer layer of the primary bandage is removed. The dorsal half of the cast is then reapplied to the existing bandage so that it contours perfectly to the leg until the level of the fetlock, after which it deviates dorsally along an ideal normal anatomical contour of the limb.

Placing the cerclage wire

A piece of 18 gauge orthopaedic cerclage wire is then placed in a loop through the toe. To allow this, a 2.5 mm Steinmann pin is inserted from the solar surface through to
the dorsal wall (distally), avoiding penetration of the sensitive laminae. Two tracks are made, one laterally and one medially, in the dorsal toe region (Fig 5). The cerclage wire is then placed in through these tracks and across the sole. It is threaded through a short length of plastic tubing (e.g. intravenous fluid transfer set tubing) to help prevent it ‘cheese-wiring’ through the soft solar horn (Fig 6). With the loop of cerclage wire placed through the toe and the free ends protruding dorsally, 2 holes are placed close to the distal margin of the cast splint using a 2.5 mm Steinmann pin and Jacobs chuck. The cerclage wires from the toe are passed directly through these corresponding sites in the splint and are tightened, drawing the toe up into forced, fixed extension (Figs 7 and 8).

Completion of splint application

The toe region of the cast is reinforced by application of a rapidly curing hoof resin (Equi-Thane Super Fast) to strengthen it at the point of greatest strain. It is important that the distal margin of the cast is approximately 0.5 cm more proximal than the distal margin of the toe once the leg is pulled into full extension. When the foal stands, weight is taken on the solar surface of the foot and the toe instead of on the distal margin of the cast itself. The dorsal cast splint is fixed to the outer bandage layer by application of elasticated adhesive bandage (Flexoplast). The foal is then recovered and allowed to stand.

Post operative management

For 3 days post operatively foals are maintained on anti-ulcer medication and oral meloxicam (0.6 mg/kg bwt; Metacam). They are kept on box rest, with a short walk out 3 or 4 times daily to encourage use and loading of the affected leg(s). The splint is checked twice daily to ensure that the fibreglass has not fractured and the wires have not broken. It is typically removed after 48–72 h at which time progress is assessed (Fig 9). If the foal walks without knuckling-over dorsally no further splinting is required. The foal is usually stabled for a further period of 24 h after splint removal to check that no relapse occurs, and is then returned to normal management and increasing turnout. If the flexural deformity is not corrected then further splints are constructed until the foal is able to ambulate normally.
Follow-up

Practice records were examined to identify cases and any relevant history was recorded. Follow-up was achieved by means of a telephone questionnaire. Owners were questioned with respect to post operative problems, resolution of deformity and details of the foal’s subsequent clinical status and athletic use.

Results

Description of cases

Thirteen foals were treated for a distal limb flexural deformity in this way at Rossdales Equine Hospital between 2004 and 2010 (Table 1). Median age at presentation was 2 days.

Six foals (46%) needed a splint on one leg, 6 (46%) had 2 legs splinted and one (Case 9) needed a splint on 3 legs. Two foals (Cases 4 and 13) had concurrent carpal flexural deformity.
deformity. The distal interphalangeal joint was the most commonly affected joint (18/25; 72%); forelimbs (16/21; 76%) were more commonly affected than hindlimbs (5/21 24%). The distribution of the joints affected is described in Table 2.

The period required for hospitalisation decreased over time and foals seen after 2006 were routinely treated as outpatients. This reflects an increasing familiarity with the procedure. The majority of the splints were removed after 3 days, with further splinting provided if warranted by the severity of the flexion. Foals were stabled for the duration of splinting and 24 h afterwards and then allowed to return gradually to normal management.

Four foals did not survive to a year of age. These included the 2 with concurrent carpal deformity. Case 13 could not stand despite splinting due to the severity of carpal flexion and was subjected to euthanasia at 9 days of age; Case 4 was subjected to euthanasia at 6 months of age due to persistent carpal deformity (however, its distal limb deformity had resolved with active tension-extension splints). Two other foals (Cases 1 and 11) were subjected to euthanasia prior to 2 years of age for unrelated reasons.

**Post operative complications**

Two foals (Cases 10 and 11) had reports of splint-related problems (swelling and bandage sores) that resolved with time and appropriate management. When owners were questioned about post operative complications that had not been severe enough to require veterinary attention, 4 (40%) reported white hairs and one (10%) reported a small fibrotic lump, both resulting from pressure on the dorsal cannon.

Septic osteitis of the distal phalanx occurred in one foal (Case 1) 43 days after initial casting. This was assumed to be due to laminar penetration by the toe wire. The infected foot was debrided under general anaesthesia, and the foal recovered fully.

**Long-term results**

In one foal mild flexural deformity was present at 5 months of age (Case 5), and an inferior check ligament desmotomy was performed at this stage.

Telephone questionnaire follow-up was available in 10 foals. Mean follow-up time was 47.2 months (range 12–72 months). All owners questioned reported that their foals had complete resolution of their distal limb deformity. Out of the 8 foals available for follow-up that were still alive, none had been affected in later life by their flexural deformity and all were sound and being used for their intended purpose. Overall the level of satisfaction from the clients’ point of view was very high.

**Discussion**

The results reported in this study are encouraging with respect to the success rate of this novel technique.

The most serious complication seen was septic osteitis of the distal phalanx. It is recommended that prophylactic perioperative antibiotics are administered if any evidence of haemorrhage is seen when tracts in the hoof horn are being made. Any damage to the sensitive laminae of the hoof may allow infection to track through to the distal phalanx. Foals should be monitored carefully during the immediate post operative period, after which ongoing review for any unexpected lameness or foot sensitivity should be advised to allow the early detection of any problems.

Owners should also be warned about the risk of scarring and white hair formation, which may be more common than with conventional splinting due to the extra pressure on the dorsal cannon bone created by the active-tension technique. However, in this series, these problems were considered cosmetic and did not result in any functional deficits. Bandage sores may also be more frequent in these foals due to this pressure on the cannon bone, but these may be seen with any casting or splinting method. No other adverse effects were seen.

In one case further intervention was deemed necessary (Case 5). It was not clear from follow-up examination whether incomplete correction, or subsequent acquired flexural deformity, was responsible for the flexion seen prior to desmotomy. Even if not successful in accomplishing complete correction of the distal limb flexural deformity,
### TABLE 1: Foals treated with an action tension-extension splint between January 2004 and April 2010

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age at presentation (days)</th>
<th>Breed</th>
<th>Sex</th>
<th>Legs splinted</th>
<th>Joints affected</th>
<th>Previous Treatment</th>
<th>Concurrent Treatment</th>
<th>Length of stay in hospital (days)</th>
<th>Number of splints made</th>
<th>Post operative complications</th>
<th>Follow-up period (months)</th>
<th>Resolution of flexural deformity?</th>
<th>Cosmetic scarring reported?</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>TB</td>
<td>M</td>
<td>RH</td>
<td>RH</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>5</td>
<td>1</td>
<td>Tension wire tightened over course of hospitalisation</td>
<td></td>
<td>Subjected to euthanasia due to unrelated reasons at 1.5 years old (trapped in trailer)</td>
<td>Yes/No</td>
<td>Unsuitable temperament for racing. Currently breeding stock</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>TB</td>
<td>F</td>
<td>RE, RH</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>5</td>
<td>1</td>
<td>1 for RF 3 for RH</td>
<td>Wire on RH pulled through hoof horn prophylactic antibiotics given</td>
<td>No 主要</td>
<td>Subjected to euthanasia at 6 months old due to carpal deformity</td>
<td>Yes/No</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>TB</td>
<td>M</td>
<td>RF, LF</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>4</td>
<td>1</td>
<td>None</td>
<td>None, although some residual carpal deformity</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 6 months old due to unrelated orthopaedic disease</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>TB</td>
<td>F</td>
<td>RF, LF</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td>i.v. atoxicurine</td>
<td>10</td>
<td>2 per leg (plus one conventional splint per leg for each carpus)</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>TB</td>
<td>F</td>
<td>LF</td>
<td>LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>3</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>ID x TB</td>
<td>M</td>
<td>RF, LF</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>3</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>u/a</td>
<td>Percheron</td>
<td>F</td>
<td>LF</td>
<td>LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>3</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>TB</td>
<td>F</td>
<td>RH</td>
<td>RH</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>3</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>TB</td>
<td>F</td>
<td>RF, LF, LH</td>
<td>RF, LF, LH</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>1</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>TB</td>
<td>F</td>
<td>RH</td>
<td>RH</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>1</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>TB</td>
<td>M</td>
<td>RF</td>
<td>RF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>1</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>TB</td>
<td>F</td>
<td>RF, LF</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>1</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>TB</td>
<td>M</td>
<td>RF, LF</td>
<td>RF, LF</td>
<td>i.v. atoxicurine</td>
<td></td>
<td>1</td>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Yes/No</td>
<td>Subjected to euthanasia at 2 weeks old due to carpal deformities</td>
<td></td>
</tr>
</tbody>
</table>

*Carpal flexural deformities were not included in an active tension-extension splint.*  
*Not severe enough at presentation to warrant splinting.*  
*TB = Thoroughbred; ID = Irish Draught; M = male; F = female; RF = right fore; LF = left fore; RH = right hind; LH = left hind; DIP = distal interphalangeal; Fetlock = metacarpophalangeal joint; u/a = information unavailable; n/a = nonapplicable.*
the initial splinting would, however, have allowed adequate resolution for the foal to ambulate and suckle, therefore prolonging the interval to surgery until after the immediate neonatal period.

The authors’ veterinary hospital is part of a large ambulatory practice with a high reproductive caseload. Therefore, the cases described here will either be the more severe deformities that cannot be managed on stud farms or the rare cases that are refractory to conservative on-study treatments (traditional casts and splints and i.v. oxytetracycline). Consequently, this technique is not recommended as a first line procedure unless the criteria above are fulfilled.

Oxytetracycline can be used prior to, or combined with, splinting to encourage relaxation of the flexor tendons. Several mechanisms have been proposed for this, including calcium chelation in the musculotendinous unit and neuromuscular blockade (McIlwraith 2002). It has also been shown to be involved with a matrix metalloproteinase-1 mediated mechanism that impedes myofibroblast collagen alignment in vitro (Arnoczky et al. 2004). Some studies have shown oxytetracycline to have a high success rate in correcting mild flexural deformities in the foal when the foal is able to place at least some part of the sole on the ground (Lokai 1992). Although in others it appears only to make a short-term difference to the joint angle (Madison et al. 1994), this may be long enough to allow the leg to strengthen in mild cases. When administered concurrently at the time of splint application, musculotendinous relaxation is likely to allow further release of the leg as it is pulled into extension by the splint and therefore will maximise the effect of splinting. Six foals in this study received oxytetracycline at the same time as active tension-extension splinting, which may have contributed in part to the resolution of their deformities. Oxytetracycline should be used judiciously as there is a risk of overextension.

Previous authors have stated a poor prognosis for foals with a flexural deformity of the distal interphalangeal joint (Adams and Santschi 2000). The distal interphalangeal joint does not need to be as severely flexed compared to the fetlock joint before precluding weightbearing on the solar surface and therefore causing the foal to knuckle-over. This case series shows positive results for these foals. More distal interphalangeal joints than fetlock joints were affected in this study (see Table 2), contrary to previously published material (Adams and Santschi 2000); however, the treatment for both is the same.

Two of the foals in this study that did not have a successful outcome had carpal flexural deformities in addition to distal limb deformities. Carpal flexural deformities carry a much poorer prognosis than lower limb problems (Charman and Vasey 2008). This is because, despite medical and surgical intervention, they often fail to extend and release. Although in Case 4 the lower limb deformity did resolve, unfortunately the carpal deformities were too severe to offer the foal any useful athletic function.

There are definite advantages for the use of this method compared to conventional casting or splinting. Most traditional methods require repeated splint/cast changes, whereas active tension allows faster correction of flexural deformities, with an associated decrease in labour, time and cost. It also avoids the need for repeat sedation in a neonate. The extra tension that the distal limb is placed under may have the potential to correct those cases for which the only other option for resolution would be surgical, with the associated concerns including risk of general anaesthesia and increased financial outlay.

Overall, this previously unreported technique has few disadvantages and has distinct advantages over many of the techniques used presently to correct severe distal limb flexural deformities in the foal. Future studies are needed to evaluate the maximum angle of flexion that can be resolved by this technique so that appropriate case selection can be implemented and to ensure that clinicians are accurately able to assess prognosis in terms of conventional or tension-extension splinting procedures. This is a technique that could be easily carried out in the field and therefore incorporated into the equine general practitioner’s repertoire.

TABLE 2: Distribution of joints treated with active tension extension splints in 13 foals presenting with distal limb flexural deformities

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Right fore</th>
<th>Left fore</th>
<th>Total forelimb</th>
<th>Right hind</th>
<th>Left hind</th>
<th>Total hindlimb</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacarpophalangeal joint</td>
<td>7</td>
<td>3</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Distal interphalangeal joint</td>
<td>7</td>
<td>3</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Authors’ declaration of interests

No conflicts of interest have been declared.

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Manufacturers’ addresses

1 Robinson Healthcare, Carlton-in-Lindrick, Notts, UK.
2 Millipledge Veterinary, Whinleys Estate, Church Lane, Clarborough, Notts, UK.
3 BS Medical, Willerby, Hull, East Yorkshire, UK.
4 SM, Loughborough, Leicestershire, UK.
5 Vettec Hoof Care Products, Utrecht, The Netherlands.
6 Boehringer Ingelheim Ltd, Brockneil, Berks, UK.

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**References**


