Extensor retinaculum syndrome of the ankle after injury to the distal tibial physis

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We describe six patients aged from 10 to 15 years who, after injury to the distal tibial physis, presented with the following clinical findings: 1) severe pain and swelling of the ankle; 2) hypoesthesia or anaesthesia in the web space of the great toe; 3) weakness of extensor hallucis longus and extensor digitorum communis; and 4) pain on passive flexion of the toes, especially the great toe.

In four patients, the fractures were not reduced for more than 24 hours. The intramuscular pressure beneath the superior extensor retinaculum of the ankle was greater than 40 mmHg in all cases (40 to 130 mmHg), and less than 20 mmHg in the anterior compartment. Treatment consisted of release of the superior extensor retinaculum and stabilisation of the fracture. All patients had prompt relief of pain and improved strength and sensation within 24 hours, although two had some residual numbness in the web space of the great toe.

Six children, who sustained displaced physeal injuries of the distal tibia, subsequently developed similar neuromuscular deficits, including weakness of the extension of the toes, severe pain in the ankle and numbness in the web space of the great toe. In all patients the pressure beneath the superior extensor retinaculum was raised to ischaemic levels, but none had an anterior compartment syndrome. The tendons of tibialis anterior and of extensor digitorum longus, and the muscle and tendon of extensor hallucis longus and peroneus tertius, lie beneath the superior extensor retinaculum (anterior crural ligament) (Fig. 1). The neurovascular elements involved were the anterior tibial artery and the deep peroneal nerve (Fig. 2). We describe the anatomy, physiology, clinical findings and treatment of this condition.

Patients and Methods

The six patients were seen over a period of 12 years; we reviewed the records and radiographs. The four boys and two girls had displaced physeal fractures of the distal tibia with: 1) pain and swelling at the ankle which were much more severe than would be expected in an immobilised fracture of the ankle; 2) hypoesthesia or anaesthesia in the web space of the great toe; 3) weakness of extensor hallucis longus and extensor digitorum communis; and 4) severe pain on passive flexion of the toes, especially in the extensor hallucis longus.

We measured the intracompartmental pressures under general anaesthesia. After reduction, the pressures proximal to the fracture beneath the superior extensor retinaculum and in the anterior compartment were noted. All other suspected compartments of the leg or foot were also examined.

An anterior longitudinal incision, 10 to 12 cm long was made over the distal tibia (Fig. 3). Care was taken not to injure the superficial peroneal nerve. The taut superior extensor retinaculum was released, as was the distal portion of the anterior compartment. This gave excellent exposure of the distal anterior tibia and the physeal injury. Usually, the periosteum of the anterior tibia was torn extensively; in two cases it was found to be trapped in the site of the fracture. After removing the periosteum, the fracture was reduced and fixed. For Salter-Harris type-II injuries stabilisation by Kirschner wire was preferred, and for the triplane fracture screw fixation was used. The wound was usually packed open. After three to four days, delayed primary closure was performed if the swelling had settled. The leg was immobilised in a cast which was split.

Results

All six children sustained a Salter-Harris type-II or type-IV (triplane) fracture with anterior displacement of the tibia into the tunnel of the superior extensor retinaculum (Table I). In two cases, unsuccessful attempts had been made to reduce the fracture under light sedation at another hospital. The mean time from injury to reduction was 25 hours. Three patients presented with a displaced fracture and the clinical finding of compression by the extensor retinaculum...
Diagram showing the tendons and ligaments of the ankle and foot involved in surgical decompression, including the superior and inferior extensor retinacula.

Diagram showing a cross-sectional view of the superior extensor retinaculum tunnel, including blood vessels, tendons, muscles and nerves.
In all patients, we measured the intramuscular pressure after reduction of the fracture. The pressure beneath the superior extensor retinaculum was greater than 40 mmHg, but it was less than 20 mmHg in the anterior compartment (Table I). One patient also had a deep posterior compartment syndrome but the anterior compartment was not affected (Table I, case 2).

After surgical decompression, within 24 hours, there was relief of pain, improved strength, and less numbness. One patient (case 2) developed an Enterococcus osteomyelitis which required multiple surgical debridements, but recovered fully without neurological sequelae. At follow-up, two patients had weakness of extensor hallucis longus and hypoesthesia in the web space of the great toe (cases 1 and 4).

Discussion

The extensor retinaculum is a thick non-compliant extension of the anterior fascia of the leg which restrains the extensor tendons passing over the front of the ankle and prevents bowstringing. There are two components of this structure: the superior extensor retinaculum proximal to the ankle overlying the physis, and the inferior retinaculum (cruciate crural) ligament (Fig. 1).1,2

With fractures at this level, anterior displacement of the distal tibia compresses the contents of the tunnel roofed by the superior extensor retinaculum, in a similar manner to injuries of the carpal canal. The deep peroneal nerve was, however, intact and the symptoms and signs developed 24 to 48 hours later (Table I). A compounding factor was the delay (mean 25 hours) from the time of injury to reduction of the fracture. This precipitated ischaemic swelling of the muscle bellies of extensor hallucis and peroneus tertius which lie within this space. The subsequent muscle oedema and resulting increased pressure caused ischaemia of the structures within this tunnel.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Gender</th>
<th>Physeal fracture</th>
<th>Injury to symptoms (hrs)</th>
<th>Injury to reduction (hrs)</th>
<th>Pressures (mmHg)*</th>
<th>Fracture treatment</th>
<th>Result</th>
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<td>1</td>
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<td>IV</td>
<td>24</td>
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<td>ORIF† (screws)</td>
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<td>Toe weakness</td>
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<td>2</td>
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<td>F</td>
<td>II</td>
<td>60</td>
<td>36</td>
<td>Ext:60 A:20 DP:70</td>
<td>ORIF (pins)</td>
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<td>3</td>
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<td>F</td>
<td>II</td>
<td>24</td>
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<td>8</td>
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<td>48</td>
<td>Ext:44 A:14</td>
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</table>

* Ext, superior extensor retinaculum; A, anterior compartment; DP, deep posterior compartment
† open reduction and internal fixation
The differential diagnosis includes acute anterior-compartment syndrome\(^3^,^4\) or direct injury to the deep peroneal nerve at the site of the fracture.\(^4\) Measurement of intracompartmental pressures confirmed the diagnosis and identified which compartments should be assessed.

This syndrome has not been reported previously, but a chronic neuropathy with similar findings was described by Marinacci in 1968.\(^5\) Termed the anterior tarsal tunnel syndrome, this entrapment neuropathy involves the deep peroneal nerve beneath the inferior extensor retinaculum.\(^5^,^6\)

The usual cause is the dorsal strap from high-heeled shoes. The patients complain of pain on the dorsum of the foot, usually with associated sensory loss in the web space of the great toe. On electromyography, the distal latency of the deep peroneal nerve is increased, with chronic denervation of the extensor digitorum brevis. Decompression of the inferior extensor retinaculum and sometimes of the extensor digitorum brevis is recommended for this condition.

The problems associated with anterior release of the superior extensor retinaculum include mild bowstringing of the extensor tendons at the ankle. To prevent more extreme bowstringing, the inferior retinaculum should not be released unless the pressure readings in the foot are high.

Untreated, the natural history of this syndrome involves a residual sensory deficit of the web space of the great toe and paresis of the extensor digitorum brevis, which will limit hyperextension of the toes. Two of the patients (cases 1 and 4) had residual hypoesthesia and mild weakness of the toe extensors. Two other cases, not included in this group, have presented with a healed type-II distal tibial fracture and residual numbness of the web space of the great toe. This syndrome can occur in adults and has been observed with a necrotic extensor hallucis muscle during open reduction and internal fixation of a pilon fracture. Prompt recognition and decompression should prevent these complications.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References