THE STRESS-TENOGRAM IN THE DIAGNOSIS OF RUPTURES OF THE LATERAL LIGAMENT OF THE ANKLE

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The stress-tenogram is a radiological technique for the investigation of injuries to the lateral ligament of the ankle, and combines the information previously provided by inversion and anterior stress radiographs, and the peroneal tenogram. It is designed to differentiate between stable and unstable ankles, and between isolated ruptures of the anterior talofibular ligament and combined tears of the anterior talofibular and calcaneofibular ligaments. A high degree of diagnostic accuracy has been confirmed at operative repair in a group of thirty-two patients.

Rupture of the lateral ligament of the ankle is a common injury in young active people. It has been shown that the elements of the lateral ligament tear in a predictable sequence during the typical inversion-plantarflexion injury (Ruth 1961; Broström 1964; Staples 1975). Increasing force produces a tear which extends posteriorly from the anterolateral capsule, through the anterior talofibular ligament which is intimately associated with the capsule, to the calcaneofibular ligament, a distinct cord-like structure. A minor tear of the anterolateral capsule does not produce an unstable joint, whereas complete tears of either the anterior talofibular ligament alone, or in combination with the calcaneofibular ligament, result in demonstrable instability. There is considerable divergence of opinion as to whether these unstable injuries, occurring in young patients with high physical demands, are best treated by early mobilisation (McMaster 1943; Freeman 1965; Jackson, Ashley and Powell 1974), by immobilisation in a plaster cast (Leonard 1949; Chirils 1973; Gross and MacIntosh 1973), or by primary surgical repair (Ruth 1961; Broström 1966; Niethard 1974; Staples 1975). One reason for this continued dispute is the difficulty of defining the anatomical severity of injury in ankles treated without surgical repair.

Techniques used to demonstrate rupture of the lateral ligament include the stress-inversion radiograph (Leonard 1949; Rubin and Witten 1960; Freeman 1965), the anterior drawer sign (Landeros, Frost and Higgins 1968; Laurin, Ouellet and St-Jacques 1968; Lindstrand and Mortensson 1977), and arthrography of the ankle (Broström, Liljedahl and Lindvall 1965; Fordyce and Horn 1972; Spiegel and Staples 1975). All have the disadvantage of failure to demonstrate with accuracy whether the anterior talofibular ligament is ruptured in isolation, or in combination with the calcaneofibular ligament. The stress-inversion radiograph demonstrates tilt of the talus in the ankle mortise. The interpretation is difficult as up to 25 degrees of tilt has been recorded in uninjured ankles (Bonnin 1944; Laurin et al. 1968), and there may also be a normal asymmetry of 19 degrees (Rubin and Witten 1960) although the difference is usually less than 10 degrees (Laurin et al. 1968). In general, talar tilt that occurs only when the foot is plantarflexed is due to rupture of the anterior talofibular ligament, and a tilt that is present both with the foot plantarflexed and plantigrade indicates an additional rupture of the calcaneofibular ligament (Leonard 1949). This test is more reliable when performed under general anaesthesia (Bonnin 1944) or spinal anaesthesia (Olson 1969). The anterior drawer test is positive when the talus displaces forward in the ankle mortise, and indicates rupture of the anterior talofibular ligament (Anderson, LeCoq and LeCoq 1952). Reproducible radiographic measurements may be obtained by applying stress for two minutes after infiltration of local anaesthetic at the site of injury (Lindstrand and Mortensson 1977). More than 3 millimetres of displacement is regarded as abnormal (Landeros et al. 1968; Lindstrand and Mortensson 1977), although up to 9 millimetres of displacement has been recorded in a normal ankle (Laurin, Mathieu and Levesque 1973). This test does not differentiate between isolated rupture of the anterior talofibular ligament and a rupture in combination with the calcaneofibular ligament.

Arthrography provides a means of diagnosing rupture of the anterior talofibular ligament with contrast medium escaping through the joint capsule into the subcutaneous tissues. The calcaneofibular ligament is a structure separate from the capsule, and is related to the deep surface of the peroneal sheath. Rupture of this

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ligament is normally associated with a tear of the wall of the sheath, allowing contrast medium to escape from the joint and outline the peroneal synovial canal (Broström et al. 1965). Recent studies, however, have demonstrated that the arthrographic diagnosis of calcaneofibular ligament rupture is accompanied by an unacceptably high incidence of false-negative interpretations (Fordyce and Horn 1972; Spiegel and Staples 1975). The presumed reason for these failures is that the contrast medium escapes from the ankle joint by the path of least resistance, which is through the anterolateral capsular tear, rather than by filling the peroneal sheath. To overcome this problem the contrast medium may be injected directly into the peroneal sheath, and in the presence of a torn sheath and ligament it will escape into the ankle joint to produce an arthrogram. This investigation, the peroneal tenogram, appears to be more accurate than arthrography of the ankle in the diagnosis of rupture of the calcaneofibular ligament (Black, Brand and Eichelberger 1978).

A combination of the stress inversion and anterior drawer radiographs together with the peroneal tenogram produces an investigation called the “stress-tenogram”. The purpose of this review is to assess the accuracy of the technique in a group of thirty-two patients in whom surgical repair of the ruptured ligaments was performed, and in whom, therefore, the anatomical extent of the rupture was known.

**CLINICAL MATERIAL**

This investigation was based on thirty-two patients, twenty-four men and eight women, with an average age of twenty-four years. Clinical examination revealed significant injury to the lateral ligament of one ankle. These patients were part of a larger group who were investigated by stress-tenography, but in only thirty-two was primary surgical repair of the ruptured ligaments performed allowing the operative findings to be available for correlation. None of these patients had clinical signs of injury to the deltoid or inferior tibiofibular ligaments. The most frequent cause of injury was sporting activity, with football being the most common. The women were either physical education students or involved in competitive sport. Fifteen were seen on the day of injury, nine the next day, and the remaining eight after this period, the latest being on the sixth day after injury. Standard radiographs of the ankle excluded lateral malleolar fractures. Stress-tenograms were then performed to define the anatomical extent of the ligamentous ruptures and similar stress radiographs were taken of the contralateral ankles without performing tenography.

**OPERATIVE TECHNIQUE**

The patient is placed recumbent on the uninjured side, with the lower leg flexed and the injured leg lying over it in an extended position. The distal calf of the injured leg rests on the padded end of the table so that
the ankle and foot are free. Under local anaesthesia the peroneal tendons are palpated posterior to the lateral malleolus by asking the patient to evert the foot against resistance. A 23-gauge needle is inserted into the sheath, and its position confirmed by again asking the patient to evert the foot against resistance, which causes the external portion to move distally as the needle point is drawn proximally by the peroneal tendons. One cubic centimetre of local anaesthetic is injected to ensure free entry of fluid which may be blocked if the needle is embedded in the peroneal tendon. Four to six millilitres of Urografin 30 is next injected into the sheath. Digital pressure is applied immediately proximal to the site of injection to encourage the contrast medium to pass distally. The needle is removed and small sterile dressings applied. Stress inversion and anterior drawer radiographs of the ankle are then obtained without delay. The ankle must be stressed slowly and progressively to prevent protective muscle spasm.

**INTERPRETATION**

The information provided by the stress-tenogram allows an injury to the lateral ligament to be classified as one which has not produced instability of the ankle joint, or alternatively as one which has produced an unstable joint by rupture of the anterior talofibular ligament either alone or in combination with rupture of the calcaneofibular ligament (Table I). If the injured ankle appears as stable as the normal side on the stress radiographs, it can be concluded that the ligament is functionally intact. If, however, the ankle is unstable the tenogram will indicate the extent of the ligamentous rupture. The tenogram is negative when the contrast medium remains within the peroneal sheath, indicating that the anterior talofibular ligament alone is torn (Figs. 1 and 2), and positive when the contrast medium enters the ankle joint, indicating a rupture of the calcaneofibular ligament (Figs. 3 and 4). Secondary subcutaneous extravasation from the ankle joint through a capsular tear often occurs. Occasionally subcutaneous extravasation is seen directly from the peroneal sheath in the absence of contrast medium in the ankle joint, and is of no diagnostic significance. On two occasions we have observed contrast medium in the subtalar joint (Fig. 5).

**Table 1. Interpretation of the radiographic features of the stress-tenogram.**

<table>
<thead>
<tr>
<th>Instability on stress</th>
<th>Peroneal tenogram</th>
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<tbody>
<tr>
<td>Stable ankle</td>
<td>–</td>
</tr>
<tr>
<td>Rupture of the anterior talofibular ligament</td>
<td>+</td>
</tr>
<tr>
<td>Rupture of the anterior talofibular and calcaneofibular ligaments</td>
<td>+</td>
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</table>

Fig. 3 Anteroposterior and lateral radiographs of the ankle showing positive stress views, plus a positive peroneal tenogram. The contrast medium has escaped from the peroneal sheath, to produce an ankle arthrogram, and secondarily has leaked through the anterolateral capsular tear into the subcutaneous tissues.

Fig. 4 A lateral radiograph showing a positive anterior drawer test and positive tenogram, with contrast medium also outlining the posterior talocalcaneal joint.

Fig. 5
RESULTS
All thirty-two patients were shown to have unstable ankles, and at operation it was found that tear of the anterior talofibular ligament was an isolated feature in sixteen, but combined with a partial or complete rupture of the calcaneofibular ligament in the remainder (Table II). The talar tilt on the stress-inversion radiograph, recorded as the increase over the uninjured side, progressively increased with the severity of ligamentous rupture (Table II). These differences, however, were minimal with gross overlap of the ranges of tilt for each degree of injury. There were at least 3 millimetres of anterior displacement in all the anterior drawer radiographs and the three cases with the most marked displacement had isolated tears of the anterior talofibular ligament.

The tenogram was negative in all sixteen cases of rupture of the anterior talofibular ligament alone, and positive in eleven out of the twelve cases with combined ruptures. The contrast medium failed to enter the ankle joint in one case of rupture of the calcaneofibular ligament and at operation the peroneal sheath appeared intact. This false-negative result was the only diagnostic failure of tenography in the twenty-eight cases in which there was either no involvement or complete rupture of the calcaneofibular ligaments. In the four cases of partial rupture, where a portion of the calcaneofibular ligament remained functionally intact, the tenogram was negative on three occasions and positive once.

There were no complications as a result of the investigation, and it caused no problems for subsequent surgical repair of the ligaments.

DISCUSSION
Stress-tenography appears to offer accurate information regarding the anatomical severity of injury to the lateral ligament of the ankle. There was one false-negative interpretation, failing to show rupture of the calcaneofibular ligament, and operative exploration in this case confirmed that the peroneal tendon sheath was intact. It would therefore appear that occasionally the calcaneofibular ligament can rupture without tearing the adjacent peroneal sheath, and in such cases the radiographic interpretation will be incorrect whether the contrast medium is injected into the ankle joint or into the peroneal sheath. In the four cases of partial rupture the tenogram indicated the presence or absence of damage to the deep surface of the peroneal sheath, with one positive and three negative tenograms.

During this investigation we had been concerned that the tenogram might produce false-positive interpretations due to a naturally occurring communication between the peroneal sheath and the ankle joint. The literature on this subject is almost entirely on ankle arthrography. Clinical studies on uninjured ankles have not revealed a communication (Broström et al. 1965; Fussell and Godley 1973). In addition, eighteen arthrograms performed on neonates and infants were examined by us, and there was no filling of the peroneal sheath. However, cadaveric studies provide conflicting information with Arner et al. (1957) failing to demonstrate a communication, Schweigel, Knickerbocker and Cooperberg (1977) claiming a 6 per cent incidence and Mehrez and El Geneidy (1970) an incidence of 12.5 per cent. The latter studies may be inaccurate as some, if not all, of the communications described may have been the result of injury. The persistence of such communication after an injury has been demonstrated in a small

Table II. Correlation of the diagnosis at operation and the investigation before operation

<table>
<thead>
<tr>
<th>Ligamentous rupture found at operation</th>
<th>Number of cases</th>
<th>Asymmetry of talar tilt (degrees)</th>
<th>Peroneal tenogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior talofibular</td>
<td>16</td>
<td>14.6 (9–28)</td>
<td>16</td>
</tr>
<tr>
<td>Anterior talofibular and partial calcaneofibular</td>
<td>4</td>
<td>15.2 (9–21)</td>
<td>3</td>
</tr>
<tr>
<td>Anterior talofibular and complete calcaneofibular</td>
<td>12</td>
<td>18 (9–24)</td>
<td>1</td>
</tr>
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</table>

minority of cases by Broström et al. (1965). In our study, all the positive tenograms were associated with injury to the calcaneofibular ligament. The longest delay between injury and the production of a positive tenogram was six days. This confirms the arthrographic findings that the communication persists for up to seven days, although less contrast medium may pass through (Broström et al. 1965).

This investigation confirms that, in the individual case, the talar tilt and anterior drawer test alone are of limited value in defining the anatomical extent of the ligamentous injury. It is difficult to know when a minor asymmetry of talar tilt represents rupture of the anterior talofibular ligament. The smallest asymmetry of talar tilt recorded in this study was 9 degrees, and these cases were proven at operation to have rupture of at least the anterior talofibular ligament. The most significant factor which appeared to limit the talar tilt was the length of time which had elapsed after injury.

The stress-tenogram has two roles in the investigation of injuries to the lateral ligament of the ankle. In the clinical context, it is unnecessary for either the minimal injury or the unequivocally unstable ankle, but may be used for the intermediate presentation to determine joint stability and the anatomical severity of the ligamentous rupture. Also, in order to compare two different methods of treatment, it may be used to define
the nature of the ligamentous injury in cases treated without operation, so that the treatment groups can be matched for severity of injury. This may help resolve the debate as to whether unstable ankle injuries occurring in young patients are best treated conservatively or by surgical repair.

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REFERENCES


