We analysed 42 weight-bearing lateral radiographs of the ankle, 20 of which were from patients with a clinical and plain radiological diagnosis of talocalcaneal coalition (TCC) who subsequently had CT. The remainder were from 22 healthy volunteers with no clinical findings suggestive of hindfoot pathology. Four observers, blinded to the CT findings, independently evaluated the radiographs on two separate occasions.

With the 95% confidence interval and using the CT findings as the comparison we calculated the sensitivity, specificity, accuracy, and positive and negative predictive values for the C-sign, and for other signs known to be associated with TCC. Similarly, we also calculated the interobserver and intraobserver reliability for these signs using the kappa statistic.

Our results suggest that the C-sign is highly sensitive and specific for TCC. It is an accurate indicator and significantly more reliable than other previously recognised radiological signs of TCC. Features of the C-sign, however, cannot be relied upon to indicate whether the TCC is fibrous or bony.

Talocalcaneal coalition (TCC) is an uncommon condition which presents with a history of repeated ankle sprains or vague, non-specific symptoms in the hindfoot, often following relatively minor injury. The coalition may not be recognised as the cause of the symptoms and the diagnosis may be missed, resulting in inappropriate treatment.

Although CT is now regarded as the best method of diagnostic imaging for talocalcaneal coalitions, all patients presenting with painful conditions of the hindfoot will invariably have had plain radiography, of which the lateral projection on weight-bearing is an integral component. Many of these radiographs will have radiological signs which are known to be associated with coalition. Primary signs on the lateral radiograph include narrowing and subchondral sclerosis of the posterior subtalar joint and failure to visualise the middle subtalar joint. Secondary signs include talar beaking and blunting of the lateral process of the talus. Not all of these are necessarily present at one time, none is specific for any type of coalition and they can be easily missed.

The C-sign (Fig. 1a) has been recently described as a C-shaped line on the lateral radiograph of patients with TCC and is formed by the medial outline of the dome of the talus and the posteroinferior outline of the sustentaculum tali. It has been named the C-sign because of its shape and its representation of the first letter of the word ‘coalition’. It has been suggested that it is a reliable indicator of TCC on the lateral radiograph and, as such, could serve to alert the clinician to the possibility, which can then be easily confirmed by CT or MRI.

Our aim was to ascertain the accuracy of this sign by determining its sensitivity and specificity, and also its interobserver and intraobserver reliability. We also sought to determine whether certain of its features related to the type of TCC.

Patients and Methods

We analysed 42 lateral radiographs of the weight-bearing foot. All had been assigned a randomised number and were cropped so that all other marks of identification were not visible. Of these, 20 belonged to patients who had presented to a foot and ankle clinic with hindfoot pain and who had a clinical and/or plain radiological diagnosis of...
TCC. There were five women (7 feet) with a mean age of 30 years (95% CI 25 to 36) and 11 men (13 feet) with a mean age of 27 years (95% CI 21 to 32). All had subsequently had CT which was available for review. The remaining 22 lateral radiographs belonged to healthy volunteers with no history or findings suggestive of hindfoot pathology. There were three women (6 feet) with a mean age of 27 years (95% CI 25 to 30) and ten men (16 feet) with a mean age of 31 years (95% CI 28 to 33). They did not have CT and there was no clinical or plain radiological suspicion of abnormality.

Four observers who had been instructed as to the recognition of the C-sign and who were blinded to the CT findings, independently evaluated the 42 lateral radiographs on two separate occasions at least seven days apart. There were two consultant musculoskeletal radiologists, a musculoskeletal radiology fellow and an orthopaedic foot and ankle fellow.

On numbered proforma sheets, corresponding to the numbered radiographs, the observers were asked to indicate the presence or not of a C-sign by marking one of four responses: ‘yes’, ‘probably yes’, ‘no’ or ‘probably no’. If they indicated ‘yes’ or ‘probably yes’, they were asked to indicate whether the C-sign was clear or faint and whether it was narrow of the posterior subtalar joint space and failure to visualise the middle subtalar joint.

Radiographs showing a) the C-sign (clear/continuous) outlined by black arrowheads (with narrowing of the posterior subtalar joint space and failure to visualise the middle subtalar joint) and b) a normal lateral radiograph of the ankle for comparison.

Radiograph showing the C-sign (faint/continuous). There is a talar beak and blunting of the lateral talar process, as well as poorly visualised posterior and middle subtalar joint spaces.
continuous or interrupted (Figs 1 to 3). They were also asked to evaluate the presence, or otherwise, of three radiological signs which can be associated with tarsal coalition namely, a talar beak, narrowing of the posterior facet of the subtalar joint, and loss of the height of the longitudinal arch. Finally, the observers were asked to indicate whether the radiograph was normal (i.e., no coalition) or, if they thought TCC was present, whether it was fibrous or bony.

In analysing the results we first used a two-way analysis of variance, to check for significant differences between the observers’ responses (no observer effect, i.e., elimination of chance) or between the two sets of observations which each observer made (replication effect). Since there were no significant differences, we combined the two sets of observations for subsequent analysis in order to increase the numbers and thus improve the stability of any findings. Also, for the purpose of analysis, ‘yes’ and ‘probably yes’, and ‘no’ and ‘probably no’ responses, were treated as a single-positive and single-negative group, respectively.

With the 95% confidence interval (CI) and using the CT findings as the comparator. We then calculated the sensitivity, specificity, accuracy and positive and negative predictive values not only for the C-sign itself, but also for the other signs known to be associated with TCC. Similarly, with the 95% CI, we also calculated the interobserver and intraobserver reliability for all these signs in terms of the κ statistic. Agreement was defined as almost perfect when $\kappa$ was 1.0 to 0.81, good when $\kappa$ was 0.8 to 0.61, moderate when $\kappa$ was 0.6 to 0.41, fair when $\kappa$ was 0.4 to 0.21 and poor when $\kappa$ was < 0.20.

### Results

Review of the CT scans of the 20 clinically abnormal hindfeet with suspected TCC showed that one of these was normal. Twelve have bony talocalcaneal coalitions and all were medial subtalar. Sensitivity for the C-sign was 0.98, within very narrow confidence intervals (95% CI 0.82 to 1.00), and much higher than for the other signs (Table I). Specificity was similarly very high at 0.98 (0.84 to 1.00), although other signs also had quite high specificity values (Table I). Positive and negative predictive values, as well as accuracy, were also very high, especially when compared with those of the other signs and with their significantly wider confidence intervals (Tables II and III).

Intraobserver reliability for recognition of the C-sign showed nearly perfect agreement ($\kappa$ 0.99; 0.96 to 1.00), whereas for the other signs it was merely good (Table IV). Similarly, interobserver reliability for the C-sign also showed nearly perfect agreement ($\kappa$ 0.94, 0.91 to 0.97), whereas for the other signs studied it decreased to good or even moderate (Table IV).

### Discussion

Tarsal coalition is a condition characterised by a restriction or absence of movement of the hindfoot, secondary to an abnormal union between two or more bones at this site or, less commonly, the midfoot. Coalitions may be cartilaginous (synchondrosis), fibrous (syndesmosis), or bony (syndostosis) and the condition may be congenital or acquired. The overall prevalence of tarsal coalition in the general population is reported to be about 1%. Since many coalitions remain asymptomatic in life, however, the actual figure may be higher. Race does not appear to be significant and, of those affected, between 50% and 60% have the condition bilaterally. The relative incidence of the two most common types is almost equal (talocalcaneal 48.1%, calcaneonavicular 43.6%), and together they account for most coalitions. Of the talocalcaneal coalitions, most

### Table I. The sensitivity and specificity of the radiological signs of TCC

<table>
<thead>
<tr>
<th>Radiological signs</th>
<th>Sensitivity</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
<th>Specificity</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-sign</td>
<td>0.98</td>
<td>0.82</td>
<td>1.00</td>
<td>0.98</td>
<td>0.84</td>
<td>1.00</td>
</tr>
<tr>
<td>Subtalar joint degenerative joint disease</td>
<td>0.63</td>
<td>0.50</td>
<td>0.75</td>
<td>0.99</td>
<td>0.85</td>
<td>1.00</td>
</tr>
<tr>
<td>Talar beak</td>
<td>0.58</td>
<td>0.46</td>
<td>0.70</td>
<td>0.89</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>Flat arch</td>
<td>0.52</td>
<td>0.41</td>
<td>0.63</td>
<td>0.95</td>
<td>0.81</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### Table II. The predictive values of the radiological signs for TCC

<table>
<thead>
<tr>
<th>Radiological sign</th>
<th>Predictive value</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-sign</td>
<td>Positive</td>
<td>0.97</td>
<td>0.82</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>Subtalar joint degenerative joint disease</td>
<td>0.99</td>
<td>0.79</td>
<td>1.00</td>
<td>0.76</td>
<td>0.65</td>
</tr>
<tr>
<td>Talar beak</td>
<td>0.81</td>
<td>0.64</td>
<td>0.99</td>
<td>0.72</td>
<td>0.61</td>
</tr>
<tr>
<td>Flat arch</td>
<td>0.89</td>
<td>0.69</td>
<td>1.00</td>
<td>0.70</td>
<td>0.60</td>
</tr>
</tbody>
</table>
involve the middle facet; posterior and anterior facet subtalar coalitions are rare.

11,12 The C-sign, as described by Lateur et al 4 may be clear, faint or negative (i.e., false-negative) in TCC; it may also be continuous or interrupted.

A clear C-sign on a lateral radiograph of TCC (Fig. 1a) is due to the prominence of the inferior outline of the sustentaculum tali. This is caused by the more horizontal orientation of the inferior surface of the sustentaculum tali in TCC as opposed to the normal upward slope, resulting in attenuation of the x-ray beam as it passes through the posteroinferior aspect of the sustentaculum over a relatively long distance (Fig. 4). This effect is further exacerbated in the presence of pathological calcaneovalgus.

The C-sign may be faint in TCC in the presence of a hypoplastic sustentaculum tali (Figs 2 and 3). In such cases, the x-ray beam strikes the inferior surface of the hypoplastic sustentaculum over a shorter distance.

A C-sign, whether clear or faint, may be continuous or interrupted. In their review of 18 cases, Lateur et al 4 state
that interruption may occur in two situations: a) in radio-
lucent fibrous or cartilaginous TCC of the medial part of
the posterior subtalar joint which is parallel to the x-ray
beam; or b) in coalition of the middle subtalar joint without
involvement of the posterior part. Of our 19 cases, seven
were fibrous TCCs. We agree that interruption of the C-sign
does occur and there was indeed evidence that the obser-
vators in our study associated a clear and continuous C-sign
with the presence of a bony TCC; 93% of such cases were
classified by the observers as bony. However, there proved
to be no basis for the accuracy of this apparent relationship
when checked against the CT diagnosis of the type of TCC
(agreement of only \(\kappa = 0.12\)).

Lateur et al.\(^4\) describe both a false-negative and a false-
positive C-sign in TCC. The former may occur with aplasia
of the sustentaculum tali and they reported one such case in
an achondroplastic patient with TCC. A false-positive C-
sign can occur in severe cases of pes planovalgus without
TCC. In such cases, the severity of hindfoot valgus results
in the inferior surface of the sustentaculum tali presenting
horizontally to the lateral x-ray beam. Such cases can be
excluded from radiological suspicion of TCC, on the basis
of absence of any other primary or secondary signs of
coalition and the presence of a broad, clearly outlined
interruption of the C-sign at the level of the posteromedial
part of the dome of the talus, and the posterior part of the
sustentaculum tali.

Our findings generally support those of Lateur et al.\(^4\)
and strongly suggest that the C-sign is an easily recognisable,
accurate indicator of TCC. It appears to be significantly
more reliable than other previously recognised non-specific
signs of coalition. Features of the C-sign, however, cannot
be relied upon to indicate whether the TCC is of a bony or
fibrous type. Just as the ‘ant-eater nose’ sign\(^13\) on a lateral
radiograph of the foot can alert a clinician to the presence
of a calcaneonavicular coalition, the C-sign is a reliable
indicator of a talocalcaneal coalition as the possible cause
of hindfoot pain and/or ‘instability’, thus prompting ap-
propriate further investigation.

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.

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