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A novel tool for measuring ankle dorsiflexion: A study of its reliability in patients following ankle fractures

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ABSTRACT

Background: Assessment of ankle joint movement in a weight bearing position has important clinical implications. The lunge ankle dorsiflexion measurement device (LAD) has been developed with the aim of facilitating ease of and standardisation of the measurement of ankle joint movement. The literature lacks studies evaluating the reliability of weight bearing measurements of the ankle joint in study groups with ankle disabilities. The objective of this study was to examine the intra- and inter-tester reliability of ankle dorsiflexion measured with the novel LAD in patients following a fracture of the ankle.
Method: This study was a randomized intra- and inter-tester reliability study with blinding of testers and participants. All participants were tested twice by each tester, with the order of testers randomized. The intra- and inter-tester reliability was assessed by the calculation of interclass correlation coefficients (ICC).
Results: The study sample consisted of 24 patients: 15 females and nine males post-immobilisation following surgery for ankle fractures. The mean age was 51.0 years, ranging from 22 to 92 years. All patients had sustained an AO classification 44- fracture of the ankle. The mean follow-up time was 9.3 months (16.2 SD) after the time of fracture. The inter-tester reliability was high, with an ICC of 0.984 (95%CI: 0.963–0.993) and SE_{meas} of 0.14 cm. The ICC for Tester A was 0.989 (95%CI: 0.974–0.995) and SE_{meas} 0.10 cm. The ICC for Tester B was 0.990 (95%CI: 0.977–0.996) and SE_{meas} 0.09 cm.
Conclusion: This study shows a high inter- and intra-tester reliability for measuring ankle dorsiflexion with the LAD following a fracture of the ankle.

1. Background

Measurement of ankle dorsiflexion is critical in quantifying physical impairment and guiding treatment [1]. Ideally it should be measured in a weight bearing position, as that is where it impacts function most [2]. Ankle dorsiflexion in weight bearing has been measured with a highly reliable weight bearing lunge test against a wall [3], which is the horizontal linear distance between the front of the knee touching a wall (the datum) and the tip of the longest toe. Whilst this is reliable, from clinical experience it often is difficult and time consuming to repeatedly position the patient correctly. In order to facilitate easier application of this measure, a lunge ankle dorsiflexion measurement device (LAD), has been devised (Fig. 1). This device overcomes the issues confronted when measuring ankle dorsiflexion against a wall, by essentially fixing the foot (at the tip of the longest toe) at the wall datum and then allowing the knee to move forward until the point at which the heel is about to separate from the floor.

Fractures of the ankle are one of the most common bone injuries [4] with the incidence reported to be between 107 and 187 per 100,000 persons each year in Europe [5,6]. Younger males and older females are more likely to fracture the ankle [7]. The management of ankle fractures involves immobilisation in a cast or surgical treatment with internal or external fixation of the fracture,

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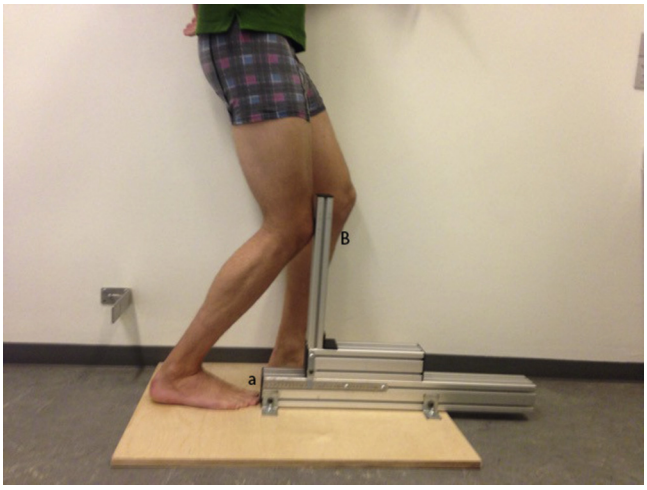

Fig. 1. The test procedure, showing the (a) fixed datum adjacent the toe and (b) the measurement indicator at the anterior knee.

increasing the likelihood of leaving the patient with ankle joint stiffness, pain and limitation in activity [8]. Dorsiflexion is commonly limited after ankle fracture [9] and impacts substantially on walking gait stride and speed, and on landing tasks [10]. Limited dorsiflexion is also a risk factor for injury in active individuals (e.g. ankle sprain, tibial stress fractures, anterior cruciate ligament, Achilles and patellar tendinopathy) [11–15].

Currently there are no studies of the reliability of weight bearing ankle dorsiflexion measurements in patients following ankle fracture. The objective of this study was to examine the intra- and inter-tester reliability of ankle dorsiflexion measured with the LAD in patients following ankle fracture.

2. Method

This study was a randomized intra- and inter-tester reliability study with blinding of testers and participants. The study was conducted in agreement with the principles of the Declaration of Helsinki and approved by the local ethics committee in North Denmark Region and the Danish Data Protection Agency J.Nr.: 2008-58-0028. All patients provided signed informed consent forms prior to their participation. The study was conducted in November 2014 at the Department of Occupational Therapy and Physiotherapy, Aalborg University Hospital, Denmark. The patients were recruited from the outpatient clinic at the Department of Orthopaedic Surgery, Aalborg University Hospital, Denmark.

A group of 29 patients with ankle fractures were recruited to participate in the study. The inclusion criteria were: 18+ years of age and recent fracture of the ankle (AO [16] classification 44-), which, upon X-ray, was presented with union. Patients with major comorbidities, neurological illness, amputation of the lower extremity, Pilon fracture, bilateral fractures of the ankle or those who were unable to participate in the test procedure due to pain, physical or mental illness were excluded from the study.

2.1. The lunge ankle dorsiflexion measurement device (LAD)

The LAD was developed to overcome the time and attention to multiple details required in achieving maximum weight bearing ankle dorsiflexion by adjusting and readjusting the position of the foot whilst maintaining it perpendicular to the wall (the datum) with the front of the knee touching that wall in order to ensure that maximum dorsiflexion was achieved with the heel remaining in contact with the floor. The LAD was designed with only one degree of freedom of motion in the sagittal plane, with the patient maintaining the foot (toe) in contact with the datum whilst the knee moved the measurement indicator forward (Fig. 1). The therapist needed only focus on ensuring that the heel maintained contact with the floor. Linear measurement of horizontal distance between anterior knee and the fixed datum at longest toe is read from a ruler (mm calibrated).

2.2. Test procedures

Three physiotherapy students were involved in testing, two performed the test procedure but did not read the measurement and were not present in the room when the other performed the procedure. All measurements on the ruler of the LAD were read by one student. In this way the two testers were blind to the actual measurement. All testers were previously naive to using the device and the test procedure. Before the start of the study, one day of clinical practice with the test procedure was performed on volunteers who were not included in the study population.

The participants were tested in a standing position. The lower limb with the injured ankle was positioned on the LAD with the foot aligned along a longitudinal line between the second and third toes, and the middle of the heel on the line. The non-injured lower limb was placed with the foot ahead of the test ankle. The middle of the patella was aligned to touch a centre line on the vertical portion of the measurement indicator. Patients were allowed to finger tip touch a wall to maintain balance if needed (Fig. 1).

The patient was instructed to bring their weight forward over the foot, pushing the measurement indicator forward with just the front of the knee keeping the middle of the patella and foot on the centre lines. No rotation of the pelvis or foot was allowed. The patients were asked to stop the movement when the heel was about to rise from the floor, which was evaluated visually by the tester and the distance travelled by the measurement indicator recorded. In accordance with the randomisation procedure, the next test began following a rest of one minute.

All patients were tested twice by each tester, with the tester order randomized. Both patients and testers were blinded to all test results throughout the test procedure.

3. Statistical analysis

The assumption of a normal distribution in variables was checked visually by QQ-plots. Continuous data were expressed as means and standard deviations (SD). Categorical data were expressed as frequencies. The intra- and inter-tester reliability was assessed by the calculation of interclass correlation coefficients (ICC), and 95%CI is given. ICC values were interpreted as: 0.0–0.3 low; 0.30–0.70 moderate; 0.70–1.0 high [17]. The standard error of the measurements was calculated using the ICC as $(SE_{meas}) = SD \times \sqrt{1 - ICC}$, and 95%CI is given. A repeated measurement of variance (RM-ANOVA) was used to analyse the difference between tests.

The statistical analysis was performed using SPSS (version 22).

4. Results

Twenty-nine patients were included in the study sample. Five patients were excluded due to the exclusion criteria; two patients were excluded due to pain, one patient due to age, one patient due to lack of co-operation and one patient due to no ankle movement. All besides the patient excluded due to age were excluded during the test procedure. Thus, the study sample consisted of 24 patients: 15 females and nine males. The mean age was 51.0 (range, 22–92) years. The mean height was 171 cm (SD 7.6), and the mean weight was 78 kg (SD 18.8). All patients had sustained an AO classification

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