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# A new approach for the pistoning measurement in transtibial prosthesis

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## Background

The lower limb prosthesis's efficiency is mainly guaranteed by its optimal suspension in order to secure the socket to the amputee's stump. Suspension and fitting have main roles in the patient's comfort and prosthetic function.[1-6] According to the amputees, the most important factor in every prosthesis is the fit of their prosthesis and suspension.[7-9] Pistoning or vertical movement[10] of the residual limb inside the prosthetic socket is said to be one of the major indications of successful or unsuccessful suspension in lower limb prosthesis.[11] Also, prosthetic fitting had been shown to be correlated with pistoning.[11-14] Thus, measuring the pistoning would be helpful in determining the optimal prosthetic fit and suspension.[13,15] Ideally, each prosthetist should be able to measure the pistoning in order to enhance the suspension and prosthetic fit. Several methods have been used to measure pistoning movement in different levels. The movement can be either between the hard socket and the liner, between the liner and the skin, or the skin and the bone.[14] Radiological methods include roentgenology,[16-18] cineradiography,[11,19,20] and roentgen stereophotogrammetric analysis.[18] Ultrasonic methods or transducers have also been used to record the pistoning or displacement inside the socket.[21-23] However, these methods require complicated devices and settings[24] and it is not possible for every rehabilitation clinic to provide such costly imaging systems. Even if the amputee is referred to an imaging centre, there might still be a risk of repeated exposure to the X-ray.[14,25] Therefore, these studies have been mostly limited to the laboratory and could not be used clinically.

The objective of this study was to introduce and assess a new method for measuring the pistoning within the socket, designed and developed in-house at Össur (Reykjavik, Iceland) for the first time.

## Methods

### *Subjects*

Five male unilateral transtibial amputees (average age 45 ± 7.3), with the mobility grade K3 (based on the American Academy of Orthotists and Prosthetists) participated in this study (Table 1). Ethical approval was granted from the University of Malaya Medical Centre (UMMC) Ethics Committee. Five transtibial prostheses with silicon liner and shuttle lock were made by one prosthetist to avoid variability due to manufacture, fitting and alignment factors. The subjects were required to complete five static trials for five different static conditions to simulate the gait, including single limb support on the prosthetic limb (full weight bearing), off-loading the prosthetic limb (non-weight bearing), and three different axial loading. Loads of 30, 60 and 90 N were added to the prosthetic foot. Average value was used for the analysis.

### *Technique for measuring the pistoning*

To identify the pistoning movement inside the prosthetic socket with this new method we used the following equipments:

-30, 60 and 90 N loads;
-a high-resolution camera (Sony A, alpha, DSLR-A200K, 3,872 x 2,592 dpi);

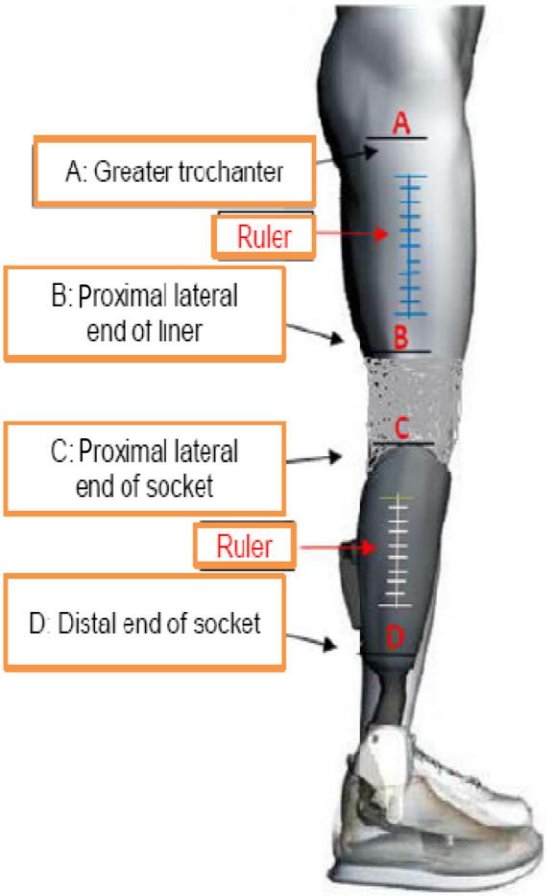


**Figure 1.** Position of markers and rulers

-two reference rulers (with known length of 100 mm) attached to the lateral side of the limb and the socket (Figure 1) as a reference to measure the real displacement on the photos;

- markers on the following positions (Figure 2): greater trochanter (A), proximal lateral end of the liner (B), proximal lateral end of the socket (C), distal end of the socket (D).

The ruler attached to the limb (thigh) was used as a measuring reference for the markers A and B, and the other ruler was used as measurement reference for the markers C and D.

In each of the five conditions below, we took a photo from a fixed distance using a photo stand. The photos were taken so that the markers and the reference rulers could be seen clearly, and were not at an angle from the stand:

Full text is available at :

**http://poi.sagepub.com/content/35/4/360.full.pdf**

**http://www.ncbi.nlm.nih.gov/pubmed/21975850**