Assessment of Muscle Atrophy in Knee Arthroplasty patients using Dynamic Ultrasound Imaging.

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Introduction
The size of muscles vary, in health and disease and this has been shown to influence the strength of a muscle. Patients who have undergone total knee arthroplasty (TKA) have been shown to have decreased strength both pre- and post surgery, with a direct effect on function. Current methods of assessing strength in TKA patients include isokinetic dynamometry, with the burst superimposition technique [1] but this method of assessing strength can be both uncomfortable and poses stresses on the knee joint.

In recent years Ultrasound Imaging (USI) technology has developed to a stage where it has found widespread application and can offer a safe, objective and relatively inexpensive means of examining the musculoskeletal system [2]. USI has been applied to study differences between normal and weak muscles [3]. Previous studies have also utilized this modality to show how changes in the shape of muscle can relate to the percentage changes in maximal voluntary contraction [4]. This study used USI to assess muscle size in both relaxed and contracted conditions in a cohort of post-operative TKA patients and an age matched healthy control group. It is hypothesized that the knee with a TKA will exhibit signs of muscle atrophy and reduced contractibility during the imaging analysis process.

Methods
Eight total knee arthroplasty patients (5 female, 3 male, mean; age 67 (range 56-75), weight 85.3kg (range 64-103)), were recruited from Southampton General Hospital, at an average of 5.75 months post-operation. Eight healthy control participants were recruited from the community (5 female, 3 male, mean; age 66 (range 60-79), weight 75.3kg (range 53-93)). Both Nation Health Service (NHS) and institutional ethics was approved for the data collection, informed consent was obtained by all participants pre-testing. The rectus femoris (RF) muscle was imaged in a supine position with the knee extended, images were taken at 1/2 distance distally from the greater trochanter to the lateral joint line of the knee in the sagittal plane (Figure 1). Patients were imaged whilst relaxed, and then again when asked to maximally contract their thigh by pushing the back of their knee into the plinth. Both operated and non-operated limbs were imaged for the TKA group.

Figure 1. USI of rectus femoris at rest, with linear measurements of muscle depth and width indicated by white arrows

USI was conducted with a Pie Medical ‘Aquila’ ultrasound scanner (ESAOTE S.p.A. Genova, Italy) with a 6.0 MHz linear transducer (60mm footprint) by an experienced USI operator (PW). Measurements of RF were made using ImageJ software. Depth of RF was measured between the inside edges of its superior and inferior borders. Width was measured at the mid-point of depth, between the two lateral borders, and CSA was measured by tracing round the circumference of the inside of the fascia (Figure 1). The mean of two measures for each dimension was taken for each scan and then the mean of the 2 images taken for each condition were used in the analysis.

Means and standard deviations were calculated for RF width, depth, and CSA. Percentage change in RF width was also calculated, from relaxed and contracted muscle conditions. Paired T-test were used to compare between operated and non-operated limbs, as well as the controls group data.

Results
Preliminary results from the 16 participants showed the control group had a larger mean muscle depth, width and CSA to those in the TKA group (Figure 2).

There was very little mean difference in width (0.05cm, SD = 0.19) and depth (-0.07cm, SD = 0.26) between the operated and non-operated limbs, however there was a difference in CSA (mean difference 0.97cm², SD = 0.32), with all of the TKA patients having smaller CSA in the operated limb p<0.05. There was also a difference for percentage change in RF width during contraction, with a reduction of 19.6%, in the operated limb and 23.1% in the non-operated limb (control group 21.3%), p<0.05.

Discussion
Preliminary results show that knee arthroplasty patients have smaller RF dimensions bilaterally when compared to an age and sex matched control group. There was also a small difference in CSA between operated and non-operated muscles in all TKA subjects supporting the theory of muscle atrophy post TKA. There was also a reduction in the patients’ percentage change of muscle dimensions under maximal contractions, supporting the theory of reduced contractibility post operation and the dynamic use of USI to detect this impairment. This finding substantiates previous research in healthy subjects, which suggested that a person's ability to produce a maximal voluntary contraction was related to changes in the RF width dimension [4]. These preliminary results must be put into the context of the sample size, and the large standard deviations across the results, giving low significance scores. Further research is needed to provide more robust statistical evidence base of the observed differences in muscle architecture.

USI is a relatively inexpensive and objective way to assess muscle architecture at rest and during contraction, and this proposed method of assessing muscle function is fast and non-strenuous. Results from the application of USI support the previous evidence base that TKA patients have muscle atrophy and reduced contractibility post-operation [1].

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References