Three-dimensional Measurement Of The Muscle Volume And The Fatty Degeneration Of The Gluteus Medius In Patients With Hip Osteoarthritis

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Introduction: Abduction muscle strength is important for gait and hip biomechanics. Abductor dysfunction often occurs and leads to joint instability and a loss of pelvic control with an impaired ability to walk in patients with osteoarthritis (OA) of the hip. The gluteus medius (GM) is the main muscle in the hip abductor muscle group. Computed tomography (CT) has been used to assess muscle volume in the trunk and around the hip. Cross-sectional area is often used to evaluate the muscle volume, however, three-dimensional analysis would be more precise. The purpose of our study is to characterize the GM muscle abnormalities in patients with hip osteoarthritis by measuring the muscle volume and the fatty degeneration using three-dimensional image analysis software. The correlation between the muscle strength of the hip abductor and the muscle volume or the fatty degeneration of the GM are also examined.

Methods: We investigated 50 patients (12 male and 38 female) with unilateral osteoarthritis of the hip scheduled for primary total hip arthroplasty between April 2012 and 2014. The overall average age of the patients was 62 years (range, 30-82 years), the mean body weight was 57 kg (range, 35-89 kg), and the mean height was 156 cm (range, 140-173 cm). The mean symptom duration was 9 years (range, 0.5-45 years).

Preoperative CT data of 50 patients was used for measuring the muscle volume of the bilateral GM. The CT data was analyzed using Synapse Vincent® (Fujifilm medical systems, Japan). (Figure 1)
Results: The muscle volume of the GM on the affected side was smaller than the contralateral healthy side in all patients. The average ratio of the muscle volume on the affected side to that on the healthy side was 79.4 % (range, 48-99 %). The amount of HA in the GM on the affected side was significantly smaller than on the healthy side. The average ratio of the amount of HA in the GM on the affected side to the healthy side was 76.5 % (range, 11-110 %). This indicates that the fatty degeneration of the GM in the OA limb was more severe than the healthy side. The muscle strength of the hip abductor on the affected side was lower and the average ratio of the muscle strength of the hip abductor on the affected side to the healthy side was 69.9 % (range, 32-104 %). (Table 1)  
Table 1. Mean values, percentage differences and p-values for muscle volume of the GM, amount of hydroxyapatite (HA) of the GM and muscle strength of hip abductor in healthy limbs compared to affected side in 50 patients with unilateral hip OA
The muscle strength of the hip abductor and the muscle volume of the GM had strong positive correlation ($r=0.70$, $p<0.001$). The muscle strength of the hip abductor also correlated significantly with the amount of HA in the GM ($r=0.55$, $p<0.001$) and the HHS pain score ($r=0.46$, $p<0.001$). (Figure 2)

**Figure 2.**

**Discussion:** Measurements of the muscle cross-sectional area (CSA) using MRI or CT images are often reported because it is simple and easy to assess the muscle volume. However, there are many variations in the shape of the muscle, so three-dimensional analysis would be more precise. In addition, there were some reports that compared the muscular strength with CSA, but there are few reports that compared the muscle volume with muscular strength. To evaluate the fatty degeneration of the muscle, correcting the CT value using a phantom should be needed.

In the present study, we performed three-dimensional analysis of the muscle volume and the fatty degeneration from the corrected CT value using a phantom. The muscle strength of the hip abductor correlated with not only the muscle volume of the GM but also the fatty degeneration of the GM and hip joint pain in patients with hip osteoarthritis. Three-dimensional measurements of muscle volume and fatty degeneration may be an useful tool for evaluation of muscle function.

**Significance:** In this study, a loss of muscle strength of the hip abductor, a substantial loss of the muscle volume and a severe fatty degeneration of the gluteus medius were showed in patients with unilateral hip osteoarthritis. The muscle strength of the hip abductor correlated with not only the muscle volume of the GM but also the fatty degeneration of the GM and hip joint pain.

**ORS 2015 Annual Meeting**
Paper No: 0014