ARE 2D MEASUREMENTS OF MUSCLE ATROPHY AND DEGENERATION VALID IN PATIENTS WITH HIP DISEASE?

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INTRODUCTION

Analyzing muscle atrophy and degeneration is important to establish rehabilitation programs for patients with hip diseases. Muscle atrophy and degeneration around the hip joint have been evaluated two-dimensionally (2D) using computer tomography (CT) or magnetic resonance imaging (Inacio 2014; Arokoski 2002; Suetta 2007). The conventional 2D method using CT images assesses cross sectional areas and the radiographic density of each muscle on transverse planes defined by anatomical bony landmarks. However, how muscle atrophy and degeneration measured in 2D reflect those measured three-dimensionally (3D) is unclear. The present study aimed to determine correlations between 2D and 3D measurements of muscle atrophy and degeneration around the pelvis and thighs of patients with unilateral hip diseases using CT images.

MATERIALS AND METHODS

We assessed preoperative CT images from the superior iliac edge to the knee joints of 20 patients who underwent total hip arthroplasty to treat unilateral hip disease. Fourteen muscles on the healthy and affected sides were extracted from the images using semi-automated segmentation methods and then these muscles were manually modified. Both the healthy and affected sides were assessed and the ratio for the amount of muscle between them was calculated as 3D measurements of muscle atrophy. The differences of radiographic density between them were also calculated as 3D measurements of muscle degeneration. Cross-sectional ratios of affected to unaffected sides were calculated for the amount of muscle as 2D measurements of muscle atrophy, and differences between them were assessed based on the radiographic density of cross-sections as 2D measurements of muscle degeneration. At first, the following muscles were measured at each bony landmark: the anterior superior iliac spine for the gluteus medius, gluteus minimus, iliacus and psoas major; the tip of the great trochanter for the gluteus, the lesser trochanter for the tensor fasciae latae and pectineus, and the middle of the femur for the adductors, biceps femoris, rectus femoris, semi-membranosus, semi-tendinosus, vastus lateralis/intermedius and vastus medialis. In addition, two-dimensional measurements were taken at 1-cm intervals from anatomical bony landmarks to investigate the transverse plane where 2D measurements show the highest correlation with 3D measurements. The radiographic density of the segmented muscle area is described as averaged Hounsfield units (HU).

We initially evaluated correlation coefficients between 2D and 3D measurements of muscle amount and averaged radiographic density using Pearson’s correlation coefficient. Correlation coefficients > 0.7 was set to be substantial. Next, the cross-sectional level with the closest correlation with the 3D measurement was identified.

RESULTS

Seven (50%) muscles had correlation coefficients of > 0.7 between the 2D and 3D measurements of the ratio of the affected to the healthy side at the anatomical bony landmarks (Table 1). Changes in cross-sectional levels from landmarks improved coefficient correlations of > 0.7 in all muscles (Table 2). The gluteus medius, iliacus, and pectineus had the highest cross-sectional correlation with 3D measurements at anatomical bony landmarks. The cross-sections of remaining muscles differed from landmarks. The mean required translation of a cross-sectional level from a bony landmark was 5.5 (range, 2 – 12) cm.

The radiographic density showed that twelve (86%) muscles had correlation coefficients of > 0.7 between 2D and 3D measurements of the affected and unaffected sides (Table 1). Correlations between 3D measurements were close at any cross-sectional level in all muscles (Table 2). The cross-sectional levels of the gluteus minimus, pectineus, and semi-tendinosus had the closest correlation with reference to bony landmarks when determined from 3D measurements. The cross-sectional levels of other muscles had to be changed to gain the closest correlation with 3D measurements. The mean required translation of cross sectional levels from landmarks was 4.3 (1 – 9) cm.

DISCUSSION

The correlation coefficient for the ratios of the affected, to the healthy side between 2D and 3D measurements was > 0.7 in half of all muscles measured at anatomical bony landmarks. Muscle cross-sections most affected by muscle volume determined using 3D measurements required a maximal translation of 12 cm from landmarks. Considering these results, muscle amounts analyzed using 2D measurements were limited and appropriate cross-sections had to be determined. There have been few studies regarding muscle atrophy and degeneration of patients with hip dieaseas. Rasch et al (Rasch 2007;

Rasch 2009) reported that patients with hip joint diseases showed no muscle atrophy in gluteus medius and minimus using 2D measurements. This results contradict with general knowledge that hip joint patients have abduction muscle weakness resulting in limping. This contradiction might be caused by 2D measurement error.

When muscle degeneration was evaluated using radiographic density, correlations between 2D and 3D measurements were close in 12 of 14 muscles with a difference between the affected and unaffected sides. Decrease of radiographic density reflected fat degerenation of muscle tissues. We consider that these results indicated that fat degeneration occurs uniformly in the muscles.

CONCLUSIONS

2D measurements of muscle atrophy on each anatomical landmark plane does not correlate well with 3D measurements in half of the muscles of patients with unilateral hip diseases. The positions of transverse planes must be changed to maximize correlations. On the other hand, it was possible to evaluate muscle degeneration with 2D measurements on the anatomical landmark planes in 86% of the muscles.

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DISCLOSURES

The author has no financial conflicts of interest to disclose concerning the presentation.

Table1. Correlation coefficient between 2D and 3D measurements at the anatomical bony landmarks

Muscle	Anatomical landmark	CC (Amount)	CC (Density)
Gluteus medius	ASIS	0.808*	0.937*
Gluteus minimus	ASIS	0.339	0.876*
Iliacus	ASIS	0.842*	0.665
Psoas major	ASIS	0.613	0.93*
Gluteus maximus	GT	0.638	0.935*
Tensor fasiae latae	LT	0.442	0.747*
Pectineus	LT	0.836*	0.914*
Adductor	Mid-F	0.919*	0.85*
Biceps femoris	Mid-F	0.554	0.68
Rectus femoris	Mid-F	0.894*	0.801*
Semi-membranosus	Mid-F	0.662	0.922*
Semi-tendinosus	Mid-F	0.661	0.78*
Vastus intermedius and lateralis	Mid-F	0.795*	0.91*
Vastus medialis	Mid-F	0.745*	0.751*

ASIS:anterior superior iliac spine
GT:tip of great trochanter
LT:lesser trochanter
Mid-F:middle of femur
CC:correlation coefficient
* : Correlation coefficient > 0.7

Table2. The mean required translation of a cross-sectional level from a bony landmark : highest correlation between 2D and 3D measurements

Muscle	Anatomical landmark	Size		Density	
		Translation (cm)	CC	Translation (cm)	CC
Gluteus medius	ASIS	0	0.808	-1	0.967
Gluteus minimus	ASIS	-2	0.878	0	0.867
Iliacus	ASIS	0	0.842	-9	0.888
Psoas major	ASIS	3	0.963	-4	0.964
Gluteus maximus	GT	-5	0.815	2	0.95
Tensor fasiae latae	LT	3	0.8	4	0.868
Pectineus	LT	0	0.836	0	0.914
Adductor	Mid-F	5	0.982	7	0.968
Biceps femoris	Mid-F	-3	0.839	-4	0.838
Rectus femoris	Mid-F	12	0.939	4	0.944
Semi-membranosus	Mid-F	-10	0.96	-5	0.931
Semi-tendinosus	Mid-F	-6	0.836	0	0.78
Vastus intermedius and lateralis	Mid-F	4	0.92	2	0.932
Vastus medialis	Mid-F	-7	0.818	-5	0.887

ASIS:anterior superior iliac spine
GT:tip of great trochanter
LT:lesser trochanter
Mid-F:middle of femur
CC:correlation coefficient