The intra-rater reliability of the supraspinatus cross-sectional area measurement using diagnostic ultrasound

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Abstract

The purpose of this study was to determine the intra-rater reliability between-scans and between-days on measurements of the supraspinatus cross-sectional area of using diagnostic ultrasound. The subjects were five male volunteers(age range:19-23 years old). The diagnostic ultrasound images were acquired using the same 7.5MHz real time probe with an Aloka Echo Camera SSD-1000 system to all subjects. The section through the midpoint of the scapular spine was observed. Right shoulders were measured three times on the same day for between scan reliability and one time on the next day for between days reliability. The reliability of measuring the CSA of the supraspinatus using diagnostic ultrasound was high in this study. The intraclass correlation coefficients of this study were 0.83 for between three scans and 0.81 for between days. These findings support that the CSA of the supraspinatus can be used as a reliable clinical parameter if the examiner has experience in using diagnostic ultrasound.

Key words：Supraspinatus, Cross-sectional Area, Diagnostic ultrasound, Measurement reliability

Introduction

Researchers have observed the supraspinatus muscle atrophy as a result of several clinical conditions, such as rotator cuff tears, neuropathy due to ganglions, overstress of the musclotendinosus unit from throwing and ischemic conditions in specific positions, and exercises[18, 19, 30]. As well, they have observed that the supraspinatus muscle atrophy has been induced by aging[19]. All of these studies employed magnetic resonance image (MRI) and computed tomography (CT) to evaluate the supraspinatus muscle atrophy.

The methods of acquiring a diagnostic image to perform the anatomical and morphological studies of muscle are considered to be MRI, CT, and diagnostic ultrasound. MRI is not an invasive technique and is reported to be the best way to get clear images of body soft tissue[16, 25]. Many of the anatomical and morphological studies for muscle such as quadriceps have been done using MRI [1, 6, 9, 11, 12, 15, 20, 21, 30, 31]. However, MRI is an expensive and time consuming examination. Although CT requires less examination time than MRI, it is an "invasive" technique in that potentially harmful x-rays are used. Thus, both of them are not an ideal examination techniques for muscle morphology in repeatable and following-up situations. In contrast, diagnostic ultrasound is noninvasive, inexpensive, and simple in application.

Diagnostic ultrasound does have some detractors concerning hardware and application difficulties: clearness of image, the reliability of understanding what is being seen and the image limited by the size of

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the examination probe. Diagnostic ultrasound can not "see" the image behind high echo reflective tissue such as bone. However, recent studies have reported its usefulness in assisting clinical management in certain areas through technological innovation, such as high resolution probes, multiple focus system, and computer image analysis [2-5,8,23,29,32]. Other studies also demonstrated the clinical usage of diagnostic ultrasound for anatomical and morphological evaluation of muscle. In these studies, the quadriceps femoris, the tibialis anterior, and the multifidus were selected as target muscles [10,17,26-28,31,33]. All of these muscles are located in front of the bone and close to skin. Of the rotator cuff muscles of the shoulder, the supraspinatus can meet these characteristics as a target muscle. It has an adequate muscle size for the diagnostic ultrasound probe, is in front of the bone tissue, and is close to the skin.

Diagnostic ultrasound may be one of the applicable tools for isolated measurement of muscle atrophy of the supraspinatus. Cross sectional area (CSA) has been used to determine the presence of the supraspinatus muscle atrophy [13,19]. The purpose of this study was to determine the intra-rater reliability between-scans and between-days on measurements of the supraspinatus cross-sectional area of using diagnostic ultrasound.

Materials and Methods

Subjects

The subjects were five male volunteers (age range:19 - 23 years old). They were recruited from students at Sapporo Medical University, using verbal contact following a circular and project information letter. Once the subject agreed to participate in this study and had been examined to determine if he was qualified, he was introduced an informed consent to read and sign. Subjects who did not have any clinical symptoms in their shoulder were considered for selection. All subjects were assured that they could drop out any time without consequence and that all information gained would be confidential.

Measurement of CSA

The diagnostic ultrasound images were acquired using the same 7.5MHz real time probe with an Aloka Echo Camera SSD-1000 system to all subjects. The system was provided by the Aloka Co. Japan in this research project. Identical probe and system were utilized in all measurements in this study.

Subjects were asked to undress to the waist for measurement. Subjects were examined in the sitting position on a chair, and the shoulder was stabilized in neutral position, with the shoulder flexed and abducted at zero degrees (arm placed the side) with the palm facing inward. The section through the midpoint of the scapular spine was observed. The midpoint of the scapular was determined using a metal tape measuring from the posterior edge of the acromion to the medial edge of the scapular spine at the medial border of the scapula. The probe was set on the surface of the supraspinatus at this midpoint of the scapular spine at the appropriate angle (range from 30 to 40 degrees) for observing the supraspinatus. Measurement of the image was observed with B-mode imaging to get the fixed slice angle for each subject based on the anatomical structure of the spine of the scapula. The B-mode demonstrates the image of the sliced cross section of the muscle on the plane perpendicular to the

Figure1 : B-mode image of the supraspinatus in diagnostic ultrasound

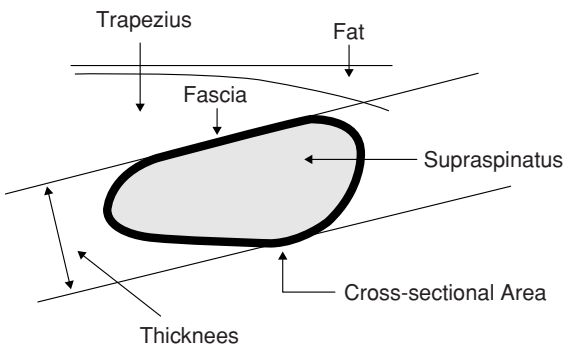

Figure 2 : Cross-sectional area of the supraspinatus

floor of the supra-scapular fossa.

These analog image data observed from B-mode were converted to the digital image data as TIFF image data format, and stored on a Macintosh computer (Model G3 450MHz). Measurement of CSA from these digital image data were analyzed on the Macintosh computer using the NIH Image program which is the public domain image processing and analysis program (developed at the U.S. National Institutes of Health and available on the internet at http://rsb.info.nih.gov/nih-image/). The measurement of CSA was taken using a square centimeter scale to two decimal points.

Right shoulders were measured three times on the same day for between scan reliability and one time on the next day for between days reliability. The intraclass correlation coefficients (ICCs) were calculated for the reliability between scans and between days. The ICC values were calculated using ICC macros on the SPSS World Wide Web site.

Results

The raw CSA data are shown in Table 1. The CSAs for all subjects combined of the supraspinatus muscle were between 6.11 cm^2 and 7.74 cm^2. Standard deviations of the four CSA measurements on each subject ranged from 0.15 cm^2 to 0.34 cm^2. The ICCs of this study were 0.83 for between three scans and 0.81 for between days (Table 2).

Discussion

Hide et al [10] demonstrated the validity of diagnostic ultrasound using the image of the lumbar multifidus.

Table 1
Cross-sectional area measurments of the supraspinatus (cm^2)

Subject	Day 1 Scan 1	Day 1 Scan 2	Day 1 Scan 3	Day 2 Scan 1	mean±SD of four scans
1	6.84	6.58	6.49	6.50	6.59±0.15
2	7.74	7.22	7.53	7.35	7.46±0.19
3	6.70	6.37	6.94	7.00	6.75±0.25
4	6.55	6.44	6.16	6.70	6.46±0.19
5	6.90	6.11	6.96	6.50	6.61±0.34

SD: Standard deviation

Table 2
Measurement reliability for cross-sectional area of the supraspinatus

	ICC
Between scans	0.83
Between days	0.81

ICC: intraclass correlation coefficient

There were no significant differences in the CSA measurements between diagnostic ultrasound and MRI. Studies which involve comparison of diagnostic ultrasound with CT scan support this result [7, 24].

The reliability of diagnostic ultrasound has also been shown in several studies [14, 17, 22]. Martinson and Stokes [17] assessed intra-rater reliability for measurement of the anterior tibial muscle CSA by analysis of the coefficient of variation. The coefficient of variation between measurements on two different days was 6.5 percent, and, that between the measurement of the two scans at same time was 3.6 percent. Kelly and Stokes [14] also reported the coefficient of variation of measurement of the anterior tibial muscle CSA. They stated a coefficient of variation of 2.0 percent between days and 2.3 percent between scans. Recently, Rankin and Stokes [22] stated the intraclass correlation coefficients and Bland Altman test for real time ultrasound for measuring muscle CSA as an appropriate reliability study method. They also reported inter-rater and intra-rater reliability. The intraclass correlation coefficient for inter-rater reliability was 0.92. The intraclass correlation coefficients between measurement scans on day 1 and day 2 were 0.94 and 0.93, respectively. The intraclass correlation coefficients between days was 0.92. The ICCs of this study were 0.83 for between three scans and 0.81 for between days. These values are similar to that reported by Rankin and Stokes [22] despite using a different target muscle.

In this study, it was decided to use slices perpendicular to the scapular spine which is the middle between the posterior edge of the acromion and medial edge of the scapular spine. This position is easy to determine clinically, because there were the medial edge of the scapular spine and the posterior edge of the scapular spine as clear landmarks.

Generally, the diagnostic ultrasound image does have

the problem of unclear image and depends on the skill of the examiner as reported in several papars [16, 27, 30]. However, the reliability of measuring the CSA of the supraspinatus using diagnostic ultrasound was high in this study. These findings support that the CSA of the supraspinatus can be used as a reliable clinical parameter if the examiner has experience in using diagnostic ultrasound.

This study was performed to establish the intra-rater reliability when looking at the supraspinatus muscle in the shoulder. According to results of the present study, it is possible for researchers to measure CSA of the supraspinatus muscle in various pathological conditions in future research.

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超音波診断画像による棘上筋断面積の測定再現性

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要　　旨

肩の様々な病態や、老化による棘上筋の萎縮が報告されている。棘上筋は肩関節の動的安定性に寄与する筋であり、この筋萎縮を検討することは臨床的に重要な指標となる。一般に筋の萎縮を測定するためにはMRI、CT、超音波画像を用いる方法がある。超音波画像はMRIやCTと比較して簡便に安全にくり返し検査を行うことができるが、画像を導出するプロ－ベの大きさや、対象となる組織の音響抵抗などに影響を受けて、鮮明な画像をくり返し導出することが難しいとされている。本研究の目的は、超音波画像を用いた棘上筋断面積計測の再現性を同一検査者がくり返して測定することにより検討することにある。健常成人男性５名の右肩棘上筋の断面像計測を同一日に３回、異なる日に１回行い、同一日の３回の測定における級内相関係数および異なる日のそれぞれ１回目の測定における級内相関係数を検討した。同一日の３回の測定間の級内相関係数は0.83、異なる日の測定間のそれは0.81であった。

＜索引用語＞棘上筋、断面積、超音波診断、測定再現性