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Intra- and Inter-Rater Reliability of Magnetic Resonance Imaging Measurements of Supraspinatus Muscle Thickness, Acromiohumeral Distance, and Coracohumeral Distance in Patients with Shoulder Pain

Omuz Ağrısı Olan Hastalarda Supraspinatus Kas Kalınlığı, Akromiohumeral Mesafe ve Korakohumeral Mesafenin Manyetik Rezonans Görüntüleme Ölçümlerinin Değerlendiriciler İçi ve Değerlendiriciler Arası Güvenilirliği

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ÖZET

Amaç: Bu çalışmada omuz ağrısında supraspinatus kas kalınlığı (SKK), akromiohumeral mesafe (AHM) ve korakohumeral mesafenin (KHM) değerlendirici içi ve değerlendiriciler arası güvenilirlik katsayılarının değerlendirilmesi amaçlanmaktadır.

Gereçler ve Yöntem: Bu retrospektif çalışma Ocak 2023 ile Ocak 2024 tarihleri arasında tek merkezde gerçekleştirildi. Çalışmaya omuz ağrısı olan 80 hasta dahil edildi. Supraspinatus kas kalınlığı, akromiohumeral mesafe ve korakohumeral mesafe, bir hafta arayla iki gözlemci tarafından elde edildi. Sınıf içi korelasyon katsayısı (ICC), minimum tespit edilebilir değişiklik ve standart ölçüm hatası hesaplandı.

Bulgular: Koronal kesitlerde değerlendirilen AHM değerlendirici içi güvenilirlik sonuçları mükemmeldi (Değerlendirici 1, ICC=0,96; %95 GA, 0,94-0,97; Değerlendirici 2 ICC=0,75; %95 GA, 0,61-0,84). Sagital kesitlerde değerlendirilen AHM değerlendirici içi güvenilirlik sonuçları mükemmeldi (Değerlendirici 1, ICC=0,94; %95 GA; 0,91-0,96; Değerlendirici 2 ICC=0,77; %95 GA, 0,64-0,85). Koronal kesitler kullanılarak ölçülen KHM sonuçları iyiydi (Değerlendirici 1, ICC=0,85; %95 GA, 0,76-0,90; Değerlendirici 2 ICC=0,82; %95 GA, 0,71-0,88). Koronal kesitler kullanılarak ölçülen SKK ölçüm sonuçları mükemmeldi (Değerlendirici 1, ICC=0,98; CI, 0,98-0,99; Değerlendirici 2, ICC=0,89; %95 CI, 0,82-0,93). Değerlendiriciler arası güvenilirlik değerleri AHM-Koronal (ICC= 0,75; %95 GA, 0,61-0,84) ve AHM-Sagital için (ICC=0,86; %95 GA, 0,79-0,91) iyi, koronal kesitlerde değerlendirilen KHM ölçümleri için orta (ICC=0,74; %95 GA, 0,58-0,83) ve koronal kesitlerde değerlendirilen SKK için mükemmeldi (ICC=0,92; %95 GA, 0,87-0,95).

Sonuç: Bu bulgular, supraspinatus kas kalınlığı, akromiohumeral mesafe ve korakohumeral mesafenin manyetik rezonans görüntüleme ölçümlerinin omuz ağrısı olan hastaların klinik değerlendirmesinde güvenilir ve tutarlı olabileceğini göstermektedir.

Anahtar Kelimeler: Güvenilirlik, omuz ölçümü, manyetik rezonans görüntüleme

ABSTRACT

Aim: The aim of this study was to evaluate the intra- and inter-rater reliability coefficients of the supraspinatus muscle thickness (SMT), acromiohumeral distance (AHD), and coracohumeral distance (CHD) in patients with shoulder pain.

Materials and Methods: This retrospective study included 80 patients who presented with complaints of shoulder pain at a single centre between January 2023 and January 2024. The supraspinatus muscle thickness, acromiohumeral distance, and coracohumeral distance measurements were obtained one week apart by two observers. The intraclass correlation coefficient (ICC), minimum detectable change, and standard error of measurement were subsequently calculated.

Results: AHD intra-rater reliability results evaluated on coronal sections were excellent (Rater 1, ICC=0.96; 95% CI, 0.94-0.97; Rater 2 ICC=0.75; 95% CI, 0.61-0.84). AHD intra-rater reliability results evaluated on sagittal sections were excellent (Rater 1, ICC=0.94; 95% CI; 0.91-0.96; Rater 2 ICC=0.77; 95% CI, 0.64-0.85). The results of CHD measured using coronal sections were good (Rater 1, ICC=0.85; 95% CI, 0.76-0.90; Rater 2 ICC=0.82; 95% CI, 0.71-0.88). SMT measurement results measured using coronal sections were excellent (Rater 1, ICC=0.98; CI, 0.98-0.99; Rater 2, ICC=0.89; 95% CI, 0.82-0.93).The inter-rater reliability values were good for AHD-Coronal (ICC= 0.75; 95% CI, 0.61-0.84) and AHD-Sagittal (ICC=0.86; 95% CI, 0.79-0.91), were fair for CHD evaluated on coronal sections (ICC=0.74; %95 CI, 0.58-0.83), and were excellent for SMT evaluated on coronal sections (ICC=0.92; 95% CI, 0.87-0.95).

Conclusion: These results suggest that magnetic resonance imaging measurements of the supraspinatus muscle thickness and acromiohumeral distance can be reliable and consistent for the clinical evaluation of patients with shoulder pain.

Keywords: Reliability, shoulder measurement, magnetic resonance imaging

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INTRODUCTION

The shoulder joint is susceptible to injuries due to its extensive range of motion and frequent use in daily living activities. Shoulder pain is a frequently reported issue in the population and is commonly seen in rehabilitation clinics. The rotator cuff (RC) is the umbrella term for the muscle group surrounding the shoulder, and this group of muscles and tendons is responsible for stabilizing the shoulder joint and facilitating arm and shoulder movement. RC problems include inflammation, tears, and subacromial impingement syndrome (SAIS), which is the most common cause of shoulder pain (1). Physical examination and conventional imaging methods such as direct radiographs (X-ray), ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) are usually sufficient for the diagnosis of RC pathologies (2). While a diagnosis can often be made through examination, imaging techniques are necessary to validate the diagnosis. In recent years, studies have shown that measurements of acromio-humeral distance (AHD), coraco-humeral distance (CHD) and supraspinatus muscle thickness (SMT) are useful in understanding the underlying pathology in RC problems. In the literature, AHD has been associated with SAIS and RC tears (3-10) and CHD with RC tears (9,11,12). The relationship between SMT and SAIS has been examined in numerous studies (13). In all those studies, AHD, CHD, and SMT measurements were made using X-ray, US, CT, or MRI images. Despite being a controversial issue in the literature, some studies have claimed that MRI is the most valuable imaging method for patients with shoulder pain (14). However, the reliability of measurements and the selected imaging method remain topics that need clarification.

There are studies in the literature investigating the reliability of AHD measurements made with direct radiography (15,16). Similarly, numerous studies have explored the reliability of AHD, CHD, and SMT measurements using ultrasonography (17-21). However, while studies have evaluated the reliability of AHD and CHD measurements made on MRI images of patients with RC pathology, there is currently a gap in research regarding the reliability of SMT measurements in addition to these (22, 23). Therefore, the aim of this study was to assess the reliability of AHD, CHD and SMT measurements of individuals with no pathology detected on shoulder MR images.

MATERIALS AND METHODS

This retrospective study was conducted in a single centre between January 2023 and January 2024. Initially, the study included a total of 80 patients who presented at the Physical Medicine & Rehabilitation clinic with complaints of shoulder pain. These patients underwent evaluation with shoulder MRI, but no shoulder pathology was determined on the MRI scans. Of these 80 patients, 5 were excluded due to image artifacts and 2 were excluded because the T1 sequence was not included in the image sequence.

Thus, the analysis was conducted on a total of 73 individuals, consisting of 28 males and 45 females, with an average age of 51.9 ± 7.4 years (range: 45 to 65 years). The study exclusion criteria were defined as the presence of any shoulder pathology on MRI, cervical radiculopathy, a history of rheumatological disease, shoulder fracture or surgery, a diagnosis of adhesive capsulitis, or the presence of artifacts determined on MRI during evaluations. The study protocol received approval from the Ethics Committee of Istanbul Training and Research Hospital (Approval no: 2023 / 243).

MRI Evaluation

A 1.5 T MRI (Signa HDxt 1.5T, GE Company) device was utilized for all measurements. Following the shooting using the Shoulder Protocol, T1 sequences (sequence thickness 3.5 mm) in coronal and sagittal sections were used for the measurements. The AHD, CHD and SMT measurements were taken by physiatrists with 15 years (MTY) and 10 years (FB) of experience in musculoskeletal system MRI evaluation. AHD was measured from the section with the narrowest gap in the T1 coronal (AHD coronal) and T1 sagittal (AHD sagittal) planes. CHD was measured from the narrowest section on T1 sagittal sections. SMT was measured at the thickest part of the muscle on T1 coronal slices. Each clinician performed a total of 3 evaluations, one week apart. During each assessment, measurements were taken three times, and the mean values were recorded. A statistical analysis was then conducted to compare the recorded values between the groups. The measurement method is shown in Figure 1.

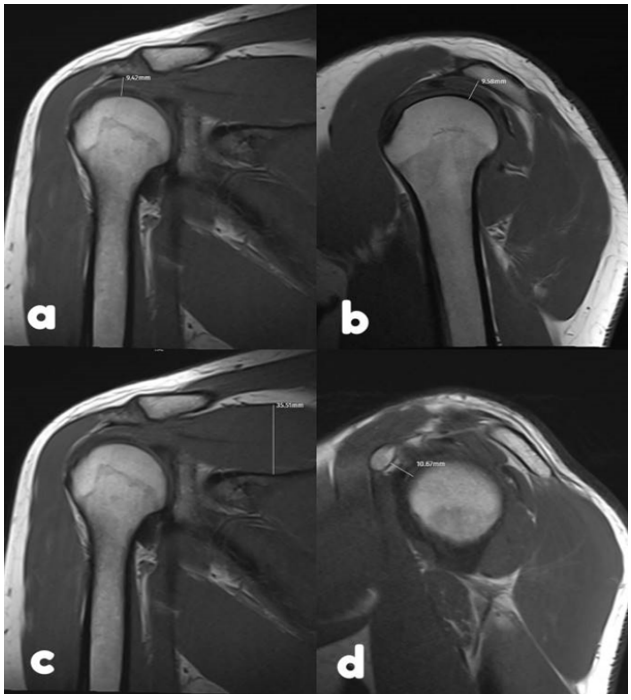

Figure 1. MRI showing the measurement of acromiohumeral distance on **(a)** coronal, and **(b)** sagittal T1 images, **(c)** suprasinatus muscle thickness measurement on coronal T1 image, and **(d)** the measurement of coracohumeral distance on sagittal T1 image.

Table 1. Reliability results of the measurements

	Intra-rater reliability						Inter-rater reliability		
	Rater 1			Rater 2			Rater 1-Rater2		
	ICC (95% CI)	SEM	MDC	ICC (95% CI)	SEM	MDC	ICC (95% CI)	SEM	MDC
AHD - coronal	0.96 (0.94- 0.97)	0.213	0.591	0.77 (0.63-0.85)	0.542	1.503	0.75 (0.61-0.84)	0.519	1.437
AHD - sagittal	0.94 (0.91-0.96)	0.238	0.660	0.77 (0.64-0.85)	0.551	1.526	0.86 (0.79-0.91)	0.370	1.027
CHD - coronal	0.85 (0.76-0.90)	0.688	1.906	0.82 (0.71-0.88)	0.962	2.665	0.74 (0.58-0.83)	0.956	2.648
SMT - coronal	0.98 (0.98-0.99)	0.520	1.440	0.89 (0.82-0.93)	1.398	3.873	0.92 (0.87-0.95)	1.083	3.002

CI; confidence interval, ICC; intraclass correlation coefficient, SEM; standard error of the mean, MDC; minimum detectable change, AHD; acromiohumeral distance, CHD; corocohumeral distance, STT; supraspinatus muscle thickness

Statistical Analysis

The data obtained were analyzed statistically using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Standard Error of the Mean (SEM) and Minimal Detectable Change (MDC) values were calculated. SEM was determined as (SD) x√(1-ICC) and MDC was calculated as (SEM)x(√2)x(1.96), where 1.96 represents a 95% confidence level. The reliability of the MRI measurements was evaluated by calculating Intraclass Correlation Coefficients (ICC) with 95% Confidence Intervals (CI) based on absolute agreement for a single measurement. In the evaluation of ICC reliability, a score between 0.5 and 0.75 signifies moderate reliability, a value between 0.75 and 0.90 suggests acceptable reliability, and a value greater than 0.90 indicates exceptional reliability.

RESULTS

The mean age of the participants was 51.9 ± 7.4 years, with a male/female ratio of 28/45 (30.4% /61.6%). The intra-rater reliability for AHD, assessed on coronal sections, was highly satisfactory. Rater 1 achieved an ICC of 0.96 (95% CI, 0.94-0.97), whereas Rater 2 achieved an ICC of 0.75 (95% CI, 0.61-0.84). AHD assessed on sagittal sections showed excellent reliability, with Rater 1 achieving an ICC of 0.94 (95% CI: 0.91-0.96) and Rater 2 achieving an ICC of 0.77 (95% CI: 0.64-0.85). CHD measurements on coronal sections were deemed satisfactory, with Rater 1 achieving an ICC of 0.85 (95% CI, 0.76-0.90) and Rater 2 achieving an ICC of 0.82 (95% CI, 0.71-0.88). SMT measurements on coronal sections yielded excellent results (Rater 1, ICC=0.98; CI, 0.98-0.99; Rater 2, ICC=0.89; 95% CI, 0.82-0.93). Specifically, the AHD-Coronal (ICC= 0.75; 95% CI, 0.61-0.84) and AHD-Sagittal (ICC=0.86; 95% CI, 0.79-0.91) measurements demonstrated good reliability. CHD measurements on coronal sections were considered fair (ICC= 0.74; 95 % CI, 0.58-0.83), while SMT measured on coronal sections showed excellent reliability (ICC=0.92; 95% CI, 0.87-0.95). Table 1 shows the reliability coefficients for both intra- and inter-rater measurements, determined by the ICC, SEM, and MDC values.

DISCUSSION

In this study, assessments were made of the reliability coefficients of magnetic resonance imaging (MRI) measurements for supraspinatus muscle thickness (SMT), acromiohumeral distance (AHD), and coracohumeral distance (CHD) parameters in patients suffering from shoulder pain. It was also aimed to investigate the reliability of MRI measurements of AHD, CHD and SMT parameters used to evaluate shoulder pain. The results demonstrated excellent inter- and intra-rater reliability for SMT measurements. AHD measurements exhibited excellent intra-rater reliability and good inter-rater reliability, and the CHD measurements showed good intra-rater reliability, and moderate inter-rater reliability.

Several studies in literature have reported a decrease in AHD in cases of RC tendon ruptures and SAIS (4,6,10), and a negative correlation has been indicated between tear severity and degeneration and AHD (22). However, there is also a study stating that AHD in SAIS is in a range similar to that of the healthy population (7), and in a study by Hunter et al. (8), AHD was found to increase in SAIS. In another study, CHD and AHD were reduced in patients with subscapular tendon rupture compared to shoulders without subscapular tendon rupture, and it was argued that CHD in particular, can be a guide for subscapular tears (9).

In another study showing that CHD decreased in subscapular tendon tears, the effect of the tear etiology on distance was discussed. While CHD was found to be significantly lower in patients with subscapular tendon ruptures due to degenerative processes, CHD in traumatic ruptures was found to be similar to that of the healthy population (12). There are also studies reporting that the SMT is thicker in SAIS compared to an asymptomatic control group (13). In the light of all these studies, it is clear that AHD, CHD and SMT measurements can be used in RC pathologies, especially SAIS. Many imaging methods, such as ultrasound, direct radiography, MRI and CT, can be used when taking measurements. MRI is considered the most appropriate imaging technique for evaluating anatomical structures with a complex appearance. However, although

there are many reliability studies, especially related to AHD measurements, it is undeniable that there is a need for further studies to investigate the reliability of these measurements.

Bernhardt et al. (15) assessed the reliability of AHD measurements using direct radiography and showed that both the intraobserver and interobserver reliability of assessments based on plain radiographs was found to be low. Another study compared reliability using 10 plain radiographs and 10 MRI/CT scans. The measurements made on MRI/CT were found to be more reliable than those on direct radiography. However, the sample set in that study was limited and the MRI/CT scans were considered a single group (16). In a study that investigated the AHD effect of abductor and adductor muscle strengths through MR imaging, the reliability of both intra-observer and inter-observer measurements was tested and was found to be safe (24). There are also studies reporting that AHD measurements made with ultrasound can be safe (17).

Similar to AHD measurements, there are studies in the literature that have evaluated coracohumeral distance measurements using ultrasound (21). In a study testing the reliability of CHD measurements made with MRI, good intraobserver and interobserver reliability was demonstrated (23). The data obtained in the current study supported that study. In other studies of the reliability of SMT measurements, ultrasound has been found to be safe within and between observers (18-20). In a study of hemiplegic patients, supraspinatus muscle thickness measurement with US was found to be a reliable method and showed a positive correlation with the cross-sectional area of the supraspinatus muscle on MRI. However, MRI is costly and not always available. In contrast, US is less expensive than MRI and is usually available in outpatient clinics (19). To the best of our knowledge, no previous study has assessed the reliability of SMT measurement using MRI. Therefore, the current study can be considered valuable, as the results demonstrate that the SMT measurement, previously associated with SAIS, is a reliable parameter.

The primary limitations of this study were the single-centre, retrospective design. Another limitation was that the measurements were taken on shoulder MRI images without detected pathology. In addition, the MRI acquisition method does not allow measurement of the acromiohumeral distance during shoulder abduction. Therefore, taking measurements on MRI of shoulder pathology in future studies may contribute further to the literature.

In conclusion, the results of this study suggest that AHD and CHD measurements, and especially SMT, obtained from shoulder MRI images without any detected pathology, can be deemed reliable. These findings may increase the clinical utility of these measurements in the assessment of shoulder pathologies.

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