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Reliability of musculoskeletal ultrasound imaging to measure calcific deposits in patients with calcified rotator cuff tendinopathy

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Abstract

Introduction. This reliability study was designed to assess intra-rater and inter-rater reliability of musculoskeletal ultrasound as a diagnostic modality to measure calcific deposits in subjects with rotator cuff tendinopathy.

Methods. Overall, 15 participants (10 males, 5 females) with calcified shoulder, aged 32–55 years, were examined in the same sitting posture. Two experienced radiologists imaged calcific deposits, measured twice daily by both raters with an interval of 2 hours for within-day reliability and re-measured after 1 week for between-day reliability. Data were analysed by using intra-class and inter-class correlation coefficient.

Results. The mean size of calcific deposits in supraspinatus tendons was 14.61 ± 1.78, 14.87 ± 1.77, and 14.88 ± 1.88 mm for the first rater and 14.89 ± 1.78, 14.98 ± 1.792, and 15.13 ± 1.84 mm for the second rater. The results reflected excellent reliability, with the intra-class correlation coefficient for within-day comparison calculated as 0.989 (0.975–0.996) for the first rater and 0.984 (0.963–0.994) for the second rater (p = 0.000). The inter-class correlation coefficient for between-rater comparison equalled 0.991 for the first measurements by the first and second raters, 0.984 for the second measurements, and 0.986 for the third measurements.

Conclusions. A high degree of within-day and between-day reliability was observed between the successive measurements. This shows that musculoskeletal ultrasound is a highly reliable diagnostic tool for measuring the size of calcific deposits in patients with tendinopathy.

Key words: musculoskeletal ultrasound, calcified rotator cuff tendinopathy, reliability

Introduction

The most prevalent cause of shoulder pain, rotator cuff (RC) tendinopathy, estimated to be present in 14% of the adult population, is the most dynamic reason for painful shoulder. Calcified RC tendinopathy, characterized by calcium crystals deposition in RC tendons, has multi-factorial aetiology, involving both extrinsic and intrinsic mechanisms [1]. One of the major complications of calcified tendinopathy is shifting of the calcium masses mainly from the supraspinatus tendon to subacromial bursae [2].

Extensive studies have investigated the accuracy of musculoskeletal ultrasound (MSKUS) imaging for detecting tendon injuries. RC tendon is the most frequently sonographically imaged tendon, and tendinopathy is a frequently revealed pathology. Ultrasonography is considered slightly more sensitive but less specific than magnetic resonance imaging (MRI) for diagnosing RC tendinopathy. While ultrasonography is highly sensitive for detecting calcified tendinopathy, MRI is not [3]. It is worthwhile to make an accurate and precise diagnosis of tendon injuries using other expensive tools; however, ultrasonography makes it more accurate and also minimizes societal costs. MRI is considered a gold standard imaging tool for musculoskeletal pathologies but it is quite expensive [4]. Advances and betterment in ultrasound technology have made it a rapidly developing alternative to MRI for accurate diagnosis of tendon injuries [5].

In the general population, 6.9–26% of individuals complain about painful shoulder joint, and about 66% of adults would experience this pain during their lifespan [6]. This pain mainly affects tasks of daily living that require adequate shoulder range of motion, like self-grooming, self-care, and overhead activities; limited shoulder ranges may not allow to fulfil the demands of daily activities of life. Shoulder and neck pain is more prevalent among office workers, affecting almost 57% of the working population [7]. RC tendinopathy is the most frequent cause of shoulder pain in the elderly, and the most vulnerable tendon is the supraspinatus tendon. Severe supraspinatus injury affects patients' quality of life. However, it can sometimes be asymptomatic and requires imaging for its diagnosis [8].

Middle-aged women with subacromial pain syndrome and with calcific deposits of more than 15 mm are more prone to suffer from symptomatic calcified RC tendinopathy [9]. In tendons, hydroxyapatite crystals deposition can shift to the surrounding structures, like bursa, and sometimes to bony structures [10]. Sonographic findings reveal the following varieties of RC calcifications: (1) hyperechogenic mass with a sharp, well-defined shadow (79%); (2) hyperechogenic mass with a faint shadow (14%); and (3) hyperechoic deposit without any acoustic shadow on the sonogram (7%). There is evidence that ultrasonography is more suitable for large and slurry calcific deposits, effective in diagnosing such conditions, but few studies have been performed to verify it as a reliable diagnostic tool [11]. The radiographic-based Gärtner classification of calcific masses distinguishes: type I, a well-defined and dense focus; type II, soft contour/dense or sharp/transparent; type III, translucent and cloudy mass [12].

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Various diagnostic tools, like MSKUS, MRI, and magnetic resonance arthrography, can be used to diagnose RC disorders [13]. The findings of ultrasound imaging mainly depend on the radiologist's expertise and require careful execution [14]. High-resolution, real-time ultrasonography has been shown to be an effective imaging tool in evaluating RC and non-RC tendinopathies. Ultrasonography technique depends on patient positioning, scanning protocol, and dynamic imaging in the case of shoulder joint examination [15].

Technological advances have improved the quality of ultrasound imaging, produced spatial resolution higher than that gained with MRI without using special coils and imaging parameters. Ultrasonography is cost-effective and offers dynamic capabilities for examining patients in multiple scanning planes and specific arm positions or movements, in addition to having the ability to focus the examination on the precise region of maximum discomfort [16].

A review concluded that MSKUS exhibited high accuracy in detecting RC tendinopathy and tears and these findings may assist clinicians in differential diagnosis. A study reported 79% sensitivity and 94% specificity of ultrasonography in diagnosing RC tendinopathy [17].

Calcified tendinopathy, among the most prevalent disorders of the shoulder joint, is lacking evidence related to the reliability of MSKUS for measuring the size of calcified masses; few studies are available to investigate supraspinatus tendon thickness, but we found no study on the current topic. The present research was designed to check intra-rater and inter-rater MSKUS reliability as a preferable non-invasive, cost-effective diagnostic imaging modality used to measure the size of calcific deposits in participants with calcifying RC tendinopathy.

Subjects and methods

This reliability study was conducted between October 2019 and March 2020, among 15 participants with calcified shoulder, of both genders, aged 32–55 years. Subjects having a full available range of movement in the shoulder, neck, and upper thoracic region were recruited from the University Teaching Hospital, University of Lahore, Pakistan. Patients suffering from musculoskeletal or neuromuscular disorders of shoulder and neck, those with pain or injury of the cervical region or shoulder, any related surgery, pregnant females, or individuals having metallic implants in the body were excluded from the reliability study [18].

The participants received an explanation of the whole study procedure. During the examination, they remained in a low sitting position; their feet were fully supported and hands positioned on the back, with the dorsum of the hand in contact with the back and palm facing outwards. The ligament was exposed in that posture by medially rotating the arm, so it could be examined by using MSKUS.

Two MSKUS experts took ultrasound images by using an ultrasonography device (Toshiba Xario, Japan, 8–14 MHz) with a linear transducer. About 7.5 MHz frequency of ultrasound waves was applied. RC tendons were examined in all planes and their thickest part was measured [19].

The examiners were randomly assigned and they took the measurements thrice. First 2 measurements were taken on a single day with an interval of 2 hours (within-day reliability), and the third reading was done after 1 week (between-day reliability). Both examiners took the readings by considering the same guidelines, one after the other. Data were analysed with the SPSS software, version 23.0, and descriptive statistics like calcific deposit measurements were expressed as means and standard deviations. Intra-class and inter-class correlation coefficients were computed. The within-day intra-rater reliability (between the first and second measurements) was determined by comparing both readings obtained by each examiner. Similarly, the inter-rater reliability (between the consecutive measurements of the first and second raters) was determined by comparing both measurements.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Review Board of the University of Lahore (approval No.: 627/IRB/UOL/2019).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

The participants were 15 subjects (10 males, 5 females) with calcified shoulder, with mean age of 44.40 ± 7.51 years, mean height of 1.70 ± 0.08 m, and mean body mass of 84.47 ± 9.92 kg. The body mass index of all individuals ranged 25–36 kg/m^2, with the mean of 28.73 ± 3.05 kg/m^2. The measured values for the size of calcific deposits in the supraspinatus tendon, determined twice on day 1 (with an interval of 2 hours) and after 1 week by both raters, are presented in Table 1.

The mean sizes of calcific deposits in supraspinatus tendons (Figure 1), with standard deviations, were 14.61 ± 1.78, 14.87 ± 1.77, and 14.88 ± 1.88 mm for the first rater and 14.89 ± 1.78, 14.98 ± 1.792, and 15.13 ± 1.84 mm for the second rater. The within-day and between-day reliability measures are presented in Table 2.

A high degree of reliability was observed between the successive measurements made by both raters i.e., the average measure intra-class correlation coefficient for within-day reliability was calculated to be 0.989 (0.975–0.996) for rater 1 and 0.984 (0.963–0.994) for rater 2, with a significant *p*-value ($p = 0.000$). Similarly, excellent agreement was reported in inter-class correlation coefficient for the between-rater comparison: 0.991 for the first measurements by the first and second raters, 0.984 for the second measurements, and 0.986 for the third measurements (Table 2).

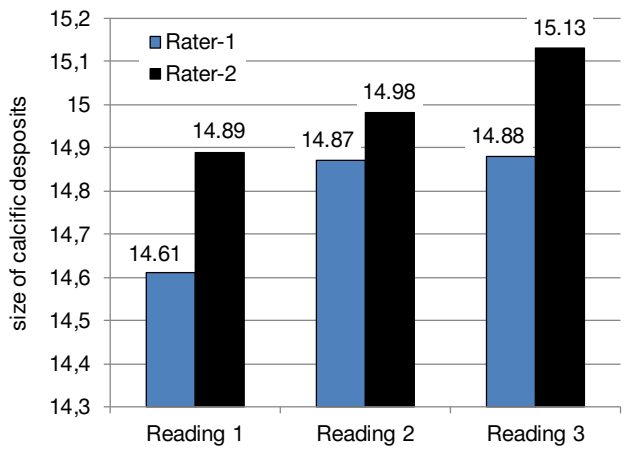

Figure 1. Mean sizes (mm) of calcific deposits in the supraspinatus tendon

Table 1. Measured sizes of calcific deposits in the supraspinatus tendon (mm)

Subjects	Gender	Rater 1			Rater 2		
		Session 1	Session 2	Session 3	Session 1	Session 2	Session 3
1	Male	12.2	12.4	12.2	12.4	12.8	13.0
2	Male	13.2	14.0	13.5	13.7	14.0	13.6
3	Female	12.4	12.5	12.9	12.8	12.6	12.9
4	Male	11.8	11.8	11.4	11.7	12.0	11.7
5	Female	15.4	15.8	16.0	15.8	15.8	15.9
6	Male	14.4	14.9	14.8	14.6	14.2	14.8
7	Female	16.5	16.5	16.7	16.9	16.4	17.0
8	Male	15.0	15.1	15.4	15.4	15.2	15.8
9	Male	15.1	15.8	15.6	15.3	15.7	16.0
10	Male	15.0	15.2	15.6	15.3	15.6	16.0
11	Male	17.6	17.8	17.7	17.3	17.8	17.4
12	Female	13.1	13.4	13.3	13.6	13.5	13.9
13	Male	14.4	14.7	14.5	14.7	14.8	14.4
14	Female	16.0	16.1	16.3	16.3	16.5	16.6
15	Male	17.0	17.1	17.3	17.6	17.8	18.0

Table 2. Mean, standard deviation, and correlation coefficients for within-day and between-day reliability measures of calcific deposits in the supraspinatus tendon

	Rater 1			Rater 2			Inter-class correlation coefficient (between-rater)		
	Session 1	Session 2	Session 3	Session 1	Session 2	Session 3	Session 1	Session 2	Session 3
Mean	14.61	14.87	14.88	14.89	14.98	15.13	0.991 (0.975–0.997)	0.984 (0.954–0.995)	0.986 (0.958–0.995)
SD	1.78	1.77	1.88	1.78	1.79	1.84			
Minimum	12	12	11	12	12	12			
Maximum	18	18	18	18	18	18			
Intra-class correlation coefficient (within-day)	0.989 (0.975–0.996)			0.984 (0.963–0.994)					
p	0.000			0.000					

Discussion

The main purpose of the current study was to evaluate the intra-rater and inter-rater reliability of MSKUS as a diagnostic modality to measure calcific deposits in participants with RC tendinopathy. Ultrasound imaging is cost-effective and portable; therefore, it should be used as the first-line diagnostic method. It is well suited for tendon injuries because of the benefits of its high-resolution and dynamic assessment [20]. The trend of ultrasonography use is prevailing among radiologists and non-radiologists in the United States [21]. The present study also proved it to be a reliable tool for measuring the size of calcific deposits. Different studies have compared various diagnostic tools but none of them applied as a sole device has achieved reliability like that of ultrasonography. In this study, measurements were taken at different levels, by different examiners, at different times.

Another study that evaluated intra-observer and inter-observer reliability by using Cohen's kappa analysis when comparing computed tomography and plain radiographs concluded that computed tomography exhibited better reliability, although the differences were not significant [22]. That study investigated potentially expensive diagnostic imaging techniques other than ultrasonography; in the current reliability study, ultrasonography was proved to be a reliable and cost-effective diagnostic tool for calcifications.

Evidence demonstrates that middle-aged women suffering from subacromial pain syndrome and calcification have an increased probability of symptomatic calcific tendinopathy. According to the current view on the epidemiology of calcified RC tendinopathy, its prevalence is estimated to be 7.8% in asymptomatic patients and 42.5% in patients with subacromial pain syndrome [9].

Three varieties of calcific deposits were found with ultrasonography: (1) hyperechoic focus along with a well-defined shadow (79%); (2) hyperechoic focus with a dull shadow (14%); and (3) hyperechoic focus and no shadow (7%) [11]. Ultrasonography has been proved to be effective for diagnosing calcification but no research has verified it as a reliable diagnostic tool. However, the current study indicates its effec-

tiveness as a reliable method because of providing consistent measurements for diagnosing calcific deposits in RC tendinopathy subjects. The study purpose was to prove ultrasonography as a reliable, cost-effective, and non-invasive tool used to assess calcific deposits in RC tendinopathy patients.

In another study, ultrasound examination of the shoulder joint and associated structures was discussed. It focused more on normal joint anatomy and pathophysiology involving RC tendon, biceps tendon, and other musculoskeletal disorders [23]. In turn, our study evaluated the reliability of MSKUS to diagnose calcified tendinopathy. Few studies were performed to determine the reliability of diagnostic tools such as ultrasound imaging. Our research helps establish the usage of ultrasonography as a reliable and authentic diagnostic imaging tool.

Limitations

A limitation of the study was the recruitment of a small sample owing to time constraints. It is recommended that more research be conducted to check the reliability of different diagnostic imaging tools, with larger sample sizes.

Conclusions

The current study indicates a high degree of within-day and between-day reliability between the successive measurements. Hence, it shows that MSKUS is a highly reliable diagnostic tool for measuring calcific deposits in patients with calcified RC tendinopathy.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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