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Diagnostic value of Sonography and MR Imaging in rotator cuff for patients with shoulder pain

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Abstract:* Introduction: Ultrasonography(US) and magnetic resonance imaging (MRI) are both capable of diagnosing rotator cuff pathology.*

Objectives*: To evaluate the diagnostic value of US and MRI in the detection of rotator cuff tears for patients with shoulder pain.*

Materials and methods*: 87 patients with clinically suspected to have rotator cuff pathology underwent both US and MRI .The standard protocols of shoulder examinations were obtained. Sensitivity and accuracy of each modality have been evaluated and the correlation between the results of both imaging methods was deliberated using MRI as reference. The study included both genders, their mean age was 49.40± 12.4.The study spanned during the period from 2014-2017*

Results*: showed no significant difference in the diagnostic results of US and MRI. Sensitivity, and accuracy of the imaging methods were found to be: for Supra spinatous tendon partial tear (91%,91.6%)and(91%,92.8%) for US and MRI in respectively. Sensitivity and accuracy in diagnosis of Supra spinatous tendon full thickness tear were equal in both methods (100%, 100%) while Subscapularis tendon partial tear were (40%, 96.4%) and (100%, 96.1%) and Infa spinatous tendon partial tear (42%,95.4%) and (100%, 95.2%). The other non rotator cuff findings were found to have sensitivity ranged between (48%-100 %) and (29-92%) and accuracy ranged between (81.8% -98%) and (82.6-99%) for US and MRI in respectively*

Conclusions *Regarding the comparable results; US proved to have high sensitivity and accuracy for full thickness tears with relatively less sensitivity in detection of partial thickness tear. Ultrasonography may be the suitable imaging method for diagnosis the rotator cuff tears when the examiner has been well trained and we recommended to be used as the first line imaging modality in evaluation of shoulder pain as it is sensitive , accurate, cheap and available, as well; for practitioners without ultrasound expertise, MRI can be used.*

Keywords - Ultrasonography, MRI ,Rotator cuff tear

I. INTRODUCTION

Rotator cuff disease is the most common cause of shoulder pain, Rotator cuff tears are a significant cause of morbidity and a financial burden to the health care system. These tears require good assessment and management. Clinical examination alone provides limited information, making imaging being as an essential component of decision making. [1,2].The identification of a rotator cuff for full or partial thickness tear, can determine whether the patient will be managed conservatively or will need surgical treatment [3, 4].

Diagnostic imaging with, sonography, or MR is an important part of the evaluation of patients with shoulder pain and suspected rotator cuff disease. These imaging techniques have many strengths and weaknesses, and their accuracies and roles in the diagnostic evaluation of rotator cuff disease should be examined. Sonography is noninvasive and has a reported accuracy of 87-94% .[5,6] Several publications have proven the diagnostic value of sonography of the rotator cuff [7,8], but the initial good results have not been confirmed by some studies [9]. sonography is an operator-dependent technique that does not allow visualization of the entire extent of the rotator cuff. On the other hand MR imaging provides direct visualization of the entire cuff, and one early study reported an accuracy of 84% [10]. In addition MRI can depict early changes in rotator cuff impingement, not visible by sonography [11] as well MRI is less operator dependent. [12] The major disadvantages of MR imaging are the long examination time and expensive.

To the best of our knowledge, there have been no reports of symptomatic shoulder findings studied at both ultrasound and MRI examinations including rotator cuff partial and full thickness tear and non rotator cuff related pathologies done for Sudanese because referring for ultrasound scanning of shoulder is of least application in our practice in Sudan. Therefore the purposes of this study were to highlight the spectrum abnormalities that may be encountered in symptomatic patients examined by ultrasound and MRI as well to assess the diagnostic value of sonography and MRI in diagnosis of rotator cuff pathology.

Awareness of the accuracy, sensitivity and specificity of each modality in the diagnosis and evaluation of the rotator cuff compartments is essential to gain the useful standpoint for selection concerning the clinical importance and patient care.

II. MATERIAL AND METHODS

2.1Area, Duration and study sample:

The study was carried out during the period from June 2014 up to August 2016 at Bashaer Hospital – Southern Khartoum. Patient verbal consent was obtained. All scans were performed according to a routine shoulder protocol using Mindray DP-20 ultrasound machine with a high-frequency (7-12 MHz) linear-array transducer.

The patient sample consisted of 87 patients. The males were 35 (40.2%) and females were 52(59.8%). All were complaining of shoulder pain and were undergone an evaluation of the rotator cuff tendons using ultrasound and MRI .The occupation of the participants were recorded. House wife, farmers, employees, free business, teachers, drivers, student and also who were of other jobs. The affected side was common in the right shoulder constituting 61 (70.1%) and 26 (29.9%) in the left shoulder.

2.2 Ultrasound Technique used:

The examination of shoulder started with the long head of the biceps tendon (LHBT) with the patient sitting, facing the examiner, the elbow joint was flexed at 90° and the arm was supinated on the patient´s thigh. The probe was placed axially (transverse) at the anterior aspect of the shoulder searching for the bicipital groove, the LHBT appears as an ovular hyperechoic structure within the groove, surrounded by a small amount of fluid in the sheath. Both transverse and longitudinal views were obtained, starting from the proximal aspect of the bicipital groove and extending distally to the musculotendinous junction.

For the evaluation of the SubScapuler tendon the elbow joint flexed at 90°. The arm was rotated externally. Long-axis scan was performed; the probe was placed axially, (transverse) approximately at the level of the coracoid process. The SubScapuler tendon appears as a convex, well-defined fibrillar echo structure. The probe was swept up and down until its full width visualization was achieved. Modified Crass (Middleton position) was applied to evaluate the Supraspinatus tendon (SupraS) with the arm posteriorly extended, flexed elbow, pointing directly posteriorly, and the palm of the hand placed on the ipsilateral iliac wing.

The (SupraS) tendon was examined in long-axis and short-axis views. The greater tuberosity and the humeral head were the important bone landmarks during the SupraS tendon examination. In long-axis view, the SupraS tendon is visualized as convex beak-shaped hyperechoic structure over the smooth hypoechoic band of the articular cartilage and the hyperechoic humeral cortex, ending into the great tuberosity. In short-axis view, the SupraS tendon has a convex shape, composed of homogeneous texture of medium-level echoes.

The subacromial-subdeltoid bursa appears as a hypoechoic linear line between two hyperchoic linear planes. The forearm was placed across the chest and the palm is placed on the opposite shoulder to evaluate the Infraspinatus and teres minor tendons. The infraspinatus and teres minor muscles appear as an individual structure filling the infraspinous fossa deep to the deltoid. After scanning these muscles, the transducer was swept toward the greater tuberosity on sagittal planes.

2.3 MRI Technique used :(MRI 1.5 Tesla)

The patient lies supine with the arms resting comfortably by the side. Patients were slided across the table to bring the shoulder under examination as close as possible to the centre of the bore. The arm to be examined is strapped to the patient, with the thumb is positioned in (neutral position) and padded so that the humerus is in horizontal. The coil was place to cover the humeral head and the anatomy superior and medial to it. Surface coil is used, and was positioned parallel to the Z axis over the humeral head. The FOV was centered on the middle of the glenohumeral joint. The patient is positioned so that the longitudinal alignment light and the horizontal alignment light pass through the shoulder joint.***Protocol used was: Axial***/coronal FSE T_1 Acts as a localizer. ***Axial*** SE/FSE T_2 thin slices/gaps are prescribed from the top of the acromio-clavicular joint to below the inferior edge of the glenoid . The bicipital groove on the lateral aspect of the humerus to the distal supraspinatus muscle is included in the image. ***FSE*****(**Short TE :20 ms ,Long TE :90 ms, Short TR :400–600 ms ,Long TR :4000 ms. ***Coronal***/oblique FSE T_1 Thin slices/gaps are prescribed from the infra-spinatus posteriorly to the supraspinatus anteriorly and angled parallel to the supraspinatus muscle

2.3 Statistical Analyses:

The frequency and percentages were calculated for each variable in the sample. A Pearson Correlation Coefficient was calculated .Significance for the tests was noted at $P \leq .005$.All of the statistical analyses were performed using Statistical Package for Social Sciences software package (SPSS for Windows, Version 16 Chicago, IL, USA).For sensitivity ,specificity and accuracy each modality was tested to be as ground truth for the other

III. RESULTS

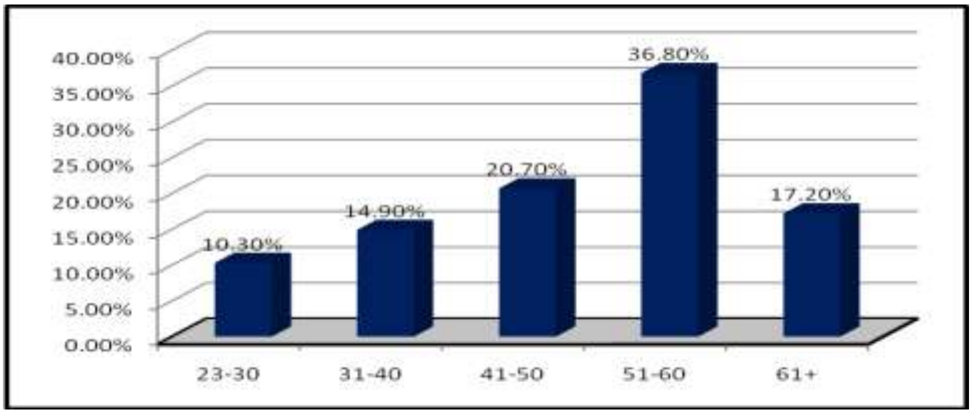

Figure No (1) Distribution of study sample according to Participant's age (Total number =87, mean age =49.40± 12.4 , Maximum=75.00 and Minimum=23.00 years old)

Table 1 shows Detailed Correlation of pathological findings on Ultrasonography(US) and MRI

Tendon	***Modality***	***Partial thickness tear***	***Full thickness tear***	***Bursa Fluids***	***Shoulder Impingement Syndrome***	***LHB Dislocation***	***Calcify Tendinitis***	***Others***	***normal***
Sub scapularis	US	2 (2.3%)	-	-	-	-	-	-	-
	MRI	5 (5.7 %)	-	-	-	-	-	-	-
Supra Spinatous	US	35 (40.2%)	8 (9.2%)	-	-	-	-	-	-
	MRI	34 (39.1%)	8 (9.2%)	-	-	-	-	-	-
Infra Spinatous	US	3 (3.4%)	-	-	-	-	-	-	-
	MRI	7 (8.0%)	2 (2.3%)	-	-	-	-	-	-
Teres minor	US	-	-	-	-	-	-	-	87 (100%)
	MRI	4 (4.6%)	-	-	-	-	-	-	83 (95.4%)
LHB	US	-	-	-	-	2 (2.3%)	-	-	-
	MRI	-	-	-	-	1 (1.1%)	-	-	-
Normal	US	-	-	-	-	-	-	-	68 (78.2%)
	MRI	-	-	-	-	-	-	-	31 (35.6%)
Bursa	US	-	-	28 (32.2%).	-	-	-	-	-
	MRI	-	-	28 (32.2%).	-	-	-	-	-
Impingment Syndrome	US				12 (13.8%)				
	MRI				23 (26.4%)				
Calcification	US						7 (8.0%)		
	MRI						3 (3.4%)		
Other Pathology	US							-	
	MRI							30 (34.5%)	

Table 2 shows the cross tabulation between the MRI and Ultrasonography diagnostic results for the rotator cuff tendons

		MRI Findings		
P-value = 0.000		Sub Scapularis tendon		Total
		Normal	Rotator cuff Partial tear	
US Findings Sub Scapularis tendon	Normal	82(94.3%)	3(3.4%)	85(97.7%)
	Rotator cuff Partial	0(0.0%)	2(2.3%)	2(2.3%)
Total		82(94.3%)	5(5.7%)	87(100.0%)

		Supra Spinatous Tendon			
P-value = 0.000		Normal	Rotator cuff Partial tear	Rotator cuff Full Thickness Tear	total
Supra Spinatous Tendon	Normal	41(47.1%)	3(3.4%)	0(0.0%)	44(50.6%)
	Rotator cuff Partial tear	4(4.6%)	31(35.6%)	0(0.0%)	35(40.2%)
	Rotator cuff Full Thickness Tear	0(0.0%)	0(0.0%)	8(9.2%)	8(9.2%)
	Total	45(51.7%)	34(39.1%)	8(9.2%)	87(100.0%)

		InfraSpinatous Tendon			
P-value = 0.000		Normal	Rotator cuff Partial tear	Rotator cuff Full Thickness Tear	Total
InfraSpinatous Tendon	Normal	78(89.7%)	4(4.6%)	2(2.3%)	84(96.6%)
	Rotator cuff Partial tear	0(0.0%)	3(3.4%)	0(0.0%)	3(3.4%)
	Total	78(89.7%)	7(8.0%)	2(2.3%)	87(100.0%)

		Teres Minor Tendon		
P-value = 0.000		Normal	Rotator cuff Partial tear	Total
Teres Minor Tendon	Normal	83(95.4%)	4(4.6%)	87(100.0%)
Total		83(95.4%)	4(4.6%)	87(100.0%)

Table 3 shows the cross tabulation between the MRI and Ultrasonography diagnostic results for the associated findings as indicator for presence of torn tendons

P-value = 0.000		Long Head of Biceps(LHB)		Total
		Normal	LHB Dislocation	
Long Head of Biceps(LHB)	Normal	85(97.7%)	0(0.0%)	85(97.7%)
	LHB Dislocation	1(1.1%)	1(1.1%)	2(2.3%)
Total		86(98.9%)	1(1.1%)	87(100.0%)

P-value = 0.000		Bursa effusion		Total
		Normal	Bursa Effusion	
Bursa effusion	Normal	55(63.2%)	4(4.6%)	59(67.8%)
	Bursa fluids	4(4.6%)	24(27.6%)	28(32.2%)
Total		59(67.8%)	28(32.2%)	87(100.0%)

Table 4 shows the cross tabulation between the MRI and Ultrasonography diagnostic results for the findings in shoulder

P-value = 0.000		Other Tendenopathy				Total
		Normal	Impingement	Calcify Tendinitis	Other Shoulder Pathology*	
Other Tendenopathy	Normal	28(32.2%)	9(10.3%)	1(1.1%)	30(34.5%)	68(78.2%)
	Impingement	1(1.1%)	11(12.6%)	0(0.0%)	0(0.0%)	12(13.8%)
	Calcify Tendinitis	2(2.3%)	3(3.4%)	2(2.3%)	0(0.0%)	7(8.0%)
Total		31(35.6%)	23(26.4%)	3(3.4%)	30(34.5%)	87(100.0%)

***Intra-Articular Pathology, Humeral Head And Acromioclavicular Joint Pathology**

Table 5: Sensitivity& Specificity of ultrasound in detecting tears and other pathology of rotator cuff tendons

	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy
Partial Tear Supra spinatous Tendon	31	49	4	3	91%	92%	91.6
Full Thickness Tear Supra spinatous Tendon	8	79	0	0	100%	100%	100
Partial Tear Subscapularis Tendon	2	82	0	3	40%	100%	96.4
Partial Tear Infa spinatous Tendon	3	80	0	4	42%	100%	95.4
long head of Biceps Dislocation	1	85	1	0	100%	98%	98
Bursa Effusion	24	55	4	4	86%	93%	81.9
Shoulder Impingement Syndrome	11	63	1	12	48%	98%	81.8
Calcify Tendinitis	2	79	5	1	67%	94%	93.1

TP: True Positive, TN: True Negative, FP: False Positive, FN False Negative

Table 6: Sensitivity, Specificity and accuracy of MRI in detecting tears and other pathology of rotator cuff tendons

	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy
Partial Tear Supra spinatous Tendon	31	49	3	4	91%	94%	92.8
Full Thickness Tear Supra spinatous Tendon	8	79	0	0	100%	100%	100
Partial Tear Subscapularis Tendon	2	82	3	0	100%	96%	96.1
Partial Tear Infa spinatous Tendon	3	80	4	0	100%	95%	95.2
long head of Biceps Dislocation	1	85	0	1	50%	100%	99.0
Bursa Effusion	24	55	4	4	86%	93%	82.6
Shoulder Impingement Syndrome	11	63	12	1	92%	84%	83.3
Calcify Tendinitis	2	79	1	5	29%	99%	93.2

$$Prevalence = \frac{(TP+FN)}{(TP+FN+TN+FP)}$$

Accuracy = Sensitivity × Prevalence + Specificity × (1 - prevalence)

IV. DISCUSSION

Shoulder pain is one of the most common causes of illnesses in patients visiting orthopedic clinics. In the current study, rotator cuff pathologies were found to be the commonest cause for referral to MRI department which was found similar to study carried out by Mitchell C et al., [13]. 87 patients were enrolled where ultrasonography and MRI were obtained where MRI was used as reference standard .The patients mean age was 49.40± 12.4, maximum age was 75.0 and minimum was 23.0 years old, the most common affected age was the ages between 51-60years old. The distribution of ages was presented in figure (1)

Out of 87 patients; MRI showed 60(68.96%) patients have either partial or full thickness rotator cuff tears whereas on ultrasonography examination 48(55.2%) patients showed rotator cuff partial and full thickness tears this was noticed in table (1)

When comparing the diagnosed cases according to anatomical region done by ultrasonography (US) and MRI the results were as follows: Us in SubScapularis showed partial tear in 2(2.3%) cases while MRI found it in 5(5.7 %) cases .SupraSpinatous partial tear was diagnosed in 35 (40.2%) of the cases however MRI found it in 34(39.1%) cases and the full thickness tear was found equally in both modalities ultrasonography and MRI in respectively 8(9.2%) and 8(9.2%) cases.

For the Infra spinatous partial tear ultrasound is able to diagnose 3(3.4%) cases while 7(8.0%) cases were diagnosed to have partial tear in MRI. No cases were diagnosed in US as full thickness where MRI found it in 2(2.3%) cases .Teres minor was found to be normal in all cases examined by ultrasound: 87(100%) where MRI showed 4(4.6%) cases to have partial tear and 83(95.4%) were normal.US showed LHB dislocation in 2(2.3%) cases and MRI found only one case to have dislocation 1(1.1%). Number of cases diagnosed as bursal effusion was found to be similar in both techniques 28(32.2%).US diagnosed 68(78.2%) cases to be without findings as normal cases where MRI reported normal results in 31(35.6%) cases. Impingement syndrome was diagnosed in 12(13.8 %) ultrasound cases while MRI found it in 23(26.4%). Calcific tendinitis in 7(8.0%) of the ultrasound cases where only 3(3.4%) was found in MRI. This was presented in table (2)

Other Shoulder findings included intra-articular pathology; humeral head and acromioclavicular joint pathology were detected in 30(.34.5%) cases by MRI, where all of those cases were found to be normal in ultrasonography.For the Rotator cuff pathology the US results were consistent with most of the cases diagnosed by MRI ,showing high sensitivity and specificity and accuracy for full-thickness tears but less for partial thickness tears (table5) this was similar to what was mentioned previously [14,15]. In the present study we have compared the findings of ultrasound with MRI and vice versa, using it as a reference standard for the detection of rotator cuff and related pathology in patients referred to our department.

Tables 4, 5 and 6 presented the analyses of findings at each modality. In US scan, the Sub Scapularis tendon were diagnosed as normal in 3(3.4%) cases and were found to be partially torn in MRI . 2(2.3%) cases the diagnosis was similar as partial tear in both modalities. US sensitivity was found to be 40% and accuracy of 96.4% while MRI was 100% sensitive and 96.1% accurate in the diagnosis of Sub Scapularis tendon .For Supra Spinatous Tendon; 3 (3.4%) cases were found to be partially torn in ultrasonography where it was found to be normal in MRI. US sensitivity was 91% and accuracy was 91.6%. The cases diagnosed to have full thickness tear were 8(9.2%) and are reliable in both methods. Ultrasound diagnosed 4(4.6%) cases as partial tear where MRI found it as normal with sensitivity of 100% and accuracy of100% for ultrasonography. Similerly Zlatkin et al., also found presence of supraspinatus tendon involvement in most of cases in their study [16].

InfraSpinatous is well demonstrated as partial tear in 4(4.6%) cases diagnosed by MRI, and full thickness tear in 2(2.3%) cases, those cases were found to be normal in ultrasonography scan . ultrasound sensitivity was 100% with accuracy of 95.2%. 4(4.6%) of the teres minor tendons were found to have partial tear in MRI while it is normal in ultrasonography. Both US and MRI are able to diagnosis long head of biceps (LHB) dislocation, ultrasonography have diagnosed 4(4.6%) cases to have bursa effusion where they were found to be normal in MRI. Some cases were diagnosed as normal in ultrasound and were found to be as Impingement syndrome in 9(10.3%) cases by MRI. Calcify tendinitis and other shoulder pathology were also been detected by the two modalities. Sensitivity in diagnosis the associated findings in MRI as long head of biceps dislocation, bursa fluids ,shoulder impingement syndrome ,calcify tendinitis were found to be 50%,86%,92% and 29%,while ultrasound was found to have sensitivity of 100%,86%,48%, and 67% for the same pathological results .The results showed that in the cases diagnosed by ultrasound it has limited role in evaluation of non rotator cuff related pathologies like bursal effusion, calcify tendinitis long head of biceps dislocation as there are many false positive and false negative results and this false negative cases were not present in the MRI diagnosis as noticed in table (5,6)

Ultrasonography results showed sensitivity ranged between 40-100% and accuracy ranged between 81.8% -100% in diagnosis of patients suspected to have rotator cuff tear. The role of diagnostic imaging is to help guide of management. The ideal imaging technique should have a high rate of TPs and an acceptable rate of FPs, In previous studies included, most of the reported sensitivities and specificities fall in the range of 60–100% for ultrasound.[17]

Our findings showed that MR is more sensitive and more specific than ultrasound in diagnosing both full- and partial-thickness rotator cuff tears. Additionally, there is no statistically significant difference between the results of MRI versus ultrasound in diagnosing either full- or partial-thickness tears and associated tendenopathy findings as seen in tables 3 and 4.

Table 5 and 6 demonstrated that MR is more accurate than ultrasound in diagnosing rotator cuff tears and associated findings. Ultrasound is as accurate as MRI for full-thickness tears(100%) and the accuracy of ultrasonography and MRI in the diagnosis of partial tear was ranged between 91.6 -96.4% and 92.8-96.1% in respectively with no significant difference in the detection of the causes of shoulder pain and the evaluation the anatomical structures and pathological results

Our study has shown a lower sensitivity and specificity for partial-thickness rotator cuff tears than previous reports concerning ultrasonography, [17] and are similar to the MRI findings of published reports.[18,19] . When comparing our results with other previous studies [20, 21] we found consistency with their results where they found agreement between US and MRI in detection of rotator cuff tears. The sensitivity and specificity seen in our study differs from what was mentioned by Cullen et al., who reported a sensitivity of 89% and specificity of 100% in detection of full thickness tear and sensitivity of 79% and specificity of 94% in detection of partial thickness tears [22].

Similarly In a review done by Dinnes et al. [23] evaluated the diagnostic effectiveness of MRI and ultrasound, in the evaluation of a painful shoulder, with rotator cuff tears .They concluded that either MRI or ultrasound could be used for equal detection of full-thickness rotator cuff tears but that MRI is cost-effective test.[23]on the other hand studies have mentioned that US is reliable in detecting full-thickness rotator cuff tears, compared with MR imaging, but detection of partial-thickness tears has been controversial .[24-26]

This observed variation for results may be due to many possible reasons including the small sample sizes ,varying quality of imaging equipment in both MRI coils , field of view and US probes of a wide range of frequencies, as well ultrasonography is an operator dependant. The most significant weakness of the present study is that there are no surgically proved cases to confirm the imaging results.

V. CONCLUSION

The results showed no significant difference in the diagnostic results of ultrasonography and MR. MRI proved to be superior in detection of rotator cuff partial and full thickness tear and certain non rotator cuff related pathologies like bursa effusion, and ACJ. US showed good sensitivity, specificity and accuracy for detection of rotator cuff tears with agreement of both imaging results in diagnosis of full thickness tears. Combined with the lower cost and availability for ultrasound, we suggest that ultrasound may be the most suitable imaging method for screening for rotator cuff tears afforded that the examiner has been well trained. And we recommended to be used as a first line investigation modality in assessment of shoulder pain as well, for practitioners without ultrasound expertise, MRI can be used. For further advanced studies MR arthrography can be performed in cases in which ultrasound and MRI are not definitive, considering using larger sample size and using the harmonic imaging methods.

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