ORIGINAL RESEARCH PAPER

Volume - 14 | Issue - 06 | June - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE STUDY ON THE ROLE OF HIGH-RESOLUTION ULTRASOUND AND MAGNETIC RESONANCE IMAGING IN PATIENTS WITH SHOULDER PAIN

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ABSTRACT

Introduction: Shoulder pain is a common clinical problem arising from diverse pathologies. High-resolution ultrasound (USG) and magnetic resonance imaging (MRI) are both used to evaluate shoulder conditions (e.g., rotator cuff tears, subacromial bursitis, biceps tendon lesions, acromioclavicular (AC) joint arthropathy, glenohumeral (GH) effusion). Ultrasound is a dynamic and cost-effective modality, though operator-dependent, whereas MRI is the gold standard for detailed soft-tissue visualization. This study aimed to compare the diagnostic performance of US versus MRI in detecting various shoulder pathologies in patients with shoulder pain. **Materials And Methods:** We conducted a prospective observational study on 100 patients with shoulder pain. All patients underwent both shoulder US and MRI. Ultrasound examinations were performed with a high-frequency (5–15 MHz) linear transducer, and MRI was done on a 1.5 T scanner with a dedicated shoulder protocol. The images were interpreted independently by radiologists. Key pathologies assessed included rotator cuff (supraspinatus, subscapularis, infraspinatus) tendon tears, biceps tendon tendinosis or subluxation, subacromial-subdeltoid bursitis, AC joint osteoarthritis, and GH joint effusion. MRI findings served as the reference standard. Diagnostic performance of ultrasound was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and Cohen's kappa (κ) for each finding. **Results:** Ultrasound detected rotator cuff tears with good overall accuracy. For supraspinatus tears (51 confirmed on MRI), US sensitivity was 74.5% and specificity 85.7% (accuracy 80%, $\kappa = 0.60$); notably, US identified all 35 full-thickness tears but missed several small partial-thickness tears. US sensitivity for subscapularis tears was lower (61.1%) with moderate agreement ($\kappa = 0.22$) due to some false-positive calls of tendinosis as tears. Infraspinatus tears were less frequent; US showed 54.5% sensitivity but 95.5% specificity for infraspinatus tears ($\kappa = 0.52$). Ultrasound reliably detected biceps tendon abnormalities: tendinosis with 54.5% sensitivity and 92.1% specificity, and dynamic long-head subluxation with 50.0% sensitivity and 93.6% specificity (but only 54.7% sensitivity for mild tenosynovitis). Importantly, ultrasound was highly effective for subacromial-subdeltoid bursitis (91.7% sensitivity, 89.3% specificity, $\kappa = 0.78$) and AC joint osteoarthritis (93.1% sensitivity, 100% specificity, $\kappa = 0.88$). However, US was poor in detecting GH joint effusions, identifying only 2 of 30 effusions seen on MRI (6.7% sensitivity). Overall, across all pathologies, ultrasound demonstrated high specificity (few false positives) and moderate-to-high sensitivity for most lesions except GH effusion. Table 1 summarizes the performance metrics of US against MRI for each pathology. **Conclusion:** In this study, high-resolution ultrasound proved to have diagnostic performance approaching that of MRI for many common causes of shoulder pain. Ultrasound was especially effective in identifying full-thickness rotator cuff tears, subacromial bursitis, and AC joint degeneration with high accuracy, while offering advantages of real-time dynamic assessment and lower cost. MRI remained superior for detecting subtle intra-articular abnormalities (such as small joint effusions or labral lesions). Our findings support using ultrasound as a first-line imaging modality for shoulder pain, reserving MRI for more complex or inconclusive cases. This tiered imaging approach can expedite diagnosis and treatment while optimizing resource utilization without significant loss of diagnostic accuracy.

KEYWORDS

INTRODUCTION

Shoulder pain is a frequent musculoskeletal complaint, often related to rotator cuff pathology, impingement syndrome, or other soft-tissue abnormalities[1]. Imaging plays a key role in diagnosis. High-resolution ultrasound (USG) provides a dynamic, accessible evaluation of the shoulder and can visualize tendons, bursae, and superficial structures in real time. Magnetic resonance imaging (MRI), by contrast, offers comprehensive visualization of intra-articular and deep soft-tissue structures and is considered the reference standard for rotator cuff tears and other internal derangements. Previous studies and meta-analyses have suggested that ultrasound's diagnostic accuracy for rotator cuff tears is comparable to MRI in many cases [2,3]. Ultrasound is highly accurate for full-thickness rotator cuff tears, with reported sensitivity and specificity approaching MRI levels [2]. However, detection of partial-thickness tears and certain internal joint abnormalities may be less sensitive with US. Given the lower cost and greater availability of ultrasound, clarifying its performance relative to MRI is important for developing efficient imaging strategies.

In this study, we directly compared high-resolution shoulder ultrasound with MRI in patients with shoulder pain. We evaluated the ability of ultrasound to detect a range of shoulder pathologies (using MRI as the standard of reference) and analyzed its diagnostic performance (sensitivity, specificity, predictive values, accuracy, and inter-modality agreement). Our goal was to determine whether ultrasound can serve as an effective first-line imaging modality for common shoulder conditions and to identify scenarios where MRI provides additional diagnostic value.

MATERIALS AND METHODS

Study Design And Patients: This was a prospective, comparative diagnostic study conducted at a tertiary care teaching hospital from 2023 to 2024. After obtaining Institutional Ethics Committee approval, 100 adult patients (age > 18 years) with shoulder pain were recruited. All patients had clinical suspicion of rotator cuff or related soft-tissue pathology and were referred for imaging. Patients with acute fractures or dislocations evident on initial radiographs, those with prior shoulder surgery, and those with contraindications to MRI (e.g., pacemakers, severe claustrophobia) were excluded. Written informed consent was obtained from all participants. The sample size of 100 was predetermined to ensure a sufficient number of rotator cuff tear cases (at least ~20 full-thickness tears) for sensitivity analysis.

Imaging Protocol – Ultrasound: High-resolution ultrasound of the affected shoulder was performed using a modern ultrasound system (Philips EPIQ 5 or GE Voluson E6) equipped with a 5–15 MHz linear array transducer. All exams were performed by an experienced musculoskeletal radiologist (over 5 years of specialized experience) who was blinded to the MRI results. A standardized scanning technique was used, systematically evaluating all major shoulder structures [4]. The patient was examined in a seated position, and the following structures were evaluated in sequence: the long head of the biceps tendon in the bicipital groove (with dynamic internal/external rotation to assess stability), the subscapularis tendon (arm in external rotation), the supraspinatus tendon (scanned in a modified Crass position), the infraspinatus and teres minor tendons (posterior transverse scanning), the subacromial-subdeltoid bursa, the AC joint, and the posterior glenohumeral recess (for joint effusion). Real-time dynamic maneuvers were performed to evaluate impingement (arm abduction) and biceps tendon subluxation (during rotation). Ultrasound diagnostic criteria were as follows: a **full-thickness rotator cuff tear** was identified by a focal non-visualization of the tendon with a full-thickness defect and discontinuity, often with retracted edges and a cartilage interface echo; a **partial-thickness tear** was defined as a focal hypoechoic or mixed echotexture defect not extending through the entire tendon thickness (either on the bursal or articular side). Tendinosis was defined as tendon thickening with heterogeneous echotexture and hypoechoic foci but no discrete tear. **Biceps tendon subluxation/dislocation** was diagnosed if the long head of the biceps was observed out of the bicipital groove on dynamic rotation (or found medially displaced for dislocation). **Biceps tenosynovitis** was indicated by fluid surrounding the biceps tendon within its sheath. **Subacromial-subdeltoid bursitis** was defined by distension of the bursa with > 2 mm of fluid or synovial thickening. **AC joint osteoarthritis** was identified by cortical irregularity and osteophyte formation at the AC joint, joint space narrowing, and capsular bulging or small joint effusion at that joint. **Glenohumeral joint effusion** on US was assessed via the posterior axillary recess; an anechoic fluid collection distending the posterior capsule indicated an effusion. All ultrasound findings were recorded immediately in a structured report.

Imaging Protocol – MRI: MRI of the shoulder was performed on a 1.5 Tesla Siemens Magnetom Avanto scanner using a dedicated shoulder coil. The MRI protocol included standard sequences in axial, oblique coronal, and oblique sagittal planes (proton-density fat-saturated, T2-weighted, T1-weighted, and STIR sequences) to optimally visualize tendons, fluid, and soft-tissue anatomy. The MRI images were interpreted by a musculoskeletal radiologist blinded to the ultrasound results. MRI diagnostic criteria were considered the gold standard for the presence of pathology. On MRI, a **full-thickness rotator cuff tear** was diagnosed by tendon discontinuity with fluid signal filling the gap (for full-thickness tears) or a focal high-signal defect on T2-weighted images not extending through the entire tendon (for partial tears). Tendinosis was defined by tendon thickening and increased intrasubstance T2 signal without a discrete tear. Biceps tendon subluxation was noted if the long head of the biceps was not properly seated in the bicipital groove on axial images (medially displaced for subluxation or completely out of the groove for dislocation). Biceps tenosynovitis was indicated by T2 hyperintense fluid surrounding the biceps tendon in the bicipital sheath. Subacromial bursitis was identified by fluid distension of the subacromial-subdeltoid bursa on fluid-sensitive sequences. AC joint osteoarthritis was diagnosed by joint space narrowing, osteophytes, subchondral cysts, and periarticular edema; an AC joint effusion was noted by fluid distending the joint capsule. A GH joint effusion on MRI was defined by fluid distending the joint capsule, especially visible in the axillary recess or posterior recess.

Data Collection And Statistical Analysis: For each patient, the presence or absence of each pathology was recorded on ultrasound and compared to MRI. The pathologies of interest were: supraspinatus tendon tear (partial or full), subscapularis tear, infraspinatus tear, biceps tendon pathology (divided into tendinosis, tenosynovitis, and subluxation/dislocation), subacromial-subdeltoid (SA/SD) bursitis, AC joint degenerative changes, and GH joint effusion. Using the MRI findings as the reference standard, we calculated the diagnostic performance of ultrasound. Sensitivity, specificity, PPV, NPV, and overall accuracy were computed using standard definitions from 2×2 contingency tables for each pathology. We also calculated Cohen's kappa (κ) to assess agreement between ultrasound and MRI beyond chance; κ values were interpreted as: < 0.20 = slight agreement, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial, and > 0.80 = almost perfect agreement. Statistical analyses were performed using SPSS (v25) and Stata (v12) software. A p-value < 0.05 was considered statistically significant for any comparisons.

RESULTS

Patient Characteristics

Among the 100 patients, 56 were male and 44 female, with a mean age of 52.6 years (range 19–78). Fifty-seven patients had involvement of their dominant shoulder, and 28 patients reported a history of significant trauma preceding symptom onset. Prior conservative treatments (physiotherapy or injections) had been attempted in 30 patients. All patients underwent ultrasound and MRI within a two-week interval, with no interim interventions.

MRI-Confirmed Pathologies

On MRI (reference standard), rotator cuff tears were common: supraspinatus tears were present in 51% of patients (35 full-thickness, 16 partial-thickness), subscapularis tears in 18%, and infraspinatus tears in 11%. Regarding biceps tendon pathology, 11% of patients showed biceps tendinosis, 53% had tenosynovitis (fluid in the sheath), and 6% had a subluxation or dislocation of the long head of the biceps. Subacromial-subdeltoid bursitis was seen in 72 patients (72%), and AC joint degenerative changes in 72 patients (72%), reflecting the high prevalence of impingement and osteoarthritis in this cohort. Glenohumeral joint effusions were noted on MRI in 30 patients (30%).

Ultrasound Diagnostic Performance vs MRI

Overall, ultrasound demonstrated high specificity and good accuracy for most shoulder pathologies, with sensitivity varying by lesion type (see **Table 1** for detailed performance metrics). For rotator cuff tears, ultrasound correctly identified 38 of 51 MRI-confirmed supraspinatus tears, yielding 74.5% sensitivity and 85.7% specificity (accuracy 80%). All full-thickness supraspinatus tears were detected on US, whereas many small partial-thickness tears were missed. Ultrasound also detected all full-thickness subscapularis and infraspinatus tears seen on MRI, but showed lower sensitivity for partial tears (overall sensitivity ~61% for subscapularis, ~54.5% for infraspinatus). Specificity was high for infraspinatus (95.5%), indicating very few false positives, while for subscapularis ultrasound tended to over-call tears (specificity ~69.5% due to some false positives).

For biceps tendon abnormalities, ultrasound had moderate sensitivity (~50–55%) but high specificity (~92–94%) in diagnosing biceps tendinosis and dynamic subluxation/dislocation of the long head. In contrast, agreement on detecting mild biceps tenosynovitis (sheath fluid) was poor, with sensitivity and specificity each around 54–55%, reflecting inconsistent detection of small fluid amounts by the two modalities.

Ultrasound was highly effective in identifying subacromial-subdeltoid bursitis and AC joint arthrosis. It achieved 91.7% sensitivity and 89.3% specificity for bursitis, and 93.1% sensitivity and 100% specificity for AC joint degenerative changes, with κ values indicating substantial to near-perfect agreement with MRI for these findings.

The main limitation of ultrasound was in detecting glenohumeral joint effusions: ultrasound detected only 2 of 30 MRI-confirmed effusions, for a sensitivity of just 6.7%, although its specificity was 98.6% (virtually no false positives for effusion). In no case did ultrasound miss a full-thickness rotator cuff tear that was visible on MRI. Overall, ultrasound findings completely matched MRI for all assessed pathologies in 68% of patients. In the remaining cases, discrepancies were usually minor – most often ultrasound missed a small partial tear or effusion, or it falsely identified a tear where MRI showed only tendinosis.

Table 1: Diagnostic performance of ultrasound compared to MRI (reference standard) for various shoulder pathologies (N = 100).

Pathology	Sensitivity	Specificity	PPV	NPV	Accuracy	Cohen's κ (agreement)
Supraspinatus tear	74.5%	85.7%	84.4%	76.4%	80.0%	0.60 (Substantial)
Subscapularis tear	61.1%	69.5%	30.6%	89.1%	68.0%	0.22 (Fair)
Infraspinatus tear	54.5%	95.5%	60.0%	94.4%	91.0%	0.52 (Moderate)
Biceps tendinosis	54.5%	92.1%	46.2%	94.3%	88.0%	0.43 (Moderate)
Biceps tenosynovitis	54.7%	53.2%	56.9%	51.0%	54.0%	0.08 (Slight)
Biceps subluxation	50.0%	93.6%	33.3%	96.7%	91.0%	0.35 (Fair)
Subacromial bursitis	91.7%	89.3%	95.7%	80.6%	91.0%	0.78 (Substantial)
AC joint arthritis	93.1%	100.0%	100.0%	84.8%	95.0%	0.88 (Almost perfect)
GH joint effusion	6.7%	98.6%	66.7%	71.1%	71.0%	0.07 (Slight)

Values are given for sensitivity, specificity, positive predictive value

(PPV), negative predictive value (NPV), accuracy, and Cohen's kappa (κ) indicating US/MRI agreement. Ultrasound shows high specificity across most conditions and strong performance for full-thickness tears, bursitis, and AC joint changes, while sensitivity is lower for partial-thickness tears and very low for small GH effusions.

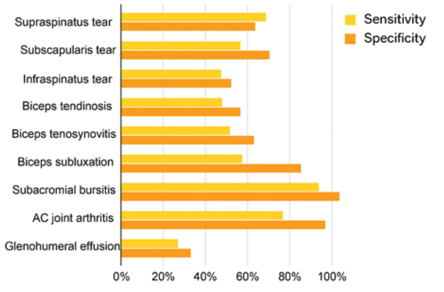

Figure 1: Bar chart comparing ultrasound vs MRI sensitivity (yellow bars) and specificity (orange bars) for various shoulder pathologies. Ultrasound demonstrates high sensitivity and specificity for subacromial bursitis and AC joint arthritis (approaching MRI's performance). Sensitivity for supraspinatus tears is moderate (~75%) with specificity ~86%. Ultrasound is less sensitive for subscapularis and infraspinatus tears (~55–60% sensitivity) although specificity remains high (≥ 70–95%). Biceps tendinosis and subluxation show moderate sensitivity (~50–55%) but high specificity (~92–94%). Biceps tenosynovitis has balanced sensitivity/specificity (~55%), indicating the difficulty of assessing mild sheath fluid. Glenohumeral effusions are an outlier, with ultrasound detecting under 10% of small effusions despite nearly 99% specificity. Overall, ultrasound is a highly specific tool with variable sensitivity across different shoulder pathologies.

DISCUSSION

Our findings indicate that high-resolution shoulder ultrasound can serve as an excellent diagnostic tool for many causes of shoulder pain, with performance that in most respects approaches that of MRI. In this study, ultrasound accurately identified the majority of rotator cuff tears, bursal inflammation, and biceps and AC joint abnormalities, closely matching MRI for these key pathologies. These results reinforce prior evidence that musculoskeletal ultrasound, when performed by an experienced operator, is highly effective for evaluating shoulder disorders [2,5,6]. Given its substantial agreement with MRI in detecting clinically significant lesions, ultrasound can be confidently used as a first-line imaging modality for rotator cuff–related shoulder pain.

Consistent with earlier studies, we found that ultrasound and MRI have comparable accuracy in diagnosing rotator cuff tears [2,5-7]. Ultrasound was particularly reliable for full-thickness tears – in our series it detected all full-thickness rotator cuff tears that were seen on MRI, echoing the near-equivalent sensitivity reported in meta-analyses [2,5]. Partial-thickness tears proved more challenging for ultrasound, with roughly 50–60% of MRI-confirmed partial tears being detected sonographically. This limitation is well-recognized: small articular-surface tears may not be evident on US if they do not disrupt the bursal contour, whereas MRI's fluid-sensitive sequences can highlight them. Notably, even MRI can miss some partial tears; for example, Duque et al. (2025) found MRI detected only ~54% of subscapularis lesions while US detected ~26% in their surgical cohort [8]. Nonetheless, studies have shown that these differences are usually not clinically significant [6,7], and overall diagnostic accuracy for any rotator cuff tear is similar between the modalities in experienced hands. Our results support that notion – while ultrasound missed some minor partial tears, it did not miss any major tears that would change management.

One advantage of ultrasound is the ability to perform dynamic assessments. We observed that ultrasound could demonstrate long head of biceps tendon subluxations during arm rotation that were not captured on static MRI images. This dynamic capability has been highlighted by other authors [9,10]. All cases of complete biceps tendon dislocation in our study were readily identified on ultrasound (and MRI), but subtle intermittent subluxations were better appreciated with the real-time ultrasound exam. Ultrasound's moderate sensitivity for biceps tendinosis in our study (~55%) suggests some mild degenerative changes were missed compared to MRI; however, these subtle findings often do not alter patient management significantly.

Ultrasound excelled in detecting subacromial-subdeltoid bursitis and AC joint osteoarthritis in our patients, in line with prior research [11,12]. It had high sensitivity and specificity for both conditions, confirming that ultrasound is very reliable for evaluating peri-tendinous effusions and peripheral joint degeneration. In practice, this means that if a patient has clinical impingement signs or AC joint pain, an ultrasound can immediately confirm bursitis or AC joint arthrosis and even be used to guide therapeutic injections in the same session. These are clear practical advantages of ultrasound. Conversely, ultrasound was very poor at identifying small glenohumeral joint effusions, which was expected since intra-articular fluid in the deep joint recesses is difficult to visualize sonographically. MRI is far more sensitive to such effusions and related intra-articular pathology [14]. Therefore, a normal ultrasound cannot exclude a small GH effusion or labral injury if clinical suspicion is high—MRI should be obtained for comprehensive intra-articular assessment.

Operator expertise is an important factor in ultrasound diagnostics. Our study was conducted by a highly experienced musculoskeletal radiologist, which likely contributed to the high accuracy achieved. Ultrasound is known to be operator-dependent, and training and standardized scanning protocols are crucial to obtaining good results [4]. With proper technique, literature indicates that ultrasound's diagnostic accuracy for rotator cuff tears can reach into the 90% range, comparable to MRI [14]. In community settings with less experienced operators, sensitivity might be lower, so investing in training and skill development is important if an ultrasound-first approach is adopted. If an ultrasound study is negative but clinical suspicion for a tear remains strong, it is prudent to follow up with MRI or a repeat ultrasound by an expert rather than assume absence of pathology.

One of the motivations for using ultrasound as an initial imaging test is its cost-effectiveness and accessibility. Ultrasound is significantly less expensive than MRI and is readily available in most clinical settings, often allowing immediate or same-day imaging. An "ultrasound-first" strategy for shoulder pain has been recommended by other investigators as the most economical approach, with MRI reserved for cases where surgery is planned or ultrasound findings are inconclusive [6,14]. Our findings support this tiered strategy: in the majority of patients, ultrasound provided the necessary diagnostic information, and MRI could be saved for the subset of patients who required further detail (for example, in our study MRI was mainly needed to confirm small intra-articular lesions or to map tear retraction for surgery). The potential cost savings and improved patient convenience (avoiding MRI wait times or contraindications) are substantial benefits of this approach.

Our study also contributes data from an Indian tertiary center that align with results reported in Western and other Asian populations [13,14]. This generalizability suggests that the diagnostic performance of shoulder ultrasound is robust across different healthcare settings when performed by skilled examiners. Additionally, in certain scenarios ultrasound may even be preferable to MRI. For instance, in patients undergoing revision shoulder surgery or pre-arthroplasty evaluation, ultrasound has been shown to accurately assess rotator cuff integrity without the susceptibility to metal artifacts that limits MRI [15]. Fischer et al. reported that ultrasound had over 90% accuracy for supraspinatus tendon integrity in the presence of shoulder arthroplasty hardware, recommending ultrasound as the preferred modality in that context [15].

Limitations: This study used MRI as the reference standard for comparison, which is a practical and ethical choice but not a perfect gold standard. MRI itself can have false negatives or positives (particularly for small partial tears or tendinopathy). We did not have surgical verification for all cases, so some MRI findings assumed to be true positives might not represent full-thickness lesions (though MRI's accuracy for full tears is very high). Our ultrasound findings reflect the performance of a single experienced operator and may not be reproducible in all settings; results could vary with different sonographers or equipment. Additionally, the prevalence of pathology in our sample was relatively high, which may influence predictive values (in a population with fewer tears, the negative predictive value of ultrasound would be even more critical). We also limited our evaluation to pathologies amenable to ultrasound; we did not assess labral tears, intra-articular loose bodies, or other conditions that ultrasound cannot visualize.

Future Directions: Future research could investigate patient outcomes and cost-benefit implications of an ultrasound-first diagnostic pathway for shoulder pain. For example, it would be useful to determine if an initial ultrasound (with MRI only as needed) leads to outcomes comparable to an MRI-first approach for certain patient groups. Technological advances in ultrasound, such as elastography or 3D ultrasound, may further improve its sensitivity for partial tears and reduce operator dependence; these developments warrant exploration.

CONCLUSION

High-resolution ultrasound is a valuable first-line diagnostic tool in the evaluation of shoulder pain, demonstrating diagnostic performance comparable to MRI for many key shoulder pathologies. In this study of 100 patients, ultrasound was especially effective in identifying full-thickness rotator cuff tears, subacromial-subdeltoid bursitis, and AC joint osteoarthritis with excellent specificity and strong agreement with MRI. While MRI remains superior for detecting subtle intra-articular abnormalities (such as small joint effusions or labral tears), the overall concordance between ultrasound and MRI findings was high for clinically significant lesions. A tiered imaging strategy is supported by these results: ultrasound can be utilized as the initial, cost-effective screening modality for most soft-tissue shoulder conditions, with MRI reserved for cases that require additional detail or surgical planning. Broad adoption of shoulder ultrasound as a first-line imaging technique could improve patient access to timely diagnosis and reduce costs, without compromising diagnostic accuracy. We recommend that clinicians consider high-resolution ultrasound as the primary imaging evaluation for shoulder pain (particularly for suspected rotator cuff tears and impingement-related problems), using MRI in a complementary second-line role when needed. This strategy leverages the strengths of each modality and can ultimately enhance patient care by providing accurate and expedient diagnoses. Future larger-scale studies, including those with surgical gold standards, will further clarify the specific scenarios in which ultrasound can fully replace MRI and those in which MRI provides incremental value.

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