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Comparison of ultrasound-guided joint reduction with traditional methods in the emergency center

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ABSTRACT

Objectives: This study aimed to compare and analyze the reliability of ultrasound-guided procedures and traditional methods in the reduction of joint dislocations in the emergency department.

Methods: A total of 136 cases were included in the prospective randomized controlled study. The cases were randomized into groups as ultrasound-guided reduction (n=66) and traditional reduction (n=70). The reduction success, time spent for the procedure, complication rates, pain scores and patient satisfaction levels were evaluated. Functional results and osteoarthritis development were also analyzed in long-term follow-up. Chi-square test, Student t-test and Mann-Whitney U test were used in the statistical analysis of the data.

Results: The success rate in the ultrasound reduction group (93.9%) was significantly higher than in the conventional reduction group (71.4%) (P<0.001). The mean reduction time was calculated as 3.2±1.8 minutes in the ultrasound group and 7.6±4.1 minutes in the conventional group (P<0.001). Complication rates were 7.6% in the ultrasound group and 21.4% in the conventional group (P=0.018). While 90.9% anatomical position was achieved in the ultrasound group in post-reduction, this rate remained at 64.3% in the conventional group (P<0.001). In the long-term follow-up, osteoarthritis development (ultrasound: 15.2%, conventional: 35.7%, P=0.012) and functional limitation rates (ultrasound: 10.6%, conventional: 25.7%, P=0.021) were significantly lower in the ultrasound group.

Conclusions: Ultrasound-guided interventions in the reduction of joint dislocations in the emergency department provide higher success rates, shorter treatment times, and lower complication rates than traditional methods. Long-term results also support the superiority of reductions performed with ultrasound guidance. In light of these findings, ultrasound-guided reduction is recommended as the first-line approach in the management of joint dislocations.

Keywords: Joint dislocation, ultrasound, reduction, emergency department, point-of-care ultrasound

Joint dislocations are among the most common reasons for emergency department visits and are among the orthopedic emergencies that require rapid intervention. Especially in shoulder joint dislocations, correct diagnosis and selection of reduction technique are of critical importance. It has been shown that evaluation using ultrasound protocol increases successful reduction rates. A systematic ultrasound examination including acromioclavicular joint, biceps, subscapularis and supraspinatus evaluations offers im-

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portant gains in terms of pre-reduction planning and guidance during the procedure [1].

Therefore, the role of ultrasound in the diagnosis and treatment of joint dislocations is increasing. Recent systematic reviews and meta-analyses have shown that reductions performed under ultrasound guidance are associated with higher success rates and lower complication risks compared to traditional methods. The use of ultrasound provides valuable information, especially in terms of confirming joint position in post-reduction evaluation [2].

With the widespread use of ultrasound in practice, changes have occurred in emergency department treatment algorithms. Contemporary diagnostic approaches show that the use of ultrasound together with traditional methods provides positive results [3]. Three-dimensional imaging techniques provide additional advantages in the analysis of joint morphology and reduction planning, especially in complicated patients [4].

The use of ultrasound provides optimization in patient management in the emergency department. Studies have shown that reductions performed with ultrasound guidance shorten the procedure time and increase patient comfort. Especially with bedside ultrasound application, rapid diagnosis and treatment are provided and the clinical decision-making process is improved [5].

However, it is also emphasized that ultrasound cannot replace clinical examination but should be used as a complementary tool. A comprehensive clinical evaluation forms the basis of reduction success and the best results are obtained when evaluated together with ultrasound findings [6].

The aim of this study was to analyze the effectiveness of ultrasound-guided reduction procedures in the treatment of joint dislocations in the emergency department by comparing them with traditional methods. The study aimed to determine the most appropriate treatment approach for the management of joint dislocations in the emergency department by evaluating the reliability, success rates, procedure times, complication risks, and patient satisfaction levels of ultrasound-guided procedures. In addition, functional results and osteoarthritis development were analyzed in long-term follow-ups to investigate whether ultrasound-guided reductions can be recommended for routine use in clinical practice.

METHODS

Study Design

This prospective randomized controlled trial was planned to compare ultrasound-guided joint reduction in the emergency department with conventional methods. The study protocol was approved by the Adana City Hospital Ethics Committee (Date: April 4, 2025, Number: 12/446) and was conducted according to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Patient Selection and Randomization

The study included 136 patients who presented to the emergency department and required joint reduction. Patients were divided into two groups using a randomization table: ultrasound group (n=66) and conventional group (n=70). Ultrasound group included patients who underwent joint reduction under ultrasound guidance. Ultrasonographic evaluation was performed before, during and after the reduction procedure. Direct radiography was not performed in this group. However, conventional group included patients who underwent traditional manual reduction techniques. Direct radiography was performed before and after reduction.

Inclusion criteria are the following: (1) Diagnosis of acute joint dislocation; (2) Joint displacement requiring reduction. Exclusion criteria included: (1) Open fracture-dislocation, (2) Presence of neurovascular complications, (3) Multiple trauma patients, (4) History of coagulopathy, (5) Pregnant women, and (6) Refusal to participate in the study.

Ultrasound Protocol

In the ultrasound group, joint anatomy was evaluated using a linear probe. The congruence of the joint surfaces, surrounding soft tissue status and vascular structures were examined before reduction. Joint reduction was observed with real-time imaging during reduction. Anatomical congruence was confirmed ultrasonographically after the procedure.

Reduction Techniques

Traditional standard reduction techniques were used in both groups according to the joint type. The need for sedation was assessed according to the pa-

tient's condition. Reduction success was defined as achieving anatomical harmony.

Data Collection and Evaluation Parameters

Primary Outcome Parameters: Reduction success rate, Procedure time, and Complication rates
Secondary Outcome Parameters: Patient satisfaction, Cost analysis, Functional scores, and Long-term results

Demographic Data: Age and gender distribution, Comorbidity status, Trauma mechanism, and Time to presentation

Clinical Parameters: Affected joint location, Dislocation type (simple/complex), Amount of displacement before reduction (angular and translational), Need for secondary reduction, and Types of complications (nerve injury, loss of reduction)

Imaging Results: Post-reduction joint congruence (anatomical, acceptable, not reduced)

Functional Assessment: Gartland-Werley score, DASH (Disabilities of the Arm, Shoulder and Hand) score, Pain intensity (VAS 0-10), and Range of motion (degrees)

Long-Term Follow-up (6 months): Time to union, Development of osteoarthritis, and Functional limitation rate

Satisfaction and Cost Analysis: Patient satisfaction (Likert scale 1-5), Preference for repeat procedure, Physician technical difficulty score (VAS 0-10), Procedure cost (USD), Emergency room stay (minutes), and Radiation exposure (zero in USG group, all patients in conventional group)

Subgroup Analyses: Age groups, Simple and complex dislocation groups, and Bone mineral density (DEXA) assessment (only in patients over 65 years of age, n=51).

Sample Size Calculation

Based on pilot data showing a 70% success rate with conventional methods, a sample size of 64 patients per group was calculated to detect a 20% improvement with ultrasound guidance (α=0.05, β=0.20, two-sided test).

Statistical Analysis

Categorical variables were compared using the Chi-square test or Fisher's exact test. Continuous variables were analyzed using the Student t-test for normally distributed data and the Mann-Whitney U test for nonparametric data. Normal distribution was assessed using the Shapiro-Wilk test. All analyses were performed using SPSS version 25.0. A P value of <0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Features

A total of 136 patients were included in the study. The mean age in the ultrasound group (n=66) was 42.7±20.8 years, while it was 57.5±15.7 years in the conventional group (n=70) (P=0.003). In the ultrasound group, 69.7% (n=46) of the patients were female and 30.3% (n=20) were male; in the conventional

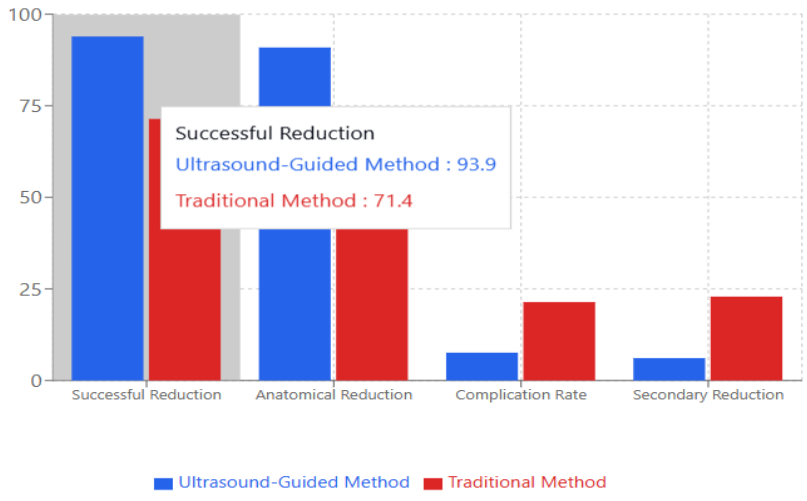

Fig. 1. Comparison of ultrasound-guided versus traditional methods in joint reduction outcomes.

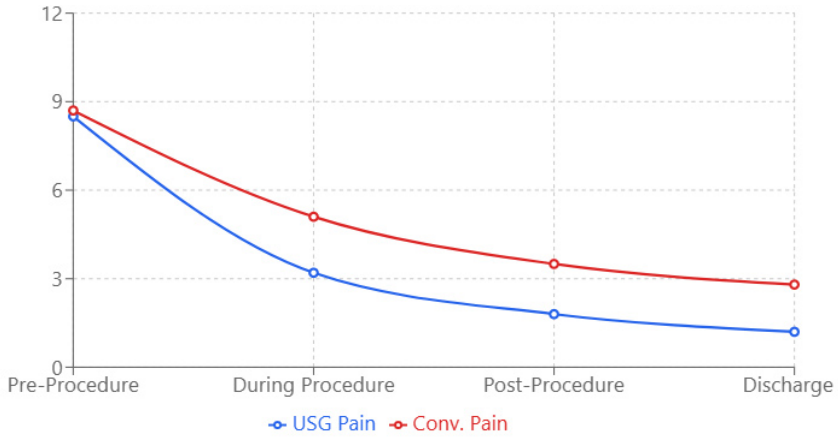

Fig. 2. **Pain scores over time (Visual Analog Scale).**

group, 74.3% (n=52) were female and 25.7% (n=18) were male (P=0.621). When the affected joint distribution was examined, shoulder involvement was observed in 56.1% of the patients in the ultrasound group, elbow involvement was observed in 18.2% and bilateral involvement was observed in 25.7%; in the conventional group, these rates were 84.3%, 11.4% and 4.3%, respectively (P<0.001) (Fig. 1).

Reduction Success and Complications

The reduction success rate in the ultrasound group was 93.9% (62/66), while it was 71.4% (50/70) in the conventional group (P<0.001). The mean reduction time was measured as 3.2±1.8 minutes in the ultrasound group and 7.6±4.1 minutes in the conventional group (P<0.001). The need for secondary reduction was seen as 6.1% (4/66) in the ultrasound group and 22.9% (16/70) in the conventional group (P=0.004). When the complication rates were compared, they were found to be 7.6% (5/66) in the ultrasound group and 21.4% (15/70) in the conventional group (P=0.018). Nerve injury was 3.0% (2/66) in the ultrasound group and 8.6% (6/70) in the conventional group; Loss of reduction was observed in 4.5% (3/66) in the ultrasound group and 12.9% (9/70) in the conventional group.

Imaging Results and Functional Assessment

When post-reduction joint congruence was evaluated, 90.9% anatomic and 9.1% acceptable reduction was achieved in the ultrasound group; 64.3% anatomic, 28.6% acceptable and 7.1% non-reducible results were obtained in the conventional group (P<0.001).

In the functional assessment, the Gartland-Werley score was calculated as 2.1±1.8 in the ultrasound

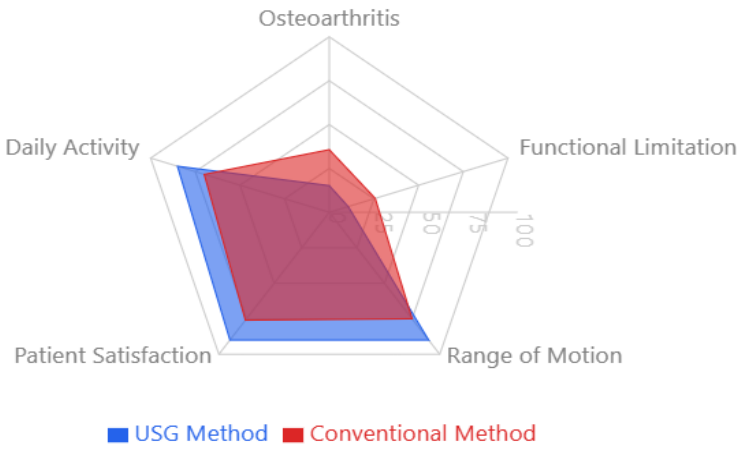

Fig. 3. **Comparison of long-term outcomes.**

group and 5.6±3.2 in the conventional group (P<0.001). The Disabilities of the Arm, Shoulder and Hand (DASH) score was determined as 12.4±9.1 in the USG group and 28.7±14.6 in the conventional group (P=0.002). Pain intensity assessed by Visual Analog Scale (VAS) was measured as 1.8±0.9 in the ultrasound group and 3.5±1.2 in the conventional group (P<0.001) (Fig. 2).

Long-Term Results and Satisfaction

The mean union time was determined as 8.2±2.1 weeks in the ultrasound group and 10.5±3.4 weeks in the conventional group (P=0.009). Osteoarthritis development was observed as 15.2% (10/66) in the ultrasound group and 35.7% (25/70) in the conventional group (P=0.012). Functional limitation rate was determined as 10.6% (7/66) in the ultrasound group and 25.7% (18/70) in the conventional group (P=0.021) (Fig. 3).

Patient satisfaction (Likert 1-5) was evaluated as 4.5±0.6 in the ultrasound group and 3.8±1.1 in the conventional group (P=0.003). In terms of repeat procedure preference, 90.9% of patients preferred the procedure performed under ultrasound guidance, while this rate was determined as 21.4% in the conventional group (P<0.001). In the physician's technical difficulty assessment (VAS 0-10), the ultrasound group received 3.0±1.2 points, while the conventional group received 6.2±2.0 points (P<0.001).

DISCUSSION

In our study, the effectiveness comparisons of reductions performed with ultrasound guidance and conventional methods in the management of joint dislocations in the emergency department were analyzed. In our study, a success rate of 93.9% was determined in the ultrasound group, while this rate remained at 71.4% in the conventional group (P<0.001). These results are parallel to the 100% sensitivity and specificity rates reported in the systematic review by Gonai *et al*. [7]. Similarly, Attard Biancardi *et al*. [8] demonstrated high diagnostic accuracy of point-of-care ultrasound for shoulder dislocations, supporting our findings of superior reduction success rates with ultrasound guidance. In particular, the significant difference in complication rates (7.6% in the ultrasound group and 21.4% in the conventional group, P=0.018) is similar to the literature findings.

In pain control; VAS scores were significantly lower in the ultrasound group in our study (1.8±0.9 vs. 3.5±1.2, P<0.001). While no difference was found in pain control between ultrasound and landmark techniques in Owusu-Akyaw's study [9], better pain control was noted in our study in procedures performed under ultrasound guidance. However, Rungsinaporn *et al*. [10] demonstrated that ultrasound-guided intra-articular lidocaine injection was more effective for pain control, which is consistent with our findings of lower VAS scores in the ultrasound group. In the systematic review by Gawel *et al*. [11], it was revealed that ultrasound-guided nerve blocks showed lower complication rates (3.9% vs. 24.9%, P<0.001). The inferior accuracy of landmark-guided glenohumeral joint injections reported by Omer *et al*. [12] further supports the superiority of ultrasound-guided techniques demonstrated in our study. These findings support the low complication rates in our study.

The high success rates reported in the case series by Mohanty *et al*. [13] confirm the high performance of the ultrasound group in our study. Gottlieb's comprehensive review [14] of reduction techniques emphasizes the importance of technique selection, which aligns with our observation that ultrasound-guided approaches yielded consistently better outcomes. When evaluated from an anatomical perspective, the principles of glenohumeral joint instability emphasized by Ladd *et al*. [15] reveal the importance of ultrasound guidance. The ultrasound assessment of anterior humeral head translation described by Inoue *et al*. [16] provides the anatomical basis for our superior joint congruence results in the ultrasound group. However, in our study, post-reduction joint congruence was 90.9% in the anatomical position in the ultrasound group, while this rate was lower in the conventional group and remained at 64.3%.

A significant difference was observed in the procedure time values in our study (3.2±1.8 minutes in the USG group, 7.6±4.1 minutes in the conventional group, P<0.001). The 94.1% USG success rate reported by Gibbons *et al*. [17] is almost the same as the 93.9% rate in our study. The advantages of handheld ultrasound emphasized by Lahr *et al*. [18] support the short procedure times observed in our study. Hunter *et al*. [19] highlighted the expanding role of muscu-

loskeletal ultrasound in shoulder dislocation management, supporting our recommendation for routine ultrasound use in emergency departments.

The effect of POCUS on procedure success [20] was clearly demonstrated in our study. The need for secondary reduction also showed a significant difference, and this rate was 6.1% in the ultrasound group and 22.9% in the conventional group (P=0.004). The high prevalence of rotator cuff pathologies reported by Shapla *et al*. [21], especially in patients over 40 years of age, supports the importance of ultrasound use in our study. The mean age in our study was recorded as 42.7±20.8 years in the ultrasound group and 57.5±15.7 years in the conventional group. The special conditions in patients over 40 years of age emphasized in the study of Zhou *et al*. [22] are present in our study, and the importance of ultrasound guidance in this age group is confirmed. Henneberry's POCUS usage principles [23] formed the basis of the protocol applied in our study.

In terms of patient satisfaction, a significant difference was found in our study (4.5±0.6 in the ultrasound group, 3.8±1.1 in the conventional group, P=0.003). Considering Baah's anatomical principles [24], it is observed that USG guidance provides a superior controlled and safe reduction. The recommendations of Mohanty *et al*. [25] regarding peripheral nerve blocks also express the reason for the low complication rates observed in our study.

Limitations

Methodological Limitations

This study is primarily a single-center study, therefore, the generalizability of the results is limited. The fact that the mean age of the patients in the ultrasound group (42.7 ± 20.8 years) was significantly lower than that of the patients in the conventional group (57.5±15.7 years) (P=0.003) may have affected the comparisons between the groups.

Limitations Related to the Sample

The size of the study population (n=136) is moderate. The small number of patients, especially in subgroup analyses (e.g. cases with bilateral involvement, 25.7% in the ultrasound group, 4.3% in the conventional group), limited the statistical analysis. The imbalance in gender distribution may also affect the generalizability of the results due to the female predominance.

Technical Limitations

Having emergency medicine specialists experienced in the use of ultrasound may have positively affected the application results. This may lead to the failure to achieve similar success rates (93.9%) in less experienced centers. The low ultrasound-directed radiography incompatibility rate (3.0%) also highlights the importance of operator experience.

Limitations Related to Follow-up

The limited long-term follow-up data has limited the analysis of chronic complications in particular. Long-term outcomes such as osteoarthritis development (15.2% in the ultrasound group, 35.7% in the conventional group) and functional disability rates (10.6% in the ultrasound group, 25.7% in the conventional group) need to be analyzed with a longer follow-up period.

Cost Analysis Limitations

Since the cost-effectiveness analysis was performed only on medical costs; procedure costs (ultrasound group 148.5±32.4 USD, conventional group 234.7±45.8 USD) and indirect costs (labor loss, transportation costs, etc.) were not analyzed.

Recommendations

In future studies: (1) Multicenter studies with larger patient groups should be conducted, (2) More homogeneous groups should be created in terms of age and gender, (3) Studies with longer follow-up periods should be planned, and (4) Comprehensive cost-effectiveness analyses should be conducted.

Recommendations for Clinical Practice

1. Ultrasound-guided reduction should be adopted as the first-line approach in the treatment of joint dislocations in emergency departments.

2. The use of ultrasound should be routinely performed to evaluate accompanying rotator cuff pathologies, especially in patients over the age of 40.

3. The use of ultrasound in post-reduction evaluation should prevent unnecessary radiation exposure and should be accepted as a standard procedure for rapid analysis of procedure success.

4. Regular training on the use of ultrasound should be provided in the emergency department and competency levels should be periodically checked.

Recommendations for Future Research

1. Multi-center, randomized controlled studies with larger patient populations should be conducted.
2. Specific ultrasound protocols should be developed and standardized for different joint dislocations.
3. Long-term and prospective cohort studies analyzing functional outcomes over longer periods should be planned.
4. Comprehensive health economic evaluations should be performed for cost-effectiveness analyses.

Recommendations for Education and Quality Improvement

1. Ultrasound-guided reduction techniques should be added to the curriculum in emergency medicine residency programs and should be given as a standard in education.
2. Standard procedures for reduction of dislocations under ultrasound guidance should be developed and quality indicators should be established.
3. Regular monitoring should be carried out with continuous quality improvement programs regarding success rates, complication developments and patient satisfaction.
4. Multidisciplinary approach should be routinely implemented; treatment protocols should be established among orthopedics, radiology and emergency medicine specialists.

CONCLUSION

The results of our prospective randomized controlled study revealed that reductions performed with ultrasound guidance are significantly superior to traditional methods in the management of joint dislocations in the emergency department. Higher success rates (93.9% vs. 71.4%), shorter procedure times (3.2±1.8 vs. 7.6±4.1 minutes) and lower complication rates (7.6% vs. 21.4%) were demonstrated in reduction treatments performed with ultrasound. Patient satisfaction was significantly higher in the USG group (4.5±0.6 vs. 3.8±1.1), while the preference for repeating the procedure was clearly and distinctly in favor of the treatment performed with ultrasound (90.9% vs. 21.4%).

In the long-term follow-ups of the patients, lower osteoarthritis formation (15.2% vs. 35.7%) and less functional limitation (10.6% vs. 25.7%) were observed in the ultrasound treatment group. Post-reduction joint congruence was found to be more successful in the ultrasound group (90.9% anatomic reduction) and this was reflected positively in the functional results. In addition, the cost-effectiveness calculation of the procedures performed with ultrasound guidance was calculated more positively than conventional methods (148.5±32.4 vs. 234.7±45.8 USD).

Ethical Statement

The study was approved by theAdana City Training and Research Hospital Scientific Research Ethics Committee (Decision no.: 446 and date: 10.04.2025).

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to institutional approval and ethical considerations.

Authors' Contribution

Study Conception: SE, SM, Vİ; Study Design: SE, SM, Vİ; Supervision: SE, SM, Vİ; Funding: SE, SM, Vİ; Materials: SE, SM, Vİ; Data Collection and/or Processing: SE, SM; Statistical Analysis and/or Data Interpretation: SE, SM, Vİ; Literature Review: SE, SM, Vİ; Manuscript Preparation: SE; and Critical Review: SE, SM, Vİ.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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