

A Review Study Will Be Conducted to Determine the Health Outcomes and Benefits of Using Ultrasound in the Treatment of Elbow Fractures

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Abstract: Background: Regardless of the positive outcomes of prior studies concerning the value of ultrasound in diagnosing elbow fractures among children, the determinants of accuracy of the examined imaging technique are still under discussion. Therefore, in this systematic review, our objective was to analyze available studies on the accuracy of ultrasonography in evaluating elbow fractures. **Patients and Methods:** We conducted a retrospective study on pediatric elbow fracture patients, which included 72 cases aged 4-14 years, both males and females. All included studies of patients were collected from Scopus and Web of Science of patients during the period from January 2023 to January 2024. To achieve the study objective, our study evaluated all the collected studies using a quality assessment tool in terms of the quality of ultrasound in pediatric fractures. **Results:** A total of last review studies were performed in children with elbow fractures which all collected in this study. The pooled outcomes of the ultrasound technique following sensitivity was 0.94 (0.90 – 0.98); specificity was 0.85 (0.82 – 0.92); positive was 63.57%; negative was 0.16%; Diagnostic ratio = 88.63%; and accuracy rate = 95.23%. **Conclusion:** Through our evaluation, we found that ultrasonography can be considered as a useful diagnostic imaging technique to detect elbow fractures in children.

Keywords: Children; Elbow Fractures; Ultrasound.

INTRODUCTION

Elbow trauma is a usual cause of acute care visits among the pediatric population, particularly in hospital emergency rooms. Previous study shows that elbow fractures comprise around 15% of fractures of children. [Fleisher, G. R. *et al.*, 2010 – Rabiner, J. E. *et al.*, 2013]

As children with elbow injuries cannot take part in the assessment and history review, the clinical diagnosis is often complicated. Hence, the early evaluation is usually done with direct X-ray imaging in two perpendicular planes [Eckert, K. *et al.*, 2014; Burnier, M. *et al.*, 2016]. Children who have sustained elbow injury and present with pain and anxiety are not easy to take the exact standard views. Also, failure to demonstrate well-delineated features such as the bony ossification centers, complicated, incomplete fractures, and non-calcified growth plates can further limit the diagnostic usefulness of radiographs in elbow fracture evaluation. [Alzen, G. *et al.*, 1992 – Brenner, D. J. *et al.*, 2003]

Although the majority of elbow fractures may be assessed with simple two-plane X-rays, the interpretation of these X-rays is contingent upon the physician's expertise, and such fractures may not be readily diagnosed or identified. In cases when radiographic assessment for elbow fractures is insufficient, computed tomography (CT) scans

could be used as alternate imaging modalities. [Bonney, O. *et al.*, 2006 – Donnelly, L. *et al.*, 1998]

Nevertheless, the use of CT scans and radiography in pediatric patients ought to be limited in order to prevent radiation exposure. Several studies suggest that ultrasonography can be appropriately used in the emergency setting for elbow fracture diagnosis without exposing the patient to any ionizing radiation [Hart, E. S. *et al.*, 2010-Hübner, U. *et al.*, 2000]

Despite prior assessments on the advantages of using ultrasonography in evaluating elbow fractures in paediatric patients, the issue of the precise diagnostic accuracy of this imaging technique is yet a subject of discussion, primarily due to the experience of the operator. [Douma-den Hamer, D. *et al.*, 2016; Schmid, G. L. *et al.*, 2017; Joshi, N. *et al.*, 2013]

PATIENTS AND METHODS

Study Methodology Strategies

Our study conducted a systematic and comprehensive review of previous studies and publications that specialized in the effect of ultrasound on pediatric patients with elbow fractures. During the period between January 2023 and January 2024, the included studies were

collected on 72 samples of children with elbow fractures under 15 years old.

Participants Data

Our researchers collected and evaluated all included studies on pediatric patients with elbow fractures to achieve the diagnostic performance and effect of ultrasound on children with elbow fractures. Our study also established a reference standard in terms of imaging the elbow of children by X-ray, computed tomography, or magnetic resonance imaging (MRI) for the purpose of diagnosing elbow fractures. We evaluated and calculated the sensitivity and specificity of ultrasound by using both true positive results (TP), false positive results (FP), true negative results (TN), and false negative results (FN) for the

purpose of determining the diagnostic accuracy of ultrasound.

Statistical Analysis

In our study, we employed SPSS version 22.0 in conducting the design and analysis of findings of children with elbow fractures. The heterogeneity among the included studies was quantified using the I2 and P- values of Cochran’s Q-statistic. A significant heterogeneity was assumed between the included studies I2>50% or P<0.05, and then the Der Simonian-Laird approach (random-effects model) was performed. Correlation calculation between the log of sensitivity and (1 - specificity) was performed in order to investigate the threshold effect as a source of the heterogeneity.

RESULTS

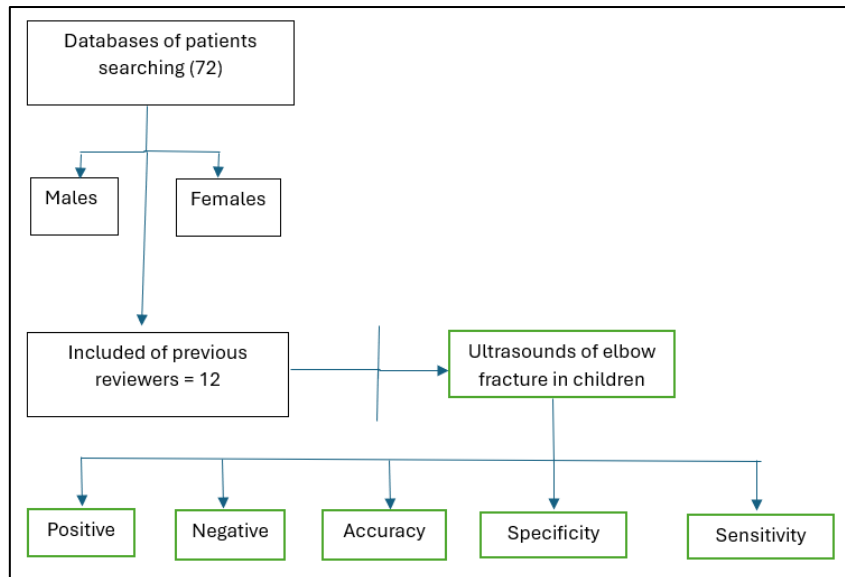


Figure 1: A flowchart performing of previous reviews which assessed the extend of ultrasound's accuracy in diagnoses of children with elbow fractures.

Table 1: - Measurements of ultrasound sensitivity in the diagnosis of children with elbow fractures according to all collected study.

All reviews	Sensitivity (95 % CI)
Ludwig, et al.,	0.94 (0.75 – 0.97)
Crowther, et al.,	0.96 (0.91 – 0.98)
Rabiner, et al.,	0.84 (0.72 – 0.94)
Eckert, et al.,	0.53 (0.18 – 0.85)
Burnier, et al.,	0.81 (0.51 – 0.93)
Alzen, et al.,	0.86 (0.48 – 0.95)
Benz-Bohm, et al.,	0.99 (0.68 – 0.83)
Bonnefoy, et al.,	0.81 (0.55 – 0.95)
Donnelly, et al.,	0.92 (0.58 – 0.97)
Hart, et al.,	0.87 (0.48 – 0.96)
McKenzie, et al.,	0.58 (0.46 – 0.74)
Schmid, et al.,	0.63 (0.51 – 0.89)
❖ Pooled Ultrasound sensitivity = 0.94 (0.90 – 0.98)	
❖ Inconsistency = 76.8%	

Table 2: - Measurements of ultrasounds specificity in the diagnosis of children with elbow fracture according to all collected study.

All reviews	Specificity (95 % CI)
Ludwig, <i>et al.</i> ,	0.86 (0.75 – 0.97)
Crowther, <i>et al.</i> ,	0.93 (0.89 – 0.96)
Rabiner, <i>et al.</i> ,	0.74 (0.60 – 0.88)
Eckert, <i>et al.</i> ,	0.89 (0.75 – 0.98)
Burnier, <i>et al.</i> ,	0.96 (0.60 – 0.98)
Alzen, <i>et al.</i> ,	0.91 (0.70 – 0.96)
Benz-Bohm, <i>et al.</i> ,	0.88 (0.63 – 0.94)
Bonnefoy, <i>et al.</i> ,	0.94 (0.68 – 0.97)
Donnelly, <i>et al.</i> ,	0.65 (0.55 – 0.95)
Hart, <i>et al.</i> ,	0.53 (0.20 – 0.74)
McKenzie, <i>et al.</i> ,	0.48 (0.33 – 0.81)
Schmid, <i>et al.</i> ,	0.58 (0.40 – 0.78)
❖	<i>Pooled Ultrasound specificity = 0.85 (0.0.82 – 0.92)</i>
❖	<i>Inconsistency = 74.2%</i>

Table 3: Measurement of pooled positive and negative of ultrasound in examination of elbow fracture in children

All reviews	Positive (95 % CI)
Ludwig, <i>et al.</i> ,	10.73%
Crowther, <i>et al.</i> ,	20.56%
Rabiner, <i>et al.</i> ,	5.83%
Eckert, <i>et al.</i> ,	65.45%
Burnier, <i>et al.</i> ,	57.36%
Alzen, <i>et al.</i> ,	78.10%
Benz-Bohm, <i>et al.</i> ,	43.68%
Bonnefoy, <i>et al.</i> ,	66.45%
Donnelly, <i>et al.</i> ,	41.57%
Hart, <i>et al.</i> ,	64.47%
McKenzie, <i>et al.</i> ,	73.89%
Schmid, <i>et al.</i> ,	63.85%
❖	<i>Pooled Positive = 63.57%</i>
❖	<i>Inconsistency = 26.35%</i>
All reviews	Negative (95 % CI)
Ludwig, <i>et al.</i> ,	0.09%
Crowther, <i>et al.</i> ,	0.01%
Rabiner, <i>et al.</i> ,	0.20%
Eckert, <i>et al.</i> ,	0.08%
Burnier, <i>et al.</i> ,	0.56%
Alzen, <i>et al.</i> ,	0.013%
Benz-Bohm, <i>et al.</i> ,	0.05%
Bonnefoy, <i>et al.</i> ,	0.17%
Donnelly, <i>et al.</i> ,	0.04%
Hart, <i>et al.</i> ,	0.40%
McKenzie, <i>et al.</i> ,	0.04%
Schmid, <i>et al.</i> ,	0.08%
❖	<i>Negative ratio: 0.16%</i>
❖	<i>Inconsistency = 84.21%</i>

Table 4: Measurements of diagnostic ratio for ultrasound technique in diagnosis of elbow fracture in children.

All reviews	Diagnostic (95 % CI)
Ludwig, <i>et al.</i> ,	82.14%
Crowther, <i>et al.</i> ,	78.46%
Rabiner, <i>et al.</i> ,	71.82%
Eckert, <i>et al.</i> ,	62.92%
Burnier, <i>et al.</i> ,	58.57%
Alzen, <i>et al.</i> ,	64.41%
Benz-Bohm, <i>et al.</i> ,	78.55%
Bonnefoy, <i>et al.</i> ,	73.35%
Donnelly, <i>et al.</i> ,	87.56%
Hart, <i>et al.</i> ,	81.11%
McKenzie, <i>et al.</i> ,	83.93%
Schmid, <i>et al.</i> ,	75.46%
❖	<i>Pooled Diagnostic ratio = 88.63%</i>
❖	<i>Inconsistency = 34.22%</i>
❖	<i>Accuracy rate = 95.23%</i>

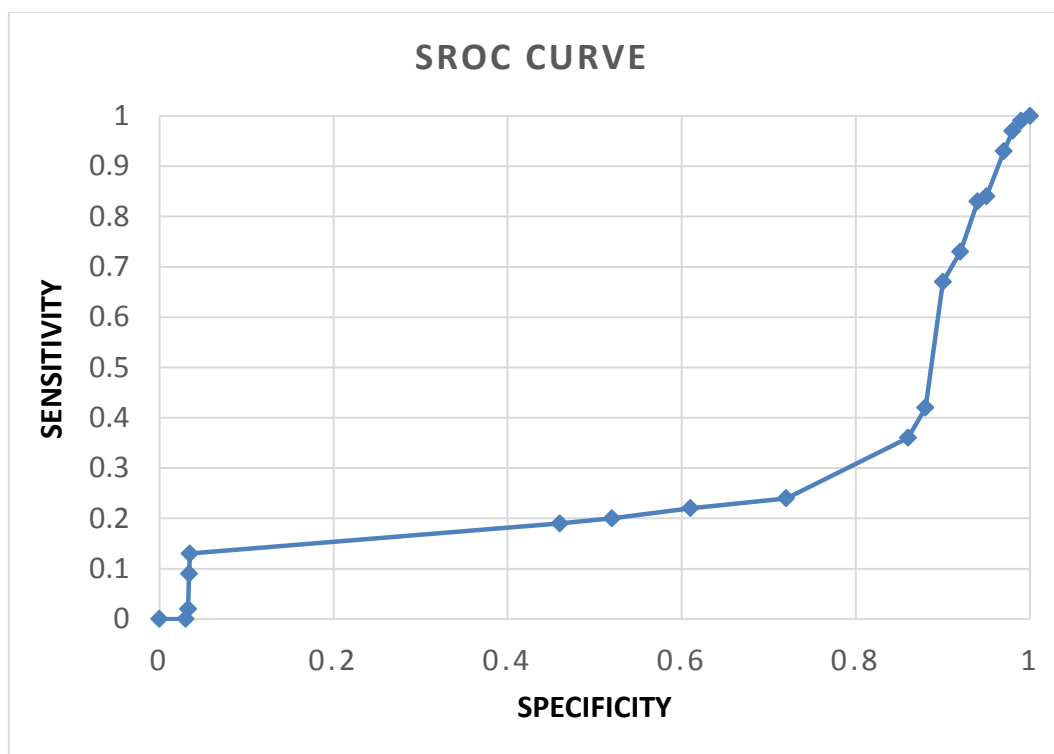


Figure 2: A (SROC) curve of ultrasonography in diagnoses of elbow fracture in children.

DISCUSSION

It was a systematic review to assess the diagnostic efficacy of ultrasonography in elbow fractures, and this review suggests that the accuracy is 0.93. In addition, the sensitivity and specificity of ultrasound for elbow fracture detection is 0.94 and 95.23, respectively.

The papers included in the review shown significant variability in the diagnostic parameters. A potential explanation for this significant variation may be attributed to the evaluation method, that is operator-dependent for this

instance—ultrasound scanning. This review showed that this factor did not influence the observed heterogeneity. [Katzner, C. *et al.*, 2016 – Tokarski, J. *et al.*, 2018]

All these findings, in unison, lend weight to the proposal that ultrasonography can be adopted as an alternative imaging modality for diagnosing elbow fractures in children. Supported by a PLR of 63.57 and NLR of 0.16, ultrasonography is an effective modality that can confirm or exclude elbow fractures in the pediatric population. [Supakul, N. *et al.*, 2010; Eckert, K. *et al.*, 2014]

In their meta-analysis [Weinberg, E. R. *et al.*, 2010], they incorporated 16 studies with a sample size of 1204 children. The combined sensitivity and specificity of ultrasonography were found to be 0.97 and 0.95, respectively. Additionally, the source of heterogeneity was examined with the help of meta-regression and subgroup analysis.

Likewise, the Swedish study [Cho, K.-H. *et al.*, 2010] sought the effectiveness of ultrasonography as compared to conventional imaging in the diagnosis of fractures in children and adult patients. They carried out a systematic search in three databases and included a total of 48 studies in the analysis. The evaluation of ultrasound for the diagnosis of fractures obtained a sensitivity of 91% and specificity of 94%.

Furthermore, their subgroup analysis has demonstrated that ultrasonographic service was more accurate in diagnosing fractures of the ankle, humerus, and forearm among children. [Zuazo, I. *et al.*, 2008] They also incorporated studies which evaluated the accuracy of ultrasonography for diagnosing fractures of the elbow. However, the outcomes of ultrasound imaging with respect to this fracture were not presented separately. [Zhang, J.-d. *et al.*, 2008]

The authors suggested the addition of ultrasonography to radiography. Another systematic review examined the results of diagnostic imaging for eight studies focused on the use of ultrasonography for the diagnosis of fractures in children [Pistor, G. *et al.*, 2003]. This research concluded that ultrasonography had many other advantages compared to radiography. However, the studies we included did not provide any information about the time taken to perform ultrasonography, patient acceptability, and cost-effectiveness. [Davidson, R. S. *et al.*, 1994]

CONCLUSION

It was found in our review study that ultrasound is quite an appealing imaging technique in the assessment of elbow fractures in pediatrics. In this regard, concerns arise for clinicians that do ultrasound scans to make a diagnosis of an elbow fracture since studies included in this review analysis possessed some drawbacks in methodological quality and are at risk of bias. To validate standard elbow ultrasonography for elbow fractures, future high-level diagnostic studies should standardize ultrasonography examination protocols.

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