

# Traumatic Elbow Arthrotomy Pediatric Case Report: The Saline Load Test is a Reliable Method of Detection

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## Learning Point of the Article:

The saline load test is a reliable method to detect a traumatic elbow arthrotomy both in pediatric and adult patients.

## Abstract

**Introduction:** Lacerations and open elbow injuries are common emergency department visits which necessitate an orthopedic surgery evaluation for a traumatic elbow arthrotomy (TEA). A delay in this diagnosis can lead to septic arthritis, requiring more invasive surgical procedures, prolonged antibiotics, and possible long-term sequelae. To date, there is scarce literature on TEA. The purpose of this case report is to better educate the orthopedic community on a reliable method of detection for a TEA, including pediatric patients.

**Case Report:** Case 1 - Twelve-year-old boy sustained a traumatic dog bite to the right elbow by a large stray dog. Evaluation in the emergency department revealed five 1 centimeter or smaller lacerations over the lateral elbow and another 1 cm laceration to the volar and proximal forearm. A saline load test (SLT) was performed from a posterior approach and was positive after 20cc of normal saline was injected into the joint. An arthroscopic irrigation and debridement were performed as definitive treatment. He was discharged with Augmentin BID for 7 days. Follow-up appointments at 1 and 4 weeks post-operatively revealed no signs of infection.

Case 2 - Seven-year-old boy who was in a bicycle accident and sustained a large laceration over the posterior elbow. Evaluation in the emergency department revealed an approximately 15 by 4 cm laceration over the posterior elbow. A SLT was positive after 30cc's was injected from the anterolateral approach. He underwent arthroscopic irrigation and debridement as definitive treatment and was discharged home with Cephalexin BID for 7 days. Follow-up appointments at 1 and 4 weeks post-operatively showed no signs of infection.

**Conclusion:** Performing a SLT is a reliable method of detection to evaluate for a TEA. Our case report demonstrated confirmation of TEA in two pediatric patients based on positive SLT. We were able to treat these injuries appropriately with early surgical intervention and prophylactic antibiotics. Our early diagnosis and time-sensitive management prevented septic arthritis based on the patient's short-term follow-up examinations.

**Keywords:** Traumatic arthrotomy, saline load test, computed tomography scan.

## Introduction

In 2009, the National Electronic Injury Surveillance System (NEISS) reported 92,601 upper extremity injuries with 10.5% to the elbow [15]. This database includes 100 hospitals pooled together by the United States Consumer Product Safety Commission. The 10.5% reported in 2009 can then be extrapolated using the CPSC algorithm to 364,245 elbow injuries for the whole United States. In 2019, the NEISS database reported 9577 elbow injuries, which extrapolates to

405, 910 in the United States. Elbow injuries are common reasons for emergency room visits, especially in the pediatric population. Usually, these visits are due to contusions, abrasions, or fractures of the distal humerus, proximal radius, or ulna. Lacerations and open injuries to the elbow are also among these reasons which frequently necessitate an orthopedic surgery evaluation for a traumatic elbow arthrotomy (TEA).

The elbow is a complex joint that is both superficial and deep in relation to the overlying soft tissue. Therefore, any laceration

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## Author's Photo Gallery



Dr. Tyler D. Kupchick



Dr. Jacob Carl

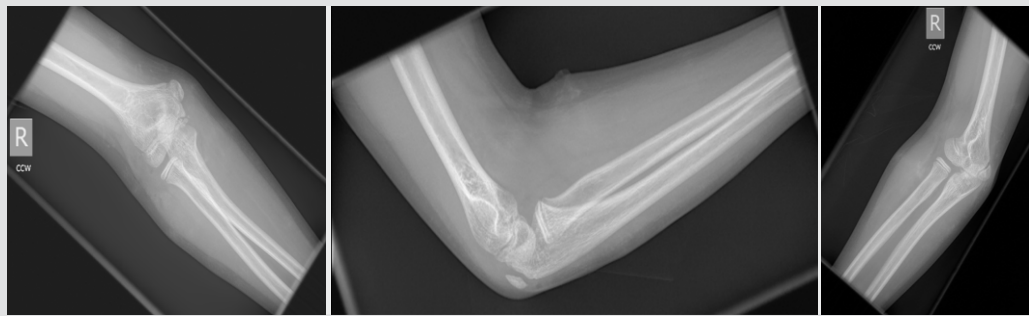


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**Figure 1:** Anterior-posterior, lateral, and oblique X-rays of the right elbow in Case 1 demonstrating soft tissue injury, however, no fracture, dislocation, or intra-articular air.



**Figure 2:** Clinical photographs of Case 1 elbow after bit by a stray dog. Five dorsal lacerations and one volar laceration.

around the elbow needs to be evaluated for a traumatic arthrotomy. A diligent physical examination of the injured extremity is required yet may not be enough to identify disruption of the joint capsule, i.e., traumatic arthrotomy [2, 6, 7, 8, 12, 14]. An open arthrotomy can seed bacteria from the skin or environment into the joint and develop into septic arthritis [1, 5, 16]. Bacteria recruit inflammatory cytokines which produce chondrolytic enzymes that destroy the cartilage within 1 week [1, 5, 16]. A delay in this diagnosis has been seen in up to 11.8% of traumatic arthrotomy of the knee (TAK) [5, 11] and will require more invasive surgical procedures and prolonged antibiotics [1, 2, 5, 16]. Conventionally, a traumatic arthrotomy is evaluated with either a saline load test (SLT) or computed tomography (CT) scan. A SLT is performed by injecting fluid into a joint, remote from the injury site. Extravasation of the fluid from the injury site yields a positive test. CT scan has been historically used to diagnose traumatic arthrotomy by evaluating for intra-articular air. Kupchick et al. [12] performed a cadaveric study on 10 specimens comparing CT scan to SLT and found the SLT to be the more sensitive method of TEA detection. Feathers et al. [6] also performed a SLT cadaveric study on 36 specimens demonstrating a 95% sensitivity after 40 mLs of fluid injected. The best method of detection for the elbow, however, remains unclear as most of the literature regarding traumatic arthrotomies references the knee

(Table 1).

Konda et al. [11] retrospectively observed 63 knee injuries and determined CT scans as the more accurate method of detection for TAK (100% sensitivity) over a SLT (92% sensitivity). Keese et al. [10] and Nord et al. [13] each studied SLT of the knee and found 95% sensitivity after 194 and 155 mL of normal saline were injected, respectively. To date, there is scarce literature on non-cadaveric TEA, let alone the pediatric population. The purpose of this case report is to better educate the orthopedic community on the reliability of a SLT to detect a TEA, including the pediatric patient.

## Methods

After approval from our institutional review board, we referenced two pediatric patients (12 and 7 years old) with open elbow injuries. Inclusion criteria consisted of open elbow injuries without any obvious physical examination findings of TEA or any intra-articular air seen on X-ray. Diagnosis of a TEA was made with a positive SLT in the emergency department. Each patient underwent an arthroscopic irrigation and debridement with a short course of oral antibiotics. On short-term follow-up, neither child had any signs or symptoms of an infection or septic joint.



**Figure 3:** Clinical intraoperative photograph of Case 2 elbow injury. The laceration measured 15 cm x 4 cm with large flap over the proximal ulna.



**Figure 4:** Anterior-posterior and lateral elbow X-rays of Case 2 demonstrating a large soft tissue injury to the posterior, proximal ulna, however, no fracture, dislocation, or intra-articular air.



**Figure 5:** Clinical intraoperative photograph of Case 2 demonstrating the saline load test technique used to diagnose a traumatic elbow arthromy. The needle was inserted into the anterolateral "soft spot" arthroscopic portal.

### Case Report

**Case #1 -** Twelve-year-old Caucasian boy sustained a traumatic dog bite to the right elbow by a large stray dog and was brought to an outside hospital. X-rays were performed and reported no fracture, dislocation, or intra-articular air (Fig. 1).

The elbow wounds were irrigated with normal saline and bathed in a normal saline/betadine mixed solution for 15 min at this outside facility. The patient was given Augmentin as well as rabies immunoglobulin and vaccine due to the unknown canine vaccination history. He was then transferred to our tertiary children's hospital for further orthopedic surgery evaluation. Evaluation in the emergency department revealed five 1 cm or smaller lacerations over the lateral elbow and another 1 cm laceration to the volar and proximal forearm, just distal to the antecubital fossa (Fig. 2).

The patient had near full range of motion, falling about 10 degrees shy of full extension and 10 degrees short of full supination, limited by pain. He was also found to be grossly neurovascularly intact of the median, radial, and ulnar nerves to motor and sensation with strong radial and ulnar pulses. A SLT was performed through the posterior arthroscopic portal site into the olecranon fossa [4]. Fluid was seen extravasating from the lateral elbow wounds once 20cc of normal saline was injected into the joint, thus a positive test. He was admitted overnight for continued antibiotics (Augmentin 875–125 mg every 8 h) and surgical arthroscopic irrigation and debridement

the next morning. For the procedure, the patient was positioned supine with the elbow across the chest. The posterior arthroscopic portal was established as well as the anterolateral arthroscopic portal with 2.7 mm cannulas [4]. Three liters of normal saline irrigation were run through the joint and all the wounds with gentle curettage debridement. The wounds were then loosely closed, and a sterile dressing with a long arm splint was applied without a drain to allow soft tissue rest. He was discharged with Augmentin 400/57mg/5 mL BID prophylactically for 7 days. The patient followed up in the office 1-week and 4-week post-operatively. He was without any erythema, drainage, or signs of infection; however, mild elbow stiffness in extension had improved.

**Case #2 -** Seven-year-old African American boy was in a bicycle accident and sustained a large laceration over the proximal ulna/posterior elbow. Evaluation in the emergency department revealed an approximately 15 by 4 cm "U" like laceration with a large flap over the posterior elbow/proximal ulna (Fig. 3).

Subcutaneous tissue, muscle, and triceps tendon were visualized, however, no obvious joint capsule violation. The patient had near full range of motion, about 10 degrees shy of full flexion and extension limited by pain. He was grossly neurovascularly intact of the median, radial, and ulnar nerves to motor and sensation with strong radial and ulnar pulses. X-ray revealed posterior elbow soft tissue injury and no intra-articular air (Fig. 4).

A small bony fragment was displaced from the posterior aspect of the proximal ulna. A SLT was performed through the anterolateral "soft spot" arthroscopic portal site, and fluid was seen extravasating from the wound after 30cc of normal saline was injected (Fig. 5).

He was admitted overnight for continued antibiotics (IV Ancef 40 mg/mL every 8 h) and surgical arthroscopic irrigation and debridement the next morning. For the procedure, the patient was positioned supine with the elbow across the chest. The posterior arthroscopic portal was established as well as the anterolateral arthroscopic portal with 2.7 mm cannulas [4]. Three liters of normal saline irrigation were run through the joint and the wound with gentle curettage debridement. The small bony fragment was deemed non-viable and excised. The wound was then loosely closed, and a sterile dressing with a long arm splint was applied without a drain to allow soft tissue rest. He was discharged home with Cephalexin 500 mg BID prophylactically for 7 days. The patient followed up in the office 1-week and 4-week post-operatively without any erythema, drainage, or signs of infection and had near full elbow range of motion.

### Discussion

A traumatic arthrotomy is a challenging diagnosis, particularly of a dynamic joint such as the elbow. The elbow has areas with minimal soft tissue overlying the joint and other areas where the laceration must penetrate much deeper. As the elbow flexes, extends, pronates, and supinates, the subcutaneous tissue glides over the muscles and fascia. This could potentially hide any capsular disruptions and trap debris. This case report demonstrated two different open elbow injuries in children which both cases confirmed a positive TEA with a SLT. The volume of fluid injected to reach a positive test, 20 and 30 mLs, is consistent with the findings of Feathers and Kupchick. Each

patient was then able to undergo minor surgical intervention of irrigation and debridement with a short course of prophylactic oral antibiotics to prevent a deep infection or septic joint. Per our literature review (Table 1), most TEA detection literature references cadaveric studies [6, 12] and only one human case report [3]. In general, the majority of traumatic arthrotomy literature pertains to the knee, which has demonstrated unparalleled results to the elbow and may cloud the judgment of TEA detection method. In addition, there have been no studies of TEA in the pediatric population. For this reason, there is no clear recommendation on the detection of a TEA.

**Table 1: Literature review of traumatic arthrotomies**

Author	Year	Study	Journal	Body Region	Results
Feathers T, et al.	2011	Effectiveness of the saline load test in diagnosis of traumatic elbow arthrotomies	J Trauma	Elbow	36 cadaveric specimens with controlled posterior arthrotomy. SLT performed with methylene blue. 40mL's of fluid needed for 95% sensitivity
Kupchick T, et al.	2020	Detection of traumatic elbow arthrotomies: CT scan vs saline load test	J Shoulder Elbow Surg	Elbow	10 cadaveric specimens with controlled posterior arthrotomy. CT scan then SLT performed. To reach 60 and 90% sensitivity, 15 and 20 mL's of fluid needed to be injected. Positive tests noted after average injection of 19mL's. CT scan 0% sensitivity.
Bunyasaranand J, et al	2017	Case report: traumatic elbow arthrotomy after motorcycle accident not evident on CT	BMJ Case Report	Elbow	One patient with 6cm elbow laceration from MCA. CT scan was negative for intra-articular air. Presented with signs of septic joint. No SLT performed at presentation.
Konda S, et al.	2013	The saline load test of the knee redefined: a test to detect traumatic arthrotomies and rule out periarticular wounds not requiring surgical intervention	J Orthop Trauma	Knee	50 patients tested with SLT. There were 19 positive SLT's; 16 true positive TAK, and 3 false positive TAK. Of the 31 negative SLT's, only 1 was a false negative. Average volume injected 75 +/- 28 mL. SLT sensitivity and specificity of 94 and 91%.
Konda S, et al.	2013	Computed tomography scan to detect traumatic arthrotomies and identify periarticular wounds not requiring surgical intervention: An improvement over saline load test	J Orthop Trauma	Knee	63 knee's were evaluated for TAK with CT scan in the ED. All 32 knees with intra-articular air on CT had CR confirmation (100% sensitivity), and none of the 31 negative CT's presented with knee infection at follow up. 37 knees underwent both CT and SLT, where the SLT sensitivity was 92%
Nord R, et al.	2009	Detection of traumatic arthrotomy of the knee using the saline solution load test	J Bone Joint Surg	Knee	56 patients with controlled knee arthrotomies in the CR for arthroscopy portal sites, evaluated with saline load tests. 75, 110, 145, 155, 175mL of fluid needed for 50, 75, 90, 95, 99% sensitivity. Average positive SLT was 64 and 95mL's for the inferomedial and superomedial injection locations
Keese, et al	2007	The accuracy of the saline load retention test in the diagnosis of traumatic knee arthrotomies	J Orthop Trauma	Knee	30 patients with controlled knee arthrotomies in the CR for arthroscopy portal sites, evaluated with saline load tests. 50 and 194mL's of fluid needed for 46 and 95% sensitivity. Average positive SLT was 71mL
Tornetta P, et al.	2008	How effective is a saline arthrogram for wounds around the knee?	Clin Orthop Relat Res	Knee	80 knees with controlled knee arthrotomies in the CR for arthroscopy portal sites, evaluated with saline load tests. Injection of only 60mL's performed with 36% static sensitivity, and 43% dynamic sensitivity.
Voit G et al.	1996	Saline load test for penetration of periarticular lacerations	J Bone Joint Surg	General	50 patients with peri-articular lacerations evaluated by clinical exam and saline load test. 39% false positive and 43% false negative clinical examinations, based on saline load test results
Goyal N, et al.	2019	Saline load test for detecting traumatic arthrotomy in the wrist	J Wrist Surg	Wrist	20 patients with controlled wrist arthrotomy in CR for arthroscopy portal sites, evaluated with saline load tests. Volume needed for 50, 90, 95, and 99% sensitivities are: 0.4, 2.2, 2.3 and 2.5mL's
Gittings D, et al.	2019	Saline load test is effective at diagnosing traumatic arthrotomies of the shoulder	J Surg Orthop Adv	Shoulder	22 cadaveric specimens with controlled posterior arthroscopic portal arthrotomy. Injection of 62, 81, and 136 mL's yielded 90, 95, and 99% sensitivities for SLT.



The normal elbow volume has been estimated to be 10–15 mL where the maximum capsular volume is about 20–25 mLs [9, 14]. Early on, detection of a traumatic arthrotomy by SLT was the method of choice [18]. Voit et al. [18] demonstrated SLTs higher diagnostic accuracy of traumatic arthrotomies over clinical examination which had a 43% false-negative and 39% false-positive rate.

Leading the way for TEA, Feathers et al. [6] performed a SLT on 36 cadaveric elbows and provided sensitivities with the injected fluid amounts. Initially, the specimens were injected with 20 mLs of saline referencing O'Driscoll's et al. elbow capsular capacity [14]. Seventy-two percent of their specimens had a positive SLT at this amount. They found that a total of 40 mLs were needed to reach a sensitivity of 95%. To incorporate the complexity of the elbow, they demonstrated a static (immobilized) sensitivity of 58–87% and a dynamic (mobile) sensitivity of 75–97% after 20 mLs were injected.

Kupchick et al. [12] is the only study to compare SLT with CT scan for TEA. Using 10 cadaveric specimens, they made a controlled arthrotomy and then brought the specimens through full range of motion. Afterward, a non-contrast CT scan was completed. Following this, a SLT was performed with normal saline and methylene blue mixed solution. All of their specimens were positive for the SLT with a 60 and 90% sensitivity after 15 and 20 mLs of fluid injected, respectively. An average injection of 19 mLs was needed for a positive test. None of the CT scans, however, were positive for intra-articular air (0% sensitivity).

Konda et al. [11] evaluated 62 patients (63 knees) for traumatic arthrotomy of the knee (TAK) with CT scan and SLT. Thirty-two knees were positive for TAK on CT scan, with OR confirmation of all 32 knees (100% sensitivity). No patients with a negative CT scan had developed septic arthritis upon follow-up. Thirty seven of the knees had undergone both CT and SLT; however, false positives of the SLT lowered the sensitivity to 92%.

In similar studies from 2007 to 2009, Keese et al. [10] and Nord et al. [13] both performed SLT with controlled knee arthrotomies on patient's scheduled for knee arthroscopy. Keese et al. found 46 and 95% sensitivity after 50 and 194 mLs of fluid were injected into the knee. Nord et al. went into more detail and found 50, 75, 90, 95, and 99% sensitivity after 75, 110, 145, 155, and 175 mLs of fluid were injected. In 2008, Tornetta et al. [17] also performed SLT on knee arthrotomies for scheduled knee arthroscopy. He, however, evaluated a fixed amount of fluid (60 mLs) for the SLT while bringing the knee through range of motion. They found a static sensitivity at 60 mLs of 36% and dynamic sensitivity of 43%.

The only case report on TEAs thus far was published by

Bunyasaranand et al. [3]. Their patient sustained a 6 cm elbow laceration from a motorcycle accident. Examination in the emergency department revealed no obvious capsular violation, and a CT scan was negative for intra-articular air. The patient received a bedside irrigation and wound repair; however, no SLT was performed. The patient presented with signs and symptoms of a septic elbow and purulent drainage at his 1-week follow-up appointment. Two separate irrigation and debridement procedures in the operating room then followed, with an intraoperative confirmed joint capsule laceration. Although only one incident, this case report demonstrates that if we were to follow the traumatic knee arthrotomy recommendations to CT scan the joint (over SLT), we may miss the arthrotomy diagnosis more often than literature suggests.

A systematic review by Browning et al. [2] yields 10 relevant studies on SLTs to evaluate for traumatic arthrotomy. The studies reviewed included Voit and Feathers et al. Their data included SLTs of the knee, elbow, ankle, and wrist. They agreed with the efficacy of SLT and however were inconclusive in the analysis and utility in the clinical setting. They also recommended more joints and pediatric patients to be studied.

## Conclusions

Our case report demonstrated the reliability of a SLT to detect a TEA, even in the pediatric population. The volume of fluid injected to yield a positive SLT was consistent with the literature. We were able to treat these injuries appropriately with early surgical intervention and prophylactic antibiotics. Our early diagnosis and time-sensitive management prevented septic arthritis and further morbidity to these children.

## Clinical Message

The diagnosis of a TEA by a SLT is a reliable method of detection, even in the pediatric population.

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