Prevalence of Rotator Cuff Tears in Adults with Traumatic Brachial Plexus Injuries

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Background: Restoration of shoulder function is a primary goal when treating patients with traumatic brachial plexus injury. A concomitant rotator cuff tear may alter the treatment approach and prognosis for these individuals. The purpose of this study was to define the prevalence of rotator cuff tears in patients with traumatic brachial plexus injuries.

Methods: This is a retrospective review of 280 adult patients with traumatic brachial plexus injury treated at a single institution over a twelve-year period. An upper-extremity magnetic resonance imaging (MRI) scan was acquired for all patients as part of the initial evaluation for posttraumatic brachial plexus injury. The radiographic and clinical data on these patients were reviewed to document partial or full-thickness rotator cuff tears, mechanism and location of the brachial plexus injury, and age.

Results: Twenty-three patients (8.2%) had a full-thickness rotator cuff tear; one patient had tears involving three tendons, eight patients had tears involving two tendons, twelve patients had a single-tendon tear, one patient had a single-tendon tear in each shoulder, and one patient had a single-tendon tear in one shoulder and a two-tendon tear in the other. Twenty-one tears involved the supraspinatus, eight involved the infraspinatus, and seven involved the subscapularis. Thirteen patients underwent surgical repair of the rotator cuff. The average age of the patients in this cohort was 33.4 years, and older age was associated with an increased risk of full-thickness rotator cuff tears (odds ratio [OR], 1.06 per year). Patients with infraclavicular brachial plexus injury had a significantly higher rate of full-thickness rotator cuff tears.

Conclusions: Concomitant rotator cuff tears are present in approximately one in ten patients with traumatic brachial plexus injury. These injuries may contribute to shoulder dysfunction; therefore, evaluation of the rotator cuff with imaging studies is appropriate when formulating treatment strategies.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. It was also reviewed by an expert in methodology and statistics. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

The prevalence of traumatic brachial plexus injury in polytrauma patients seen at a level-I trauma center has been previously reported to be 1.2%, with the injuries mostly seen in young males. These brachial plexus injuries result in a spectrum of dysfunction ranging from temporary neurologic deficits to complete loss of limb function, and they can have devastating lifelong consequences. Shoulder dysfunction may be caused by neurologic and/or musculoskeletal impairment. As a result of their high-energy nature, traumatic brachial plexus injuries are often associated with osseous and soft-tissue injuries around the shoulder girdle, yet the prevalence of concomitant rotator cuff tears in the setting of brachial plexus injuries has not been previously defined, to our knowledge. There have been case reports describing rotator cuff tears with associated brachial plexus injuries. These cases have most commonly involved an anterior shoulder dislocation, an injury pattern that has been described as...
the terrible triad of the shoulder\textsuperscript{2,3}. Isolated injuries of the brachial plexus along with a rotator cuff tear have also been reported\textsuperscript{4}. Detection of such injuries by clinical examination is extremely challenging because brachial plexus injuries often produce shoulder girdle weakness that overshadows or mimics the rotator cuff tear.

Detecting and treating rotator cuff tears in patients with brachial plexus injury are important for two reasons. First, many brachial plexus surgeons consider shoulder stability and motor function a priority of treatment\textsuperscript{5}. The rotator cuff muscles are critical as they contribute to shoulder strength, motion, and stability\textsuperscript{6-8}. Second, in patients with nerve injuries that include the suprascapular nerve, procedures for reinnervation of the supraspinatus and infraspinatus muscles are considered if shoulder function does not show evidence of recovery\textsuperscript{9}. These procedures include nerve transfers to the suprascapular nerve or a nerve graft repair. Before embarking on such an operation it would be valuable to know if the target rotator cuff muscles are torn, as it has been shown that asymptomatic patients in the general population who have a large or massive rotator cuff tear have decreased abduction strength when compared with the strength on the contralateral side\textsuperscript{6}.

The above findings suggest that optimal restoration of function in a patient with a brachial plexus injury depends on an intact rotator cuff. In addition, nerve transfers or grafting to the suprascapular nerve have had variable success, with several studies demonstrating overall disappointing results\textsuperscript{10-12}. The cause of these variable results is unknown, but brachial plexus surgeons may seek to optimize outcomes in any way possible, including repair of rotator cuff tears when present. The appropriate screening criteria for associated soft-tissue injury around the shoulder in a patient with a brachial plexus injury has not been established, perhaps in part because the prevalence of concomitant rotator cuff tears is unknown.

Therefore, we reviewed shoulder magnetic resonance imaging (MRI) scans in a series of patients with traumatic brachial plexus injury to define the prevalence of concomitant rotator cuff tears.

**Materials and Methods**

After institutional review board approval was obtained, we performed a retrospective review of the charts of all patients who had presented to a tertiary multidisciplinary brachial plexus clinic from 1998 to 2010. Any adult patient with a traumatic brachial plexus injury and a dedicated MRI of the shoulder was eligible for inclusion. During this time interval, MRI of the shoulder was routinely performed as part of the standard protocol for evaluation of all patients with brachial plexus injury presenting to our institution, regardless of whether a concomitant shoulder injury was suspected. Patients presenting with an MRI of the brachial plexus who did not also undergo a dedicated shoulder MRI were excluded. Additionally, any patient with nondiagnostic MRI secondary to poor quality or artifact were excluded, as were patients whose MRI was not available in the electronic medical record for review.

A total of 307 patients were evaluated in the brachial plexus clinic during this time period, and 280 of them met the inclusion criteria. Electronic records of these patients were examined for demographic data and findings from physical and electrophysiologic examinations, imaging studies, and operative notes. As part of the global evaluation at the brachial plexus clinic, all patients were routinely asked about relevant medical history, including prior injury or surgical procedures in the upper extremity or shoulder (see Appendix). The following data were recorded for

![Fig. 1](https://example.com/fig1.jpg)

**Fig. 1**

Status of the rotator cuff stratified by injury mechanism. FT = full-thickness. ATV = all-terrain vehicle accident, MVA = automobile accident, and Peds VS MVA = pedestrian-automobile accident.
each patient: (1) age, (2) interval between the injury and presentation at the brachial plexus clinic, (3) mechanism of injury, (4) location of nerve lesion, (5) extent of rotator cuff injury (if present) based on MRI, and (6) operative treatment for the brachial plexus lesion and/or rotator cuff tear (if performed). MRI interpretations by fellowship-trained musculoskeletal radiologists were utilized to determine which rotator cuff tendons (supraspinatus, infraspinatus, subscapularis, and/or teres minor) were involved. Additionally, the tears were defined as either full-thickness or partial-thickness as determined by the musculoskeletal radiologists at our institution. The location of the brachial plexus injury was determined on the basis of serial physical examinations by a minimum of two of the three brachial plexus surgeons (A.Y.S., A.T.B., and R.J.S.), computed tomography (CT) myelography and electrophysiologic testing, and operative findings. The location of the brachial plexus injury was broadlly categorized as either supraclavicular or infraclavicular. Supraclavicular lesions were defined as those involving the nerve root, trunk, or division, whereas those involving cords or terminal nerve branches were classified as infraclavicular. The mechanism of injury was categorized into one of eight common groups for purposes of analysis (Fig. 1).

Statistical Methods

The clinical data were recorded in a spreadsheet, and statistical analysis software was used. The average age and average interval between injury and presentation were calculated for all patients as well as for the subset of those with a full-thickness tear. A one-tailed t test was used to evaluate for a significant difference in age between the populations with and without a full-thickness tear as well as between the infraclavicular and supraclavicular injury populations. A logistic regression analysis was performed to examine the effects of increasing age on the probability of having a full-thickness rotator cuff tear. A binary outcome reflecting the presence of a full-thickness tear was compared with a continuous variable reflecting age. The association between full-thickness tears and the location of the nerve injury was examined with use of a one-tailed Fisher exact test. Significance was set at an alpha value of 0.05.

Source of Funding

There was no outside source of funding for this study.

Results

A total of 307 adult patients were evaluated for a traumatic brachial plexus injury. Twenty-seven patients were excluded because of inadequate MRI. Of these, one patient had an MRI performed at an outside facility that was not available for review electronically. An additional six were excluded because their MRIs were considered nondiagnostic secondary to metal artifact in the shoulder, and another twenty patients presented with MRIs of the brachial plexus or the biceps, or magnetic resonance angiograms of the chest, without dedicated shoulder MRIs. Therefore, 280 patients formed our cohort; 242 were men and thirty-eight were women with an average of 33.4 years.

Twenty-three patients (8.2%) had a full-thickness rotator cuff tear. One patient had tears involving three tendons, eight patients had tears involving two tendons, twelve patients had a single-tendon tear, one patient had a single-tendon tear in each shoulder, and one patient had a single-tendon tear in one shoulder and a two-tendon tear in the other. Twenty-one tears involved the supraspinatus, eight involved the infraspinatus, and seven involved the subscapularis. Seventy-seven patients (28.0%) had a partial-thickness rotator cuff tear. Additional details regarding the patients with a full-thickness tear are presented
in the Appendix. The total number of patients who had either a full or partial-thickness tear was 100 (35.7%).

**Association Between Age and Injury, and Rotator Cuff Tears**
The average age was 46.1 years for the patients with a full-thickness rotator cuff tear and 32.1 years for those without a full-thickness tear (p < 0.05). Thirty percent of the patients with a full-thickness tear were under the age of forty, and 83% were less than sixty years old (Fig. 2). A logistic regression analysis demonstrated an odds ratio of 1.06 (95% confidence interval, 1.03 to 1.09) for the likelihood of having a full-thickness cuff tear with each increasing year of age (Fig. 3).

The average age was 36.6 years for patients with a supraclavicular injury and 32.4 years for those with an infraclavicular injury. The median ages of these groups were twenty-nine and thirty-two years, respectively.

**Association Between Location of Brachial Plexus Injury and Rotator Cuff Tears**
The brachial plexus injury was at the infraclavicular level in sixty-two patients (22%) and at the supraclavicular level in 218 (78%). A full-thickness rotator cuff tear was present in 19% (twelve) of the sixty-two patients with an infraclavicular injury and 5% (eleven) of the 218 with a supraclavicular injury (Fig. 4) (p < 0.05).

**Discussion**
Restoration of shoulder function is one of the primary goals of the treatment of brachial plexus injuries. For this reason, attention should be given to diagnosing and treating rotator cuff tears in these patients. To our knowledge, the prevalence of rotator cuff tears in the setting of traumatic brachial plexus injuries has not been defined. In our series, 8% of patients with brachial plexus injury also had a full-thickness rotator cuff tear. Given the young age of our patient population, it is even more critical to recognize and repair tears as early as possible. Young age has been shown to be a positive predictor of healing after rotator cuff repair, and progression of fatty atrophy of rotator cuff tendons has been halted in patients with an intact repair.

We also found an association between full-thickness rotator cuff injuries and infraclavicular nerve injuries. The reason for this association is unclear. It may be due to the age distributions in these groups, as those with infraclavicular injury were slightly older, with a four-year difference in the average ages. However, given the relatively young age of both groups, it seems more likely that the association between full-thickness rotator cuff injuries and infraclavicular nerve injuries is a consequence of the mechanism of injury. Forces that cause widening of the shoulder-neck angle produce supraclavicular injuries while those that increase the scapulohumeral angle usually result in infraclavicular injuries. It is possible that the latter produces a greater degree of rotator cuff damage. In many studies, a fall onto an outstretched hand or forceful external rotation of an adducted or abducted arm was the most common mechanism of injury for traumatic rotator cuff tears, particularly those involving the subscapularis. Severe, sudden abduction of the arm would be more likely to result in an infraclavicular injury. Although infraclavicular injuries were relatively rare in our series, they were disproportionately found in patients with a rotator cuff tear. This finding is similar to that in a series from Louisiana State University, in which 28% of 509 stretch injuries were infraclavicular. In that patient population, Kim et al. found the prevalence of shoulder dislocation, fracture, and vascular injury...
to be higher in patients with infraclavicular injury than in those with supraclavicular injury.

As noted previously, twenty-seven of the 307 patients evaluated in our clinic were excluded because of a lack of appropriate shoulder imaging. Therefore, it may be helpful to consider how the excluded patients may have biased our results. If all twenty-seven of them had a full-thickness rotator cuff injury, the prevalence of full-thickness tears would be 16%. If none had a full-thickness cuff tear, the prevalence would be 7.5%. Both of these extremes seem unlikely, but it should be noted that six of the patients were excluded because metal artifact (suture anchors, plates, and screws) rendered their MRI unreadable. It seems highly probable that those patients had an increased prevalence of rotator cuff tears compared with our clinic population. If all six of those patients had a full-thickness rotator cuff tear, our prevalence would increase from 8.2% to 10.1%.

This study has limitations inherent to retrospective studies of a population that is heterogeneous with respect to injury, mechanism, and disability. Perhaps more importantly, we are unable to determine with absolute certainty whether the rotator cuff tears were traumatic injuries or preexisting degenerative tears. Screening MRI studies have demonstrated a 28% prevalence of asymptomatic rotator cuff tears in patients over sixty years old and none in patients between nineteen and thirty-nine years old. Tempelhof et al. examined the age-related prevalence of asymptomatic rotator cuff tears and found an increasing prevalence of full-thickness tears with increasing age. Patients in the sixth decade of life had a 13% prevalence of rotator cuff tears, and this number increased with each decade. In our population, 30% of those with a full-thickness tear were below the age of forty years and 83% were under the age of sixty years.

In general, our patients were on the younger end of the spectrum of individuals with possible atraumatic tears; therefore, a preexisting degenerative tear is possible but less likely. Yamamoto et al. examined the prevalence of rotator cuff tears in the general population of a mountain village in Japan and found that 20.7% of participants had a full-thickness rotator cuff tear, with the risk for a rotator cuff tear increasing with a history of trauma or advancing age. No patient in their twenties and only 2.5% of patients in their thirties had a rotator cuff tear. Braune et al. found that the average age of patients with a traumatic tear was significantly younger than that of patients with an atraumatic tear (34.2 compared with 54.1 years). Their criterion for diagnosis of a traumatic tear was no preexisting shoulder pain or dysfunction with a sudden loss of function accompanied by an adequate traumatic mechanism. In that study, an age of fifty years was used as the cutoff to exclude patients from their group with a traumatic tear. The average age of the patients with a rotator cuff tear in our study population was forty-six years. However, the authors of a recent meta-analysis including 511 traumatic rotator cuff tears from nine studies reported a weighted average age of 54.7 years. If a threshold of fifty years was applied instead, eighteen patients would remain, for a prevalence of 6.4%. Therefore, while we cannot say with certainty whether or not the tears were preexisting, we believe it is highly improbable in the younger population.

The exact etiology of the tear is secondary to the fact that full-thickness tears exist and may present a hindrance to postoperative recovery after a major shoulder reconstruction. Perhaps more important than MRI findings, is preexisting pain or dysfunction of the shoulder prior to the injury. The patient’s history, along with his or her age, can be invaluable in delineating acute from chronic tears and determining the likelihood of future disability from such tears. As shown in the Appendix, only one patient had a history of difficulty with shoulder abduction >90°. In that patient, it is possible that the rotator cuff tear preceded the trauma; however, only two of the remaining affected patients had any notable shoulder history. The absence of a history of shoulder problems, combined with the overall youth of those affected, strongly suggests that the majority of the full-thickness tears resulted from the traumatic injury. The association of advancing age with increasing risk of rotator cuff tears in the regression model suggests that older patients may be predisposed to sustaining a full-thickness rotator cuff tear with a traumatic injury. This association is likely due to one of two factors: older patients had preexisting asymptomatic tears that were detected by our screening protocol or older patients had rotator cuffs that were at greater risk as a result of preexisting degenerative changes. We were unable to control for these confounding factors with our current data.

Previous publications also have demonstrated that older patients are more likely to sustain both traumatic and degenerative rotator cuff tears. Neviaser et al. reported on thirty-one patients with a traumatic rotator cuff tear following anterior shoulder dislocation, and all were older than thirty-five. Our study was not sufficiently powered to establish an absolute age below which a rotator cuff tear will not be present. The youngest patient in our series with such an injury was nineteen years old.

This study has demonstrated that the prevalence of full-thickness rotator cuff tears in patients with a traumatic brachial plexus injury is approximately 10%, and the risk of such an injury increases with age. We believe that this prevalence is high enough to warrant a preoperative shoulder MRI to assess the status of the rotator cuff as part of the global evaluation of a patient presenting with a traumatic brachial plexus injury.

Appendix

A table summarizing the data on the patients with a full-thickness rotator cuff tear is available with the online version of this article as a data supplement at jbjs.org.
References


