Pseudoparalysis: The Importance of Rotator Cable Integrity

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abstract

The purpose of this study was to clinically examine the relationship between rotator cable integrity and the presence of pseudoparalysis. A retrospective review was performed of a consecutive series of arthroscopic repairs of massive rotator cuff tears performed between January 2007 and June 2009. A total of 127 massive tears were identified. Group 1 comprised 24 patients with preoperative pseudoparalysis. Group 2 comprised 97 patients (103 repairs) with active forward flexion more than 90°.

In group I, no patient maintained integrity of both rotator cable attachments; 1 rotator cable attachment was disrupted in 45.8% of cases; and both rotator cable attachments were disrupted in 54.2% of cases. In group II, both rotator cable attachments were intact in 22.3% of cases; 1 rotator cable attachment was disrupted in 62.1% of cases; and both rotator cable attachments were disrupted in 15.5% of cases. The difference in the distribution of cable attachments between the 2 groups was statistically significant ($P<.001$). Overall, preoperative pseudoparalysis predicted a disruption of both rotator cables with 88.8% specificity, 44.8% sensitivity, and 77.8% accuracy.

Pseudoparalysis requires the disruption of at least 1 rotator cable attachment. This study reinforces the concept of rotator cable integrity and the ability of patients to maintain forward flexion above shoulder level and highlights the importance of reinforcing the rotator cable attachments in the repair of massive rotator cuff tears.

Figure: Superior (A) and posterior (B) projections of the rotator cable and crescent. The rotator cable extends from the biceps to the inferior margin of the infraspinatus (I), spanning the supraspinatus (S) and infraspinatus insertions. Abbreviations: B, mediolateral dimension of the rotator crescent; BT, biceps tendon; C, width of the rotator cable; TM, teres minor. (Adapted with permission from Burkhart et al. The rotator crescent and rotator cable: an anatomic description of the shoulder’s “suspension bridge.” Arthroscopy. 1993; 9(6):611-616. Copyright © 1993, Elsevier.)
Massive rotator cuff tears comprise approximately 20% of all cuff tears and approximately 80% of recurrent rotator cuff tears.1,2 Some patients with massive cuff tears are functional with limited pain. Others are severely debilitated and can present with pseudoparalysis of the shoulder, or the inability to actively raise the affected arm above shoulder level.

It has been suggested that patients with pseudoparalysis and an irreparable rotator cuff tear require a reverse shoulder arthroplasty to regain active motion above shoulder level.3,4 Recently, reverse shoulder arthroplasty has been reported in patients without glenohumeral arthritis.5 Although several factors have been implicated, the definition of an irreparable rotator cuff tear remains controversial.6-8 It is the authors’ experience that an arthroscopic rotator cuff repair with a balancing of force couples can reverse pseudoparalysis in many cases. Furthermore, this approach avoids the substantial complication rate of 50%3 and a 58% 10-year survivorship that has been associated with reverse shoulder arthroplasty.9

To understand which patients with pseudoparalysis can benefit from an arthroscopic repair, it is critical to establish the anatomic requirements for overhead motion. The rotator cable has been proposed as a biomechanical explanation for the ability of a shoulder to maintain function in the setting of a massive rotator cuff tear.10-12 Cadaveric investigations have reinforced the concept of the rotator cable as a vital structure in maintaining force generation and shoulder motion in the face of massive rotator cuff tears.13-15 However, to the authors’ knowledge, no clinical studies have characterized the relationship between rotator cable integrity and pseudoparalysis.

The purpose of this study was to clinically examine the relationship between rotator cable integrity and the presence of pseudoparalysis. Rotator cable integrity was characterized in patients with and without preoperative pseudoparalysis who underwent arthroscopic repair of a massive rotator cuff tear. The hypothesis was that pseudoparalysis requires the disruption of at least 1 of the rotator cable attachments.

**Materials and Methods**

**Study Population**

A retrospective review was performed of a consecutive series of arthroscopic repairs of massive rotator cuff tears performed between January 2007 and June 2009. Inclusion criteria was a primary arthroscopic repair of a massive rotator cuff tear, defined as 5 cm or larger in diameter in the greatest dimension according to the DeOrio and Cofield15 classification. Revision repairs and tears smaller than 5 cm in size were excluded.

A total of 127 massive tears were identified during the study period. The tears were divided into 2 groups based on the preoperative presence or absence of pseudoparalysis of the shoulder. Group 1 comprised 24 patients with preoperative pseudoparalysis, defined as active forward flexion of less than 90° in association with full passive elevation.1,5 None of these patients had anterosuperior escape because this was considered a contraindication to repair, and this study comprised individuals who underwent surgical repair. Group 2 comprised 97 patients (103 repairs) without pseudoparalysis, defined as active forward flexion more than 90°.

**Clinical Assessment and Rotator Cuff Tear Pattern**

The senior author (S.S.B.) performed all preoperative clinical evaluations and arthroscopic rotator cuff repairs. Preoperative active and passive forward flexion, as well as basic demographic information, were determined by a chart review. Operative indications, rotator cuff repair technique, and rehabilitation protocol were essentially unchanged during this time period. Operative records were reviewed to record tear size, tendon involvement, and tear pattern. All patients had 100% tears of the supraspinatus tendon.

Tear patterns were assessed for the integrity of the anterior and posterior rotator cables based on a previously published description of the rotator cable attachments.10 That study showed that the anterior rotator cable attachment bifurcates and the anterior limb terminates at the proximal portion of the lesser tuberosity. The posterior limb of the anterior rotator cable attachment inserts at the anterior portion of the footprint of the supraspinatus. The posterior rotator cable attachment was shown to extend to the inferior infraspinatus (Figure 1). Therefore, disruption of the anterior rotator cable attachment was defined as a tear that involved 50% or more of the subscapularis insertion; this definition ensured complete disruption of the anterior attachment of the rotator cable. Disruption of the posterior rotator cable attachment was defined as a tear that involved 100% of the infraspinatus insertion; the definition ensured complete disruption of the posterior attachment of the rotator cable.

**Statistical Analysis**

Baseline patient characteristics and rotator cuff patterns were compared between groups 1 and 2 with Wilcoxon rank sum test and chi-square test. The usefulness of pseudoparalysis as a predictive marker for rotator cable integrity was examined with chi-square test to determine statistical significance. Sensitivity and specificity were determined with 95% confidence intervals. Two-tailed significance was assessed at a P value less than .05. A power analysis with an alpha value set at 0.05 determined that this study had a 97% power to detect a difference in the proportion of pseudoparalysis in patients with disruption of 2 rotator cables compared with the proportion in the remaining patients.

**Results**

**Rotator Cuff Tear Patterns**

Mean rotator cuff tear size in the anterior-to-posterior dimension was larger in the group with preoperative pseudoparalysis than in the group without pseudoparalysis. The mean tear size in the group with pseudoparalysis was 6.5 cm, whereas the mean tear size in the group without pseudoparalysis was 7.8 cm. The difference was statistically significant (P=.0001). The anterior and posterior rotator cuffs were involved in 80% of recurrent rotator cuff tears. However, to the authors’ knowledge, no clinical studies have characterized the relationship between rotator cable integrity and pseudoparalysis.
doparalysis (group 1) than in the group with preserved forward flexion (group 2) (7.4±1.5 vs 6.1±1.1 cm, respectively; P<.001). In group 1, no patient maintained integrity of both rotator cable attachments, 1 rotator cable was disrupted in 45.9% of cases, and both rotator cables were disrupted in 54.2% of cases (Figure 2). In group 2, both rotator cable attachments were intact in 22.3% of cases, 1 rotator cable attachment was disrupted in 62.1% of cases, and both rotator cable attachments were disrupted in 15.5% of cases (Figure 3). These distributions were significantly different (P<.001).

**Prediction of Pseudoparalysis**

Patients with pseudoparalysis were older and more likely to be women compared with patients with preserved forward flexion (Table 1).

Overall, 63 cases had 100% tears of the infraspinatus, 57 cases had partial infraspinatus tears, and 8 cases had intact infraspinatus tendons. Pseudoparalysis was present in 30.2% of cases with a complete infraspinatus tear and 7.8% of cases with a partial infraspinatus tear or an intact infraspinatus, demonstrating a significant difference between the 2 groups (P=.001).

Overall, 71 cases had a subscapularis tendon tear more than 50% in length, 29 cases had a subscapularis tear less than 50% in length, and 28 cases had no subscapularis tendon tear. Pseudoparalysis was present in 25.7% of cases with a subscapularis tear larger than 50%, in 10.3% of cases with a subscapularis tear smaller than 50%, and in 10.7% of cases with no subscapularis tendon tear; this association trended toward, but did not achieve, statistical significance (P=.094).

Among 23 cases in which both rotator cables were intact, no instance of pseudoparalysis was observed. In 76 cases, the anterior (41 cases) or posterior (34 cases) cable was disrupted; pseudoparalysis was present in 14.7% of these cases. In 29 cases, both the anterior and posterior rotator cables were disrupted. Pseudoparalysis was present in 44.8% of these cases, which was significantly different from no rotator cable disruption or 1 cable disruption (P<.001) (Table 2). Preoperative pseudoparalysis predicted a disruption of both rotator cables with 88.8% specificity, 44.8% sensitivity, and 77.8% accuracy.

**DISCUSSION**

This study examined the relationship between rotator cable attachments and the ability of the rotator cuff to maintain bal-
anced force couples. A primary function of the rotator cuff is to balance the force couples about the glenohumeral joint. A force couple is a pair of forces that act on an object and tend to cause it to rotate. For any object to be in equilibrium, the forces in a force couple must create moments about a center of rotation that are equal in magnitude and opposite in direction. This situation creates a balanced force couple with a stable fulcrum. In the shoulder, coronal and transverse plane force couples exist between the subscapularis anteriorly and infraspinatus and teres minor posteriorly.

Balanced force couples are particularly important in the setting of massive rotator cuff tears in which the tear may extend more posteriorly or anteriorly, leaving only a remnant of intact posterior cuff (infraspinatus or teres minor) or intact anterior cuff (subscapularis). In cases where the infraspinatus is torn, the posterior rotator cuff may be so weak that it cannot balance the anterior moment created by the large infraspinatus muscle. In cases where the subscapularis is disrupted, the weak anterior forces may not be able to balance the posterior moment created by the infraspinatus and teres minor.

When arthroscopically viewed from the glenohumeral joint, the articular surface of the intact rotator cuff demonstrates an arching, cable-like thickening of the capsule surrounding a thinner crescent of tissue that inserts into the greater tuberosity of the humerus.10 This rotator cable has an anterior attachment that bifurcates to attach to bone just anterior and posterior to the proximal aspect of the bicipital groove. Its posterior attachment comprises the inferior 50% of the infraspinatus. In a cadaveric model, Halder et al13 confirmed that in small and medium rotator cuff tears, the rotator cuff muscle forces are effectively transmitted along the rotator cable, bypassing the torn supraspinatus tendon. Therefore, the rotator cable explains why patients with rotator cuff tears, even massive ones, can maintain active forward flexion, and why even after only a partial rotator cuff repair, good functional results can be achieved.17,18 However, in massive rotator cuff tears, a muscle deficiency may exist such that the moments created by the opposing muscular forces are insufficient to maintain equilibrium in the coronal plane. The inability to maintain a stable fulcrum of motion with a strong force couple can result in pseudoparalysis, or the inability to forward flex the arm above shoulder level.

To the authors’ knowledge, no clinical studies have examined how the concepts of force couples and the rotator cable relate to the phenomenon of pseudoparalysis. This study’s findings reinforce the importance of the rotator cable in the ability of an individual to maintain active forward flexion in the setting of a massive rotator cuff tear. Among cases in which both rotator cable attachments were intact, no cases of pseudoparalysis were observed. With disruption of 1 rotator cable, the prevalence of pseudoparalysis was 15%. With the disruption of both rotator cables, the prevalence of pseudoparalysis increased to 45%. Therefore, from a technical standpoint it is critical to reestablish the rotator cables when managing massive rotator cuff tears. Furthermore, for patients with known massive rotator cuff tears, the sudden loss of active forward flexion should alert the surgeon to disruption of the rotator cables. Although it is not the subject of the current study, the authors have observed that with early operative intervention in such a setting, restoration of the rotator cables can restore overhead motion.

Not all of the current cases with disruption of both rotator cables had pseudoparalysis. Some of these patients may have had better compensatory mechanisms to deal with the loss of the force couples and rotator cable attachments. Perhaps the teres minor played a bigger factor in stabilizing these shoulders, or perhaps some of these patients developed an acromiohumeral fulcrum that enabled active overhead motion. However, although one can have pseudoparalysis in association with disruption of the anterior or posterior rotator cable attachments, a combined disruption of both increases the likelihood of pseudoparalysis.
Limitations of the current study include the retrospective design and absence of an evaluation of rotator cuff muscle atrophy and fatty infiltration. The goal of the study was to characterize the relationship of the rotator cable to pseudoparalysis. Further studies can be performed to clarify the relationship between muscle quality and pseudoparalysis. This study also did not examine the ability of arthroscopic rotator cuff repair to reverse pseudoparalysis. This topic is the subject of an ongoing investigation at the authors’ institution.

**CONCLUSION**

Pseudoparalysis requires the disruption of at least 1 rotator cable attachment. This study reinforces the concept of rotator cable integrity and the ability of patients to maintain forward flexion above shoulder level and highlights the importance of reinforcing the rotator cable attachments in the repair of massive rotator cuff tears.

**REFERENCES**


