INTRODUCTION:
The marked variation in symptoms and physical exam findings among patients with massive rotator cuff tear is not easily explainable. While some patients demonstrate considerable disability with inability to forward elevate the extremity ("pseudoparalysis"), other patients have remarkable preservation of active motion. One possible explanation is that axial plane balance of the subscapularis anteriorly and the teres minor posteriorly may provide a stable axis for rotation by compressing the humeral head into the glenoid fossa. This stable, well-balanced glenohumeral joint then allows full active motion [1]. Conversely, deficient or torn posterior rotator cuff muscles may impair active motion by uncoupling the balanced mediolaterally directed forces and stable axis of rotation. This theory has been validated clinically as patients with intact subscapularis and teres minor tendons without atrophy have better overhead function and range of motion compared to patients with deficient teres minor tendons [2, 3].

While the relationship between a healthy teres minor and shoulder function with active motion has been suggested, we have not found any published series that have correlated the maintenance of the teres minor muscle with active shoulder function. We hypothesize that hypertrophy or relative hypertrophy of the teres minor correlates with preserved forward elevation in the setting of massive rotator cuff tears.

METHODS:
After obtaining approval from our institutional review board, a retrospective review was performed on 614 patients who underwent rotator cuff repair at our institution from 2002-2007. Inclusion criteria required that tears had to involve both the supraspinatus and infraspinatus tendons, and 244 patients met this criterion. Exclusion criteria included teres minor tears, subscapularis tears, deltoid muscle pathology, acute tears, axillary nerve or brachial plexus injury, or frozen shoulders. The patients were divided into three groups: (1) patients with massive rotator cuff tears who maintained active forward elevation [Tear-FE]; N=17, (2) patients with massive rotator cuff tear who had decreased active forward elevation [Tear Poor-FE] N=15; and (3) patients with no rotator cuff pathology [No Tear] N=20. Patients who had instability, subacromial impingement or SLAP tears without a rotator cuff tear were used as controls.

MRI analysis was performed by identifying the “Y-view,” the most lateral sagittal cut at which the scapular spine is in contact with the scapular body [4]. Mimics software (Materialise, Ann Arbor, MI) was used to compute the cross-sectional area (CSA) of the teres minor (TM), infraspinatus (ISP), supraspinatus (SSP), subscapularis (SCP), and the supraspinatus fossa (SF), which was measured as a size standard to compare with each of the rotator cuff muscles [5].

The ratio of TM/SCP was computed to evaluate for absolute hypertrophy, the TM/SCP was computed to evaluate the axial balance, and the TM/RTC was computed to evaluate for hypertrophy relative to the entire rotator cuff. Statistical analysis was performed using one-way ANOVA and Dunnett's multiple comparison tests.

RESULTS:
Patients in the “Tear Poor-FE” group had an average forward elevation of 74.6 ± 28.8°, which was decreased 88.9 ± 37.1° compared to the contralateral, unaffected arm (p<0.05). Patients in the “Tear FE” group had forward elevation of 172.9 ± 8.5°, and patients in the “No Tear” group had forward elevation of 180.0 ± 0°. There was no difference in the side-to-side motion between these groups (4.0 ± 7.1°, and 0 ± 0°, respectively).

The ratios of the cross sectional area of the teres minor at the “Y-view” compared to the supraspinatus fossa, subscapularis and the rotator cuff are shown in Figures 1 and 2. TM/SCP ratio was largest in the “Tear-FE” group (0.91 ± 0.22), followed by the “No Tear” group (0.84 ± 0.26) and the “Tear Poor-FE” group (0.76 ± 0.33), showing a trend towards absolute hypertrophy of the teres minor in that group, though this difference was not significantly significant (p = 0.07). The TM/RTC ratio was significantly higher for the “Tear-FE” group (40 ± 10) than for either the “No Tear” and “Tear Poor-FE” group (0.30 ± 0.09 and 0.27 ± 0.09) respectively (p <0.01). The TM/RTC ratio was highest in the “Tear-FE” group (0.18 ± 0.04), followed by the “Tear Poor-FE” group (0.15 ± 0.06), and “No Tear” group (0.11 ± 0.02), (p= 0.0019).

DISCUSSION:
The teres minor accounts for up to 45% of external rotation power in normal shoulders [6], and has a heightened role in the setting of massive rotator cuff tears involving both the supraspinatus and infraspinatus tendons. The hypertrophy of teres minor size, and presumably, strength as compared to the intact subscapularis muscle and RTC as a whole may contribute to balance of muscles in the axial plane. The significantly increased TM/Subcap ratio supports the hypothesis and aids shoulder function and range of motion in the setting of a massive RCT [2,3].

There are several limitations to this study. The control, or “No Tear” patients were drawn from a pool of instability patients and those with SLAP tears, and hence were younger than the patients in either group that had two-tendon rotator cuff tear. Furthermore, there was no standard MRI protocol, and though we extrapolated the approximate volume of rotator cuff muscles from their cross sectional areas, detached muscle will likely appear smaller in CSA at a particular cut than intact tendons due to retraction of the entire musculotendinous unit.

This study was designed as a retrospective study, and therefore a large number of patients were excluded due to incomplete data, unavailable, or sub-optimal MRI images that did not include the “Y-view”. A prospective study, which is underway, is required to confirm the conclusions, which will include full range of motion and strength testing, a standardized MRI protocol, and computerized volume measurements of the full muscle bellies of all rotator cuff muscles to obtain a more accurate picture of muscle volumes after massive rotator cuff tears.

REFERENCES: