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ORIGINAL ARTICLE

Computed tomography underestimates rotator cuff pathology in patients with glenohumeral osteoarthritis

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Background: Computed tomography (CT) is the standard assessment of glenoid morphology before shoulder arthroplasty and is commonly used to evaluate rotator cuff pathology in patients with glenohumeral osteoarthritis (GHOA). Magnetic resonance imaging (MRI) is not routinely used in this setting but has higher sensitivity in diagnosing full-thickness rotator cuff tears (RCT) and is considered the gold standard. The purpose of this study was to determine the sensitivity and specificity of CT in diagnosing full-thickness RCTs and compare the evaluation of fatty infiltration and muscle atrophy on CT vs. MRI in the setting of GHOA.

Methods: In this retrospective case-controlled study, we identified 49 patients from a prospectively maintained 2-surgeon registry who received preoperative CT and MRI scans for the evaluation of GHOA between 2011 and 2016. Three fellowship-trained shoulder surgeons assessed rotator cuff integrity, fatty infiltration, and muscle atrophy in the CT and MRI scans.

Results: CT sensitivity and specificity were 20% and 95.5%, respectively. Fatty infiltration was significantly lower on CT for the supraspinatus ($P = .003$), infraspinatus ($P < .001$), and subscapularis ($P = .0182$), whereas muscle atrophy was significantly lower on CT for only the supraspinatus ($P = .0023$).

Conclusions: Our results suggest that CT underestimates the frequency of full-thickness RCTs and the severity of fatty infiltration and muscle atrophy in the setting of GHOA before total shoulder arthroplasty.

Level of evidence: Level III; Diagnostic Study

Keywords: Primary osteoarthritis; rotator cuff; fatty infiltration; atrophy; computed tomography; magnetic resonance imaging; shoulder arthroplasty

Computed tomography (CT) is routinely used as the only advanced 3-dimensional imaging for glenohumeral osteoarthritis (GHOA) before total shoulder arthroplasty (TSA), mainly to evaluate glenoid pathology.[3,8] Because full-thickness rotator cuff tears (RCTs) are considered uncommon in this setting,[3] the CT scan is considered adequate to evaluate rotator cuff pathology even though magnetic resonance

The New England Baptist Hospital Institutional Review Board approved this study (Protocol No. 679572).

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imaging (MRI) is the gold standard based on its accuracy, optimal soft tissue visualization, and noninvasive nature.[9,13]

However, the literature suggests that secondary RCTs and dysfunction are common after TSA, with proximal humeral migration seen in 16% of patients at 10 years and in 55% of patients at 15 years.[18] Furthermore, increased rotator cuff fatty infiltration and muscle atrophy[5,7,10,11] have been correlated with worse surgical outcomes after TSA.[2,8] Some have suggested the use of reverse shoulder arthroplasty (RSA) in GHOA with significant concomitant rotator cuff pathology.[1]

Advanced preoperative imaging to evaluate rotator cuff integrity, fatty infiltration, muscle atrophy, and glenoid wear patterns thus plays a critical role in surgical planning before shoulder arthroplasty. The purpose of our study was to evaluate the sensitivity and specificity of CT in diagnosing full-thickness RCTs and compare the evaluation of fatty infiltration and muscle atrophy on CT vs. MRI. We hypothesized that CT fails to correctly identify full-thickness RCTs and underestimates the severity of fatty infiltration and muscle atrophy compared with MRI in patients with GHOA.

Materials and methods

In this retrospective case-controlled study, we identified 49 patients from a prospectively maintained 2-surgeon registry (A.J. and S.M.) who received preoperative CT and MRI scans for the evaluation of GHOA between 2011 and 2016. At the time of the clinical evaluation, all patients were considering elective shoulder arthroplasty for treatment of primary GHOA. Given the concern for RCT in preoperative planning, all patients in this time frame were recommended to have both CT and MRI scans. Patients were evaluated by author S.M. from 2011 to 2012 and by author A.J. from 2014 to 2016. Patients were excluded from the study if their initial radiographs indicated signs of superior humeral head migration or they did not have both CT and MRI scans. Patients with rheumatoid, post-traumatic, or postcapsulorrhaphy arthritis were also excluded to minimize confounding variables that might have altered the observer's interpretation of the scans.

The 49 helical CT scans and 49 MRI scans were obtained at the same institution. CT scans were obtained using the LightSpeed VCT system (General Electric, Fairfield, CT, USA). Settings were maintained at 1.25-mm slice thickness with 2.5-mm multiplanar 3-dimensional reconstructions. MRI was performed using a General Electric high-field 1.5 T scanner with an 8-channel shoulder coil. Scan settings were maintained at 3-mm slice thickness and 0.5-mm gap width, with a field of view of 14 or 15 cm. There were 6 diagnostic sequences with axial, coronal, and sagittal T2 weighting, as well as coronal T2 with frequency selective fat suppression and coronal and axial intermediate echo time proton density images.

Three fellowship-trained surgeons (A.J., M.M., and R.N.) were presented with deidentified CT and MRI scans and asked to identify the presence or absence of a full-thickness RCT and classify the Goutallier and Warner grades of each rotator cuff muscle. Goutallier grades were evaluated according to the original guidelines proposed by Goutallier et al[5] and analyzed using the modified guidelines proposed by Fuchs et al.[4] Warner grades were evaluated according to the guidelines proposed by Warner et al.[15] All results were determined by consensus. The surgeons were blinded to the identity, demographics, laterality, diagnosis, and type of arthroplasty performed. Study staff presented all imaging to surgeons on the same radiologic viewing software.

To determine whether CT serves as a viable modality to diagnose full-thickness RCT in the setting of GHOA, we conducted our analysis under the assumption that MRI is the gold standard and yields the most accurate results. Thus, measurements obtained by CT were tested for accuracy using the benchmark established by MRI.

Statistical methods

A Pearson χ^2 test was used to compare the frequency of full-thickness RCTs on CT vs. MRI and was also used to compare the frequency and severity of fatty infiltration (Goutallier classification) and muscle atrophy (Warner classification) on CT vs. MRI. A Pearson correlation compared the mean fatty infiltration and muscle atrophy grades of each rotator cuff muscle. We interpreted the strength of the Pearson correlation coefficient as 0.00 to 0.19, very weak; 0.20 to 0.39, weak; 0.40 to 0.59, moderate; 0.60 to 0.79, strong; and 0.80 to 1.0, very strong.[17] Statistical analysis was performed by an experienced biostatistician using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA). The 2-tailed threshold of significance was set at $P < .05$.

Results

Forty-nine patients (15 women and 34 men) met inclusion criteria. Mean age was 64.2 ± 7.2 years (range, 43-79 years). Mean body mass index was 29.5 ± 6.9 kg/m^2 (range, 20.2-61.5 kg/m^2).

Diagnosis of full-thickness RCT

Five full-thickness RCTs were indicated by MRI and confirmed by intraoperative findings at the time of surgery (high positive). CT identified 1 of 5 patients (20%) in which a full-thickness RCT was present (true positive), failed to identify 4 of 5 patients (80%) in which a full-thickness RCT was present (false negative), and incorrectly identified 2 patients as having a full-thickness RCT when there was no indication on MRI (false positive). CT sensitivity, specificity, positive predictive value, and negative predictive value were 20% (95% confidence interval [CI], 0.01-0.72), 95.5% (95% CI, 0.85-0.99), 33.3% (95% CI, 0.01-0.91), and 91.3% (95% CI, 0.79-0.98), respectively.

Evaluation of fatty infiltration and muscle atrophy

Fatty infiltration was significantly lower overall for the supraspinatus (SS), infraspinatus (ISP), and subscapularis (SSC)