Quantitatively evaluation of fatty degeneration and atrophy in the infraspinatus and teres minor muscle using MRI IDEAL technique

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INTRODUCTION:

The rotator cuff muscles especially, infraspinatus (ISP), and teres minor (TM) are essential for external rotation of the shoulder joint. Dysfunction of external rotation is closely related to disorder of ADLs. In the cases of large to massive rotator cuff tears with loss of active external rotation, the need for various tendon transfer techniques and Reverse Shoulder Arthroplasty (RSA) has been noted. However, there were few studies on the quantification of fatty degeneration of the external rotators such as ISP, and TM using MRI. MRI IDEAL technique, which uses the proton difference between water and fat, had recently been used to quantitatively assess fat content in muscles. The purpose of this study was to evaluate TM and ISP fat mass and muscle atrophy in patients undergoing RSA, arthroscopic rotator cuff repair (ARCR) and patients without rotator cuff tears using the MRI IDEAL technique and to evaluate cut off value of causing dysfunction of external rotation.

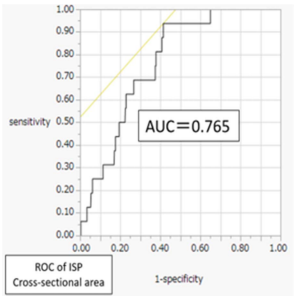
METHODS: 567 shoulders who underwent MRI IDEAL technique at our institution between September 2012 and June 2022 were included in this study. The patient background was male 277, female 262, mean age 69.5±10.6 years, mean height 158.1±10.5 cm, mean weight 60.7±13.1 kg, mean BMI 24.1±3.9 kg/m^2. Patients were classified into three groups: ISP non-tear group (group I) 364cases (39 intact rotator cuff, ARCR for small rotator cuff tears in 209 shoulders, ARCR for medium rotator cuff tears in 116 shoulders), ISP tear group (group T) 185 cases (90 underwent RSA, ARCR for large to massive rotator cuff tears in 95 shoulders), 18 cases of external rotator dysfunction group (group C) (who underwent RSA+ modified L'episcopo procedure). Rotator cuff's tear sizes were evaluated during intraoperative findings in the ARCR group. Pre-operative MRI was performed, and a freehand ROI was set at ISP and TM in the outermost part of the scapula Y view of the oblique sagittal section. The fat content ratio was defined as Fat-phase/In-phase*100(%) using the average signal intensity in the ROI in Fat-phase and In-phase obtained by the IDEAL technique. Fat content and cross-sectional area of ISP and TM in each group were compared. Statistical methods were the Kruskal-Wallis test and logistic regression analysis. Cross-sectional area and fat content were analyzed with a receiver operating characteristic (ROC) curve, and cutoff values were calculated when the external rotation dysfunction group was considered positive. Statistical analysis was done using JMP Pro 15.0.0 by SAS. $P < .05$ was defined as a significant difference.

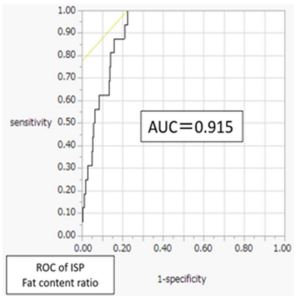
RESULTS:

The mean age was 65.3±9.7, 72.5±9.2, and 72.1±7.8 years for groups I, T, and C, respectively. However, mean height was significantly higher in group I (160.4±9.2 cm, 156.0±10.6 cm, and 152.5±12.4 cm, respectively), and mean weight and BMI were not significantly different among the three groups. The fat content ratio of ISP/TM was 20.3±9.0%, 42.2±18.2%, 59.8±14.2% and 26.6±14.1%, 31.4±16.2%, and 63.5±18.0% in groups I, T and C, respectively, and was significantly higher in group C, T and I in that order($p<.001$). The cross-sectional areas were 7.5±2.4 cm^2, 5.5±2.0 cm^2, 4.8±1.3 cm^2 and 2.7±1.2 cm^2, 2.5±1.0 cm^2, 1.5±0.61 cm^2, respectively. The cross-sectional area of group C was significantly smaller than that of group I in TM ($p<.001$) , however, there was no significant difference between group I and group T. The cut-off values of cross-sectional area and fat content ratio for ISP and TM were 6.24 cm^2 and 36.0% for ISP and 2.31 cm^2 and 46.0% for TM, respectively, when group C was considered positive (figure). Defects number of the TM were found in 16 patients in group I, 9 patients in group T, and 10 patients in group C, with significantly more defects in group C, group T, and the group I, in that order.

DISCUSSION AND CONCLUSION:

Although TM showed no change in cross-sectional area and increased fat content of TM in the ISP tear group, there was a progressive decrease in cross-sectional area and a worsening of fatty degeneration in the external rotation dysfunction group in this study. From these results, fatty degeneration and atrophy of TM coincided with external rotation deficit so tha it was also suggested that external rotation dysfunction might occur when the fatty degeneration exceeds approximately 46%. Severe fatty degeneration of more than half of the TM muscle is thought to be one of the causes of external rotation deficit.


sensitivity
AUC=0.765
ROC of ISP
Cross-sectional area
1-specificity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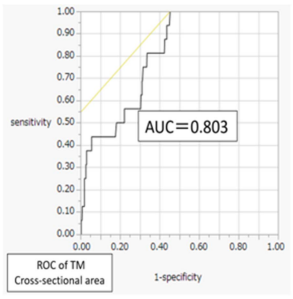
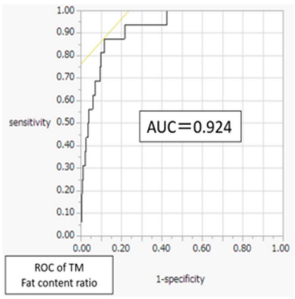
AUC=0.915
ROC of ISP
Fat content ratio
1-specificity


sensitivity
AUC=0.803
ROC of TM
Cross-sectional area
1-specificity


sensitivity
AUC=0.924
ROC of TM
Fat content ratio
1-specificity