J Shoulder Elbow Surg (2016) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Hypertrophic teres minor restores shoulder strength and range of external rotation in posterosuperior rotator cuff tears

Kenshi Kikukawa, MD, PhD[a,*], Junji Ide, MD, PhD[b], Yusuke Terakawa[c], Koji Takada, MD, PhD[a], Makoto Morita, MD[a], Kenzo Hashimoto, MD[a], Hiroshi Mizuta, MD, PhD[d]

[a]*Department of Orthopaedic Surgery, Kumamoto General Hospital, Japan Community Healthcare Organization, Yatsushiro, Kumamoto, Japan*
[b]*Department of Advanced Joint Reconstructive Surgery, Kumamoto University Hospital, Kumamoto University, Kumamoto, Japan*
[c]*Department of Rehabilitation, Kumamoto General Hospital, Japan Community Healthcare Organization, Yatsushiro, Kumamoto, Japan*
[d]*Department of Orthopaedic Surgery, Faculty of Life Sciences, Kumamoto University, Kumamoto, Japan*

Background: In posterosuperior rotator cuff tears (PS-RCT), the progression of infraspinatus (ISP) muscle atrophy seems to induce compensatory hypertrophy of the teres minor (TM) muscles. However, the effect of these changes on shoulder strength and range of external rotation (ER) remains unclear. This study determined the strength and range of ER in patients with PS-RCT with atrophic ISP and hypertrophic TM and compared this with patients with PS-RCT and normal or deficient TM.

Methods: We investigated 35 patients with PS-RCT and atrophic ISP. TM muscles were classified as hypertrophic (type A) in 17, normal (type B) in 10, or deficient (type C) in 8. The strength ratio of the affected shoulder to the healthy contralateral shoulder was calculated, and the active range of motion was measured for both shoulders.

Results: The strength ratios of ER in types A, B, and C were 60%, 33%, and 7% ($P < .01$) with the patient's arm at the side and were 60%, 35%, and 5% ($P < .001$) at 90° abduction, respectively. The average ranges of ER in types A, B, and C were 22.6°, 15.0°, and −12.5° ($P < .001$) with the patient's arm at the side and were 71.6°, 44.5°, and 21.9° at 90° abduction ($P < .01$), respectively. The differences between shoulder types in other measures of strength or ER range were not significant.

Conclusions: In patients with PS-RCT and atrophic ISP, shoulders with compensatory hypertrophy of the TM had greater strength and range of ER than shoulders with normal or atrophic TM.

Level of evidence: Basic Science Study; Kinesiology

Keywords: Hypertrophy; teres minor; atrophy; infraspinatus; rotator cuff tear; compensatory

The Kumamoto General Hospital Ethics Committee approved this study.

*Reprint requests: Kenshi Kikukawa, MD, PhD, Department of Orthopaedic Surgery, Kumamoto General Hospital, Japan Community Healthcare Organization, 10-10 Tohricho, Yatsushiro, Kumamoto 866-8660, Japan.

E-mail address: kikukawakenshi@yahoo.co.jp (K. Kikukawa).

1058-2746/$ - see front matter
http://dx.doi.org/10.1016/j.jse.2016.04.016

Tears of the teres minor (TM) are rare, even in massive irreparable rotator cuff tears (RCTs). Because of the difficulty in clinically assessing the TM, research and assessment of the true nature of the TM has been limited compared with other rotator cuff muscles. However, with the increase in reverse shoulder arthroplasty during the past 2 decades, the importance of the TM as the remaining cuff has greatly increased.[1,14,15] The actual condition of the TM is now considered to be a valuable postoperative prognostic factor for achieving good functional improvements after reverse shoulder arthroplasty. Several recent studies have reported the importance of TM integrity in latissimus dorsi tendon transfer for massive irreparable RCT.[5,12,13]

Kikukawa et al[10] reported that the TM appeared hypertrophic on magnetic resonance imaging (MRI) in patients with posterosuperior RCTs (PS-RCT) with atrophic infraspinatus (ISP) muscles, and the progression of this ISP atrophy seemed to induce the development of a compensatory TM hypertrophy. However, the strength and active range of external rotation (ER) were not evaluated, and the clinical inference of the hypertrophic change in the TM still remains to be determined. This study investigated the strength and active range of ER in patients with PS-RCT with atrophic ISP. We hypothesized that PS-RCT with atrophic ISP patients whose TM muscles had become hypertrophic would retain greater strength and active range of ER compared with individuals with normal or deficient TM muscles.

Materials and methods

This prospective study was performed at our institution between July 2012 and August 2015. Inclusion criteria were patients diagnosed by MRI evaluations to have supraspinatus and ISP tears and atrophic ISP.[10] Exclusion criteria were previous shoulder surgery, fractures, dislocation, infection, cuff tear arthropathy (Hamada grade 4 or 5[8]), and axillary nerve palsy on the affected shoulder. The study also excluded patients with rheumatoid arthritis, cervical neuropathy, previous physical therapy on the affected and contralateral sides, or a contralateral symptomatic shoulder.

Evaluation of the ISP and TM muscles

We used the MRI evaluation criteria from the study by Kikukawa et al[10] to assess the status of the ISP and TM muscles. Briefly, the ISP muscle area, TM muscle area, and anatomic ER (a-ER) muscle area were measured on the most lateral oblique plane in which the scapular spine was in contact with the scapular body using ImageJ software (National Institutes of Health, Bethesda, MD, USA). The occupational ratios of the ISP and TM muscle areas were calculated (Fig. 1). The 95% confidence intervals of the occupational ratios of the ISP and TM muscles in the group with no RCT were 0.586 to 0.810 (data not shown) and 0.112 to 0.288,[10] respectively; therefore, ISP muscles with a ratio of <0.586 were defined as atrophic, TM muscles with a ratio of <0.112 were defined as atrophic, and TM muscles with a ratio of >0.288 were defined as hypertrophic.

MRI revealed that all affected shoulders in this study had tears of the supraspinatus and ISP tendons at the superior and middle facets of the greater tuberosity[11] (Fig. 2). The average occupational ratio of the ISP muscle of all affected shoulders was 0.28 ± 0.16 (range, 0.05-0.58); ISP muscles were classified as atrophic in all affected shoulders. The affected shoulders were divided into 3 types according to the status of the TM muscles: hypertrophic (type A), normal (type B), or deficient (type C) according to a previous report[10] (Fig. 3).

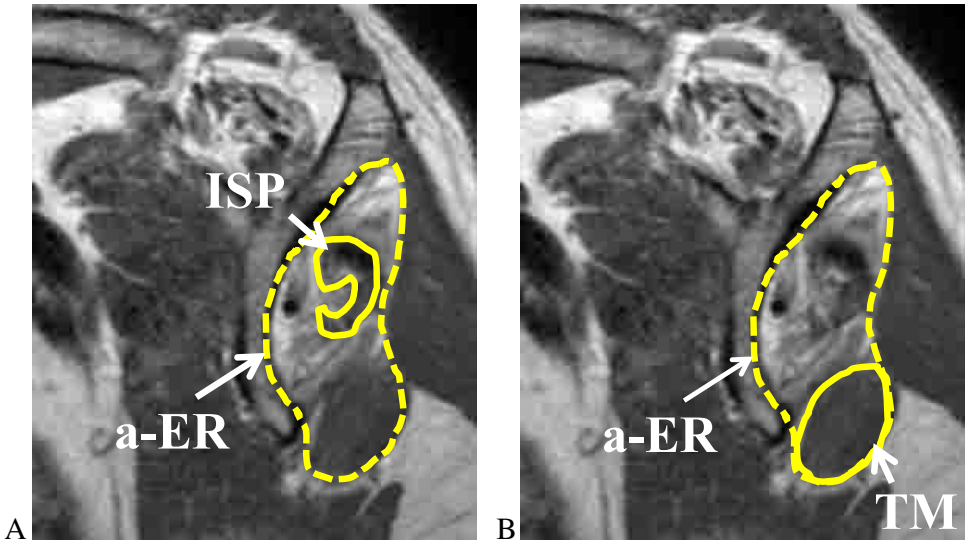

Figure 1 The area of infraspinatus (*ISP*), teres minor (*TM*), and the anatomic external rotator (*a-ER*) muscles on the most lateral oblique sagittal magnetic resonance image in which the scapular spine was in contact with the scapular body. The a-ER muscle area was traced on the lateral margin of the scapula, the inferior margin of the TM muscle, and the medial margin of the deltoid. **(A)** The occupational ratio of ISP muscle = the area of ISP muscle/the area of a-ER muscle, and **(B)** the occupational ratio of TM muscle = the area of TM muscle/the area of a-ER muscle.