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## Location and thickness of delaminated rotator cuff tears: cross-sectional analysis with surgery record review

Motoki Tanaka, MD <sup>a</sup>, Akimoto Nimura, MD, PhD <sup>b,\*</sup>, Norimasa Takahashi, MD, PhD <sup>c</sup>, Tomoyuki Mochizuki, MD, PhD <sup>d</sup>, Ryuichi Kato, MD, PhD <sup>b,e</sup>, Hiroyuki Sugaya, MD, PhD <sup>c</sup>, Keiichi Akita, MD, PhD <sup>a</sup>

<sup>a</sup> Department of Clinical Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan

<sup>b</sup> Department of Functional Joint Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan

<sup>c</sup> Shoulder and Elbow Center, Funabashi Orthopaedic Hospital, Chiba, Japan

<sup>d</sup> Department of Orthopaedic Surgery, Nissan Tamagawa Hospital, Tokyo, Japan

<sup>e</sup> JA Kyosai Research Institute, Tokyo, Japan

### ARTICLE INFO

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**Background:** To facilitate better treatment, we analyzed morphologic features of delamination from the viewpoint of the location of delamination and the thickness of each layer.

**Materials and Methods:** Of 270 shoulders that consecutively underwent arthroscopic rotator cuff repair, 210 were included. During the operation, the surgeon assessed the size of the rotator cuff tear, determined the presence and location of delamination, and compared the thickness between superficial and deep layers if delamination was present. Immediately after the operation, the surgeon wrote down the data in the record form. The authors retrospectively referred to these surgical records to investigate those items.

**Results:** Delamination was found in 111 of 210 shoulders. The overall preoperative Constant score did not significantly differ between the 2 groups. In terms of the location, 7.2% cases had delamination in the anterior part, 74.8% in the posterior part, and 18.0% in both parts (Fleiss  $\kappa = 0.9$ ). The larger the rotator cuff tear, the more frequently the delamination was limited to the posterior part (trend  $P = .001$ ). As for layer thickness comparison, 40.0% of the shoulders with small tears, 38.8% with medium tears, 66.0% with large tears, and 80.0% with massive tears had a thicker deep layer than superficial layer (Fleiss  $\kappa = 0.9$ ). The larger the size of the rotator cuff tear, the more frequently the deep layer was thicker than the superficial layer (trend  $P = .001$ ).

**Conclusions:** The larger the rotator cuff tear, the more carefully shoulder surgeons should observe and treat the posterior and deep part of delamination.

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In terms of treatment of rotator cuff tears, precise perception of the anatomy of the rotator cuff insertion is an important element and facilitates correct repair, according to the shape of the torn site, thereby improving the prognosis. Although delamination, defined as “distal layer separation and normal horizontal retraction of the deep layer” (Fig. 1), is one of the negative prognostic factors,<sup>2,7,8,18</sup> its pathologic process remains unclear. In various approaches to diagnosis of delamination, the prevalence of delamination has been reported to vary among studies from 5.2% (magnetic resonance

imaging by Walz et al<sup>24</sup>) to 92.0% (arthroscopic surgery by Han et al<sup>19</sup>).<sup>3,7,12,20</sup> To date, clinical features of delamination are still unclear because of the paucity of previous reports. Clark and Harryman<sup>4</sup> noted that the deepest layer of the normal rotator cuff consisted not only of musculotendinous units but also of the capsule of the shoulder joint. Nimura et al previously reported that the width of the capsular attachment on the humerus varies according to the location.<sup>17</sup> Based on these facts, the deep layer of delamination should consist of both the musculotendinous and capsular structures, and the histologic composition of the deep layer should differ from that of the superficial layer. Thus, we hypothesized that the occurrence of delamination varies according to the anteroposterior location, and the thickness of each layer is changed in relation to the expansion of the torn site of the rotator cuff tendon. The objective of this study was to analyze the morphologic features of delamination by retrospectively reviewing surgical records from the viewpoint of the location of the delamination and the thickness of

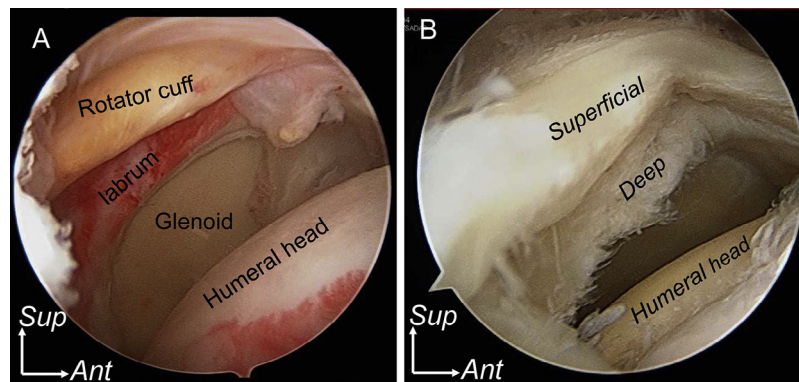
This study was approved by the Institutional Review Board of Funabashi Orthopaedic Hospital (No. 2015038), and all of the patients provided informed written consent.

\* Corresponding author: Akimoto Nimura, MD, PhD, Department of Functional Joint Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo, 113-8519, Japan.

E-mail address: [nimura.orj@tmd.ac.jp](mailto:nimura.orj@tmd.ac.jp) (A. Nimura).

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**Figure 1** Representative pictures of the torn site of the rotator cuff as arthroscopically viewed from the posterolateral portal. (A) Nondelaminated rotator cuff tear of the right shoulder. (B) Delaminated rotator cuff tear of the right shoulder. Distal separation and horizontal retraction of the deep layer were observed.

each layer to better understand the pathologic process of delamination.

## Materials and methods

### Patient selection

The study flow chart is shown in Figure 2. A total of 270 patients underwent arthroscopic repair for rotator cuff tear between August 2011 and February 2013 by the senior surgeon (H.S.) or under his direction. The repair operation was performed on 160 men and 110 women. The average age at the time of the operation was 62 years (range, 28–81 years). All of the patients had a history of chronic shoulder pain that had been treated with medication or physical therapy before resorting to surgery. The indication for surgical repair included pain and functional disability refractory to conservative care. The criterion for inclusion in this investigation was a cuff repair

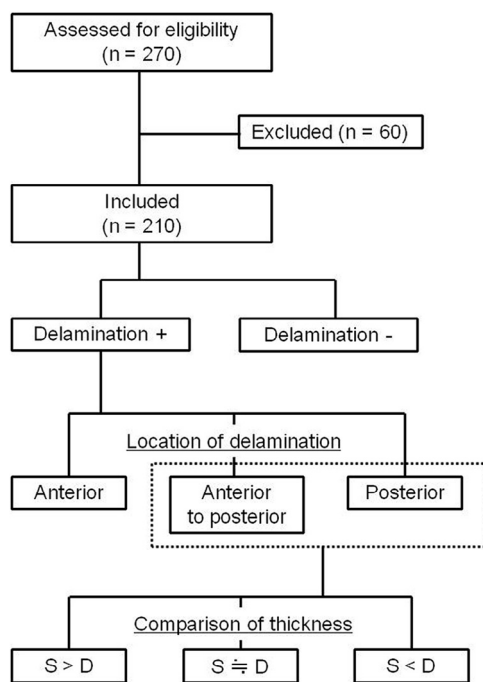
performed solely by the use of arthroscopic techniques. The exclusion criteria included the presence of an isolated subscapularis tear, incomplete rotator cuff tears (only a partial tear), acute traumatic tears, and revision cases (52 cases were excluded). In addition, we retrospectively reviewed the preoperative information including the Constant scores, which were acquired before the operation from 210 patients (data of 8 cases were lost). Thus, we excluded 60 patients, leaving 210 patients for this study.

### Surgical techniques and recording of operative notes

The operation was performed in the beach chair position with general anesthesia.<sup>22</sup> A radiofrequency ablator (VAPR; DePuy Mitek, Westwood, MA, USA) was introduced into the anterolateral portal, and a thorough bursectomy with removal of any subdeltoid adhesions was performed. A posterolateral portal was made approximately 1 cm from the inferior border of the lateral acromion. The surgeons assessed the rotator cuff tear using the posterolateral portal as the viewing portal with a 30° arthroscope. For clear visualization of the torn site of rotator cuff tendons, the surgeon removed synovial tissues from around the torn site by using a shaver (DYONICS; Smith & Nephew, Andover, MA, USA) and radiofrequency ablator. During the operation, the surgeon assessed the size of the rotator cuff tear and determined the presence and location of delamination as described later. In addition, if delamination of the torn site was present, the surgeon compared the thickness of the delaminated layers between the superficial and deep ones. In each operation, an arthroscopic video was made to film the operation. Immediately after the operation, the surgeon routinely recorded the results on a form (Fig. 3). We retrospectively referred to those records to investigate the following items.

### Classification of the size of rotator cuff tear

The extent of the tear was determined intraoperatively under direct arthroscopic visualization in the posterolateral portal after débridement of the degenerative tendon edges and bursal tissues. Evaluation of the tear size was carried out according to the system described by DeOrio and Cofield.<sup>5</sup> The length of the greatest diameter of the tear, in either the coronal or sagittal plane, was defined as small if the tear was <1 cm in diameter, medium if the tear was ≥1 cm but <3 cm in diameter, large if the tear was ≥3 cm but <5 cm in diameter, and massive if the tear was ≥5 cm in diameter. The surgeon assessed the sizes of all tears using a calibrated probe during surgery and recorded the results immediately after the operation.



**Figure 2** Study flow chart.  $S > D$ , superficial layer was clearly thicker than the deep layer;  $D > S$ , deep layer was clearly thicker than the superficial layer;  $S = D$ , both layers were of nearly an equivalent thickness.

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