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The anatomic relationship between the morphology of the greater tubercle of the humerus and the insertion of the infraspinatus tendon

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Background: The objective of this study was to evaluate the topographic relationship between the morphology of the greater tubercle and the insertion of the tendon of the infraspinatus.
Materials and methods: First, we defined an impression of the greater tubercle, which has not been recognized in classic textbooks, as the ''lateral impression'' and then measured the dimensions of the ''lateral impression'' of the greater tubercle in 71 samples of dry bone of humeri. Next, we examined 16 cadaveric humeri with rotator cuff tendons by micro–computed tomography to analyze the positional relationship between the lateral impression and the infraspinatus tendon.
Results: In all samples of dry bones, the lateral impression could be identified as a triangle shape. The lateral impression was composed of the border with the highest impression (mean, 6.3 mm), the border with the middle impression (mean, 5.0 mm), and the border with the lateral wall of the greater tubercle (mean, 8.5 mm). In all samples of humeri with rotator cuffs, we could confirm the lateral impression, and the border between the highest impression and the lateral impression corresponded to the anterior border of the insertion of the infraspinatus tendon.
Conclusion: We propose a new anatomic concept of the lateral impression that could enable the precise diagnosis of and facilitate repair techniques for infraspinatus tear, according to specific anatomic characteristics, by applying 3-dimensional computed tomography assessment preoperatively.

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In anatomic textbooks, the greater tubercle is marked by 3 flat impressions: the highest impression gives insertion to the supraspinatus muscle; the middle, to the infraspinatus; and the lowest, to the teres minor.[3-5] In these descriptions, the shapes of impressions of the greater tubercle have been simply described as adjacent squares (Fig. 1).[1]

However, in dry bone samples for anatomy practice or 3-dimensional (3D) computed tomography (CT) images, we sometimes encounter specimens that have a different shape of the greater tubercle; the tubercle has another impression, in comparison with the conventional description in textbooks. In addition, Mochizuki et al[7] previously reported that the infraspinatus inserted into the anterior edge of the greater tubercle and occupied a substantial area of the greater tubercle, which was in complete contrast to traditional anatomic concepts of the insertions of the supraspinatus and infraspinatus to the greater tubercle. On the basis of the study of Mochizuki et al,[7] strangely enough, the border between the supraspinatus and the infraspinatus also delineated the area of the highest impression. We hypothesized the consistent existence of this additional impression of the greater tubercle of the humerus and that this impression might be related to the insertion of the infraspinatus tendon that was newly described in Mochizuki's report.[7]

The first aim of this study was to define the additional impression of the greater tubercle as the ''lateral impression'' and to evaluate the existence of this impression. The second aim was to identify the topographic relationship between the morphology of the lateral impression of the greater tubercle and the insertion of the infraspinatus tendon.

Materials and methods

This study is an anatomic research using dry bone samples and embalmed cadavers at Tokyo Medical and Dental University. All of the donors voluntarily declared before their death that their remains would be donated as materials for education and study. This voluntary donor system of cadavers is universally spread throughout Japan, and our study completely complies with the current laws of Japan. History of any shoulder problem was not available. Of 78 samples of dry bone of humeri, we excluded 7 samples with severe deformities or destruction of the greater tubercle. In 71 samples including 34 right and 37 left samples, we observed another triangular impression that was located posterolateral to the highest impression, anterolateral to the middle impression, and medial to the lateral wall of the greater tubercle; we defined it as the lateral impression of the greater tubercle (Fig. 2). Then, we measured the dimensions of the lateral impression according to each boundary with the highest impression (*star* in Fig. 3), the middle impression (*square* in Fig. 3), and the lateral wall of the greater tubercle (*circle* in Fig. 3) with a vernier caliper. One observer repeated these measurements twice and calculated the intraclass correlation coefficient to evaluate the validity of the measurement within each group. The scores of intraclass correlation coefficient for *star*, *square*, and *circle* were 0.810, 0.792, and 0.821, respectively.

Next, a 3D image of the greater tubercle in 28 cadaveric humeri with rotator cuff tendons was taken with a micro-CT scanner (inspeXio SMX-100 CT; SHIMADZU, Kyoto, Japan) with application software (VGStudio Max 2.0, Heidelberg, Germany). Of the 28 samples, we excluded 12 specimens with an unclear bone surface (10 specimens) or marked osteophytes on the greater tubercle (2 specimens) on 3D CT images (Supplemental file). After imaging, we carefully dissected the remaining 16 samples so as not to damage the bone surface and identified the anteromedial border of the infraspinatus tendon. Radiopaque markers (0.8 mm in width) were placed along the identified border of the infraspinatus at the base of the tendon. We performed micro-CT scan and analyzed the positional relationship between the lateral impression and the identified border of the infraspinatus.

Finally, the spatial relationship between the lateral impression and the anterior edge of the infraspinatus with the radiopaque marker was analyzed by the consensus of a board-certified orthopedic surgeon and a radiologist.

Results

We could identify a remarkable impression delineated as a triangle that was located posterolateral to the highest impression, anterolateral to the middle impression, and medial to the lateral wall of the greater tubercle. We termed this triangular impression the lateral impression. In all samples of dry bones, the lateral impression could be identified, although there was some variability in the size (Fig. 4). To analyze the size variance of the lateral impression, we measured each side of the triangle in all samples (Fig. 3). The lateral impression was composed of the border with the highest impression (mean, 6.3 mm; *star* in Fig. 3) (Table I), the border with the middle impression (mean, 5.0 mm; *square* in Fig. 3), and the border with the lateral wall of the greater tubercle (mean, 8.5 mm; *circle* in Fig. 3).

To understand the significance of the lateral impression of the greater tubercle in reference to the insertion of rotator cuff tendons, we took 3D images of cadaveric humeri with rotator cuff tendons by micro-CT. In all 16 samples that showed the clear surface of the greater tubercle, we