The Anatomic Relationship Between The Morphology Of The Greater Tubercle Of The Humerus And The Insertion Of The Infraspinatus Tendon

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Introduction: Based on anatomic textbooks, the greater tubercle is marked by three flat impressions: the highest impression gives insertion to the supraspinatus muscle, the middle to the infraspinatus, and the lowest to the teres minor. In these descriptions, the shapes of impressions of the greater tubercle have been simply described as adjacent squares. However, in dry bone samples for anatomy practice or 3-dimensional computed tomography images we sometimes encounter specimens which 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. 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. Based on the study of Mochizuki et al, 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.

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.

Methods: This study is an anatomic research using dry bone samples and embalmed cadavers. Of 78 samples of dry bone of humeri at Tokyo Medical and Dental University. We excluded 7 samples with severe deformities or destruction of the greater tubercle. In 71 samples, we observed another triangular impression which 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.
Then, we measured the dimensions of the “lateral impression” using a vernier caliper.

Next, a 3-dimensional image of the greater tubercle in 28 cadaveric humeri with rotator cuff tendons was taken using a micro-computed tomography (micro-CT) scanner (inspeXio SMX-100 CT, SHIMADZU, Kyoto, Japan) with application software. Of the 28 samples, we excluded 12 specimens with an unclear bone surface or marked osteophytes on the greater tubercle on 3D-CT images. After imaging, we carefully dissected the remaining 16 samples so as not to damage the bony surface, and identified the antero-medial border of the infraspinatus tendon. Radiopaque markers 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.

**Results:** We could identify a remarkable impression delineated as the triangular shape, which was located postero-lateral to the highest impression, antero-lateral 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. To analyze the size variance of the “lateral impression”, we measured each side of the triangular shape in all samples. The “lateral impression” was composed of the border with the
highest impression (mean; 6.3mm), the border with the middle impression (mean; 5.0mm), and the border with the lateral wall of the greater tubercle (mean; 8.5mm).

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 using micro-CT. In all 16 samples which showed the clear surface of the greater tubercle, we could confirm the “lateral impression” as the triangular shape. In addition, we marked the anterior edge of the infraspinatus tendon with a radiopaque marker and took 3D-images of the same specimens again. The anterior side of the “lateral impression”, in other words, the border between the highest impression and the “lateral impression” was shown to correspond to the insertion of the anterior edge of the infraspinatus tendon in all 16 samples.

**Discussion:** In classical textbooks of anatomy, the shapes of impressions of the greater tubercle have been simply described as adjacent squares; superior and middle impression. However, we could confirm the existence of the “lateral impression” as a triangle facet, which was separated from the highest and middle impression in all samples of dry bones and on 3-dimensional micro CT images. The size of the “lateral impression” varied from small to large. As a reason for the discrepancy between previous knowledge and actual images of the greater tubercle of the humeri, it could be speculated that for the smaller “lateral impression”, the configuration of the greater tubercle seemed more similar to that as
described in classical textbooks. In contrast, for the larger “lateral impression”, this impression could be clearly identified to be like cases which we have sometimes encountered in clinical images and in anatomy practice dissections.

In the previous literature, the highest impression was expressed as the prominence where the supraspinatus inserted; and the middle impression where infraspinatus inserted. The configurations of each impression were approximately delineated as simply adjacent squares. Curtis et al. also analyzed the supraspinatus and infraspinatus insertions based on the concept that the greater tubercle was simply divided into three “facets”. In contrast to these concepts, Mochizuki et al. reported that the tendon of the infraspinatus extends to the anterolateral area of the highest impression of the greater tubercle, meaning that it was not limited to the middle impression. However, it was enigmatic that the border between the supraspinatus and the infraspinatus insertion also served to separate the area of the highest impression of the greater tubercle, as Mochizuki et al. described. In the present study, the border between the highest impression and the “lateral impression” corresponded to the anterior border of the insertion of the infraspinatus tendon. In other words, the “lateral impression” corresponded to the anterior part of the infraspinatus insertion.

**Significance:** To date, there has been no bony landmark for the identification of the original insertion of the infraspinatus, even though the new anatomic concepts regarding the insertion were reported by Mochizuki et al. However, based on the current study, the location of the “lateral impression” could be identified by preoperative assessment of 3-dimensional CT images of the humerus and this will be useful for the specific diagnosis of infraspinatus tear and for the planning of anatomic repair of the infraspinatus tendon.

*ORS 2015 Annual Meeting*
*Poster No: 2024*