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ORIGINAL ARTICLE

The effect of humeral tunnel locations on radiographic tunnel changes in baseball players following medial ulnar collateral ligament reconstruction: comparison of anatomic and nonanatomic locations

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Background: There has been no study on radiologic changes after medial ulnar collateral ligament (MUCL) reconstruction and related clinical features.
Methods: Data from 39 baseball players who underwent MUCL reconstruction were collected and analyzed. The baseball players were classified into 2 groups according to the starting point of the humeral tunnel: (1) the lower tip of the medial epicondyle (group NA, n = 21) and (2) the remnant of the MUCL (group A, n = 18). Bone tunnel characteristics and changes were evaluated by computed tomography (CT) at 3 and 9 months postoperatively. Outcome measures consisted of the visual analog scale, range of motion (ROM), the Conway scale, and the presence of ulnar nerve irritation postoperatively.
Results: The mean diameter of the humeral entry was 4.0 mm (range, 3.4-5.1 mm) on the first CT scan, which increased to 5.5 mm (range, 3.2-7.2 mm) on the follow-up CT scan ($P < .001$). The mean diameter of the ulnar tunnel was 2.8 mm (range, 1.1-3.3 mm) on the first CT scan, which decreased to 1.6 mm (range, 0-4.3 mm) on the follow-up CT scan ($P < .001$). The between-group comparison revealed no differences in the changes in the diameter of the humeral and ulnar tunnels. A statistically significant correlation was not found between athletic performance measured by the Conway scale and the radiologic changes on CT evaluation ($P = .182$). Group A showed improvement in extension from 7° preoperatively to 1° postoperatively ($P < .001$) and in flexion from 126° preoperatively to 136° postoperatively ($P < .001$), while group NA did not achieve statistical significance in ROM improvement after the operation.
Conclusions: Humeral tunnel widening was commonly observed, while the ulnar tunnel was maintained or became narrowed conversely. The humeral tunnel placements did not affect tunnel changes after the surgical procedure; however, MUCL reconstruction with the anatomic location of the humeral tunnel yielded substantial improvement in elbow ROM.

Our institutional review board approved this study.

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Medial ulnar collateral ligament (MUCL) tears are commonly observed in baseball pitchers, which result from high tensile and shearing stresses during the late cocking to early acceleration phases of throwing.[1,3,10,11,17] With advancements in surgical techniques from figure-of-8 graft reconstruction to the docking technique, the results of MUCL reconstruction were reported to be excellent in 90%-95% of cases.[2,8,20,25,27] Related complications have been mostly reported as temporary ulnar nerve palsy, stiffness, or myositis ossificans.[7,8,26] There is a paucity of literature on the tunnel changes over time after the surgical procedure, which has been a well-known issue in anterior cruciate ligament (ACL) reconstruction.[9,14,21,22] Bone tunnel widening in ACL reconstruction is characterized as an expansion of the tibial and femoral bone tunnels on postoperative radiographs.[14] A general consensus has been reached, concluding that this phenomenon has no significant correlation with clinical outcomes after ACL reconstruction.[4,6,12,21,24] However, tunnel widening at time points greater than 6 months may suggest poor graft-to-bone healing, which may lead to increased laxity over time.[30] Although the ACL and MUCL have different roles and intra-articular locations, some of the mechanical factors known to cause tunnel widening after ACL reconstruction may have similar effects after MUCL reconstruction. However, there has been no study yet on what radiologic changes appear after MUCL reconstruction and how these changes affect clinical outcomes.

In this study, we aimed to investigate the changes in the humeral and ulnar tunnels using 3-dimensional (3D) computed tomography (CT) and the clinical relevance according to 2 different starting points of the humeral tunnel: the MUCL remnant and the lower tip of the medial epicondyle (Fig. 1). The working hypothesis was that MUCL reconstruction with a nonanatomic starting point of the humeral tunnel (lower tip of the medial epicondyle) would result in a more advanced progression of bone tunnel widening than that with an anatomic starting point of the humeral tunnel (MUCL remnant). Primary outcome measures included changes in the humeral and ulnar tunnel diameters as measured by serial 3D CT evaluations. Secondary outcome measures included the visual analog scale (VAS) score for pain, range of motion (ROM), the Conway scale, and the presence of ulnar nerve irritation.

Materials and methods

Patient selection

We retrospectively reviewed the medical records of 100 consecutive athletes who underwent MUCL reconstruction between October 2010 and May 2013. Among them, 57 underwent 3D CT scans 3 and 9 months postoperatively. The remaining 43 athletes refused to undergo a second CT scan considering the possible radiation hazard.

The exclusion criteria were as follows: having follow-up of less than 2 years after the index operation (n = 0), undergoing figure-of-8 graft reconstruction (n = 5), undergoing revision surgery (n = 4), and not being baseball players (n = 7). In addition, 2 patients met 2 or more of these exclusion criteria and were thus excluded. The baseball players were classified into 2 groups according to the starting point of the humeral tunnel: (1) nonanatomic location on the lower tip of the medial epicondyle (group NA, n = 21) and (2) anatomic location on the remnant of the MUCL (group A, n = 18).

Radiologic assessments

We obtained 3D CT scans (Light Speed VCT XT; GE Medical Systems, Waukesha, WI, USA) at 3 months postoperatively and additionally at 9 months postoperatively. The first 3D CT scan was used for the investigation of humeral tunnel characteristics, such as length and angle, and the second 3D CT scan was used for the

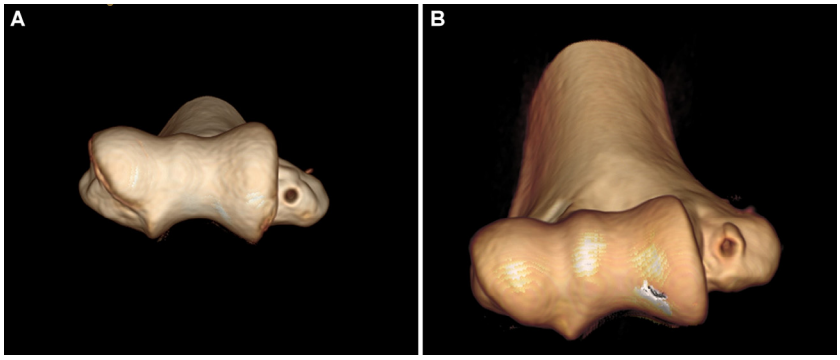

Figure 1 Reconstructed 3-dimensional computed tomography images at 3 months postoperatively showing starting point of humeral tunnel: lower tip of humerus (**A**) and remnant of medial ulnar collateral ligament (**B**).