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Docking 술식을 이용한 야구선수의 내측측부인대 재건술에서 상완골 터널 시작위치에 따른 임상결과 비교

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Comparison of Two Different Humeral Entries in Medial Ulnar Collateral Ligament Reconstruction Using Docking Technique in Baseball Players

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The purpose of this study was to evaluate the humeral tunnel characters and clinical relevance according to entry point of the humeral tunnel in the baseball players. It was hypothesized that the medial collateral ligament (MCL) reconstruction with nonanatomical starting location of the humeral tunnel (inferior edge of the medial epicondyle: group NA) provided less favorable radiological and clinical outcomes compared to that with anatomical starting location (original footprint of the MCL: group A). The retrospective case review yielded 19 consecutive athletes who underwent isolated MCL reconstruction using the docking technique. Three dimensional-computed tomography scan was performed at 3 months, and the iso-surfacing by marching cubes algorithm were applied to evaluate the length and angle of humeral tunnel. Three outcome measures were used in this study: the visual analog scale for pain, range of motion and the Conway scale. The angle of the humeral tunnel was measured 12.2° (range, 7.9°－25.2°) in the group NA and 15.5° (range, 9.8°－30.4°) in the group A ($p<0.05$). The mean length of humeral tunnel is measured 16.3 mm (range, 11.7－20.1 mm) in the group NA and 15.2 mm (range, 10.3－19.1 mm) in the group A ($p<0.05$). MCL reconstruction brought substantial improvement in pain and function. However, between-group comparison revealed no statistical differences in all outcome measurements. The MCL reconstruction using the docking technique provided favorable clinical outcomes in baseball players. Although the humeral tunnel angle and length were different depending on the humeral entry points, clinical differences between the two entry points were not found.

Keywords: Medial collateral ligament, Reconstruction, Humeral, Tunnel

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Introduction

The anterior bundle tear of the medial collateral ligament (MCL) in baseball pitchers is common injury, which results from tremendous valgus torque during late cocking to early acceleration phases of throwing[1-4]. Although athletes with partial tear of the MCL may return to play after having well-established rehabilitation, surgical intervention must be considered in case of persistent pain and consequent fall-off in athletic performance[5]. The MCL reconstruction technique has been advanced from figure-of-eight graft reconstruction (commonly known as the Tommy John surgery) composed of reflecting the flexor pronator mass, ulnar nerve anterior transposition and making three holes in the medial epicondyle for the graft passage[6] to the docking technique which minimized soft tissue damage, decreased the number of large drill holes in the medial epicondyle and provided firm fixation[7]. Clinical studies demonstrated high success rate of the docking technique, either original or modified, reporting excellent results in 90%–95%[7-11]. Compared with the figure-of-eight graft reconstruction, the docking technique requires more surgical skill in making the humeral tunnel with proximal exit anterior to the intermuscular septum through the narrow surgical window. However, there is a paucity of literature concerning the anatomical feature of the humeral tunnel such as starting location, tunnel angle and length, and its clinical relevance, which would be beneficial information regarding preparation of the humeral part for the docking technique. Byram et al.[12] investigated ideal placement of the humeral tunnel to gain maximal tunnel length with a computed simulation, suggesting that the humeral tunnel should be directed 30° from the long axis of the humerus in the sagittal plane and 15° from a central or slightly lateral starting point in the coronal plane. Although comparing radiological and clinical outcomes according to starting location of the humeral tunnel would provide valuable information for maximization of tunnel length and longevity of the reconstructed structure, clinical study has not yet evaluated these aspects.

The purpose of this study was to evaluate the humeral tunnel characters and clinical relevance according to starting location of the humeral tunnel in the baseball players. It was hypothesized that the MCL reconstruction with nonanatomical starting location of the humeral tunnel (inferior edge of the medial epicondyle) provided less favorable radiological and clinical outcomes compared to that with anatomical starting location (original footprint of the MCL).

Methods

This study was approved by the institutional review board, and informed consent was obtained from each patient.

1. Patient selection

The retrospective case review yielded 25 consecutive athletes who underwent isolated MCL reconstruction between November 2010 and October 2011. Patients were excluded if they (1) had a time interval of less than 1 year between MCL reconstruction and last contact (n=1); (2) had not a three dimensional-computed tomography (3D-CT) postoperatively (n=2); (3) were operated using figure-of-eight graft reconstruction (n=2); (4) had revision surgery (n=1); (5) were not baseball player (n=0). If a patient did not visit outpatient clinic for regular follow-up, we contacted the patient by telephone interview to complete outcome measurement questionnaires. Patients were divided into two groups according to starting location of the humeral tunnel: group of nonanatomical location on the inferior edge of the medial epicondyle (NA) and group of anatomical location on the original footprint of the MCL (A) (Fig. 1).

2. Operative procedure

All procedures were performed by the senior author (J.Y.P.). Patients with the posteromedial impingement and MCL injury underwent staged operations. Arthroscopic spur resection was done at first, and then MCL reconstruction was performed 2 weeks later. We did not perform the two procedures concomitantly to prevent surgical inconvenience such as blurred surgical field related to prior arthroscopy or water excretion caused by prior UCL reconstruction. For the MCL reconstruction, the palmaris longus tendon of the contralateral side was used as an autograft in all patients. In attempt to prevent subtle deterioration in pitching performance due to ipsilateral palmaris longus graft harvesting, the senior author performed the harvest on the contralateral arm. The average length of the palmaris longus tendon was 15.7 cm (range, 13.5–17.9 cm). The flexor-pronator muscle splitting

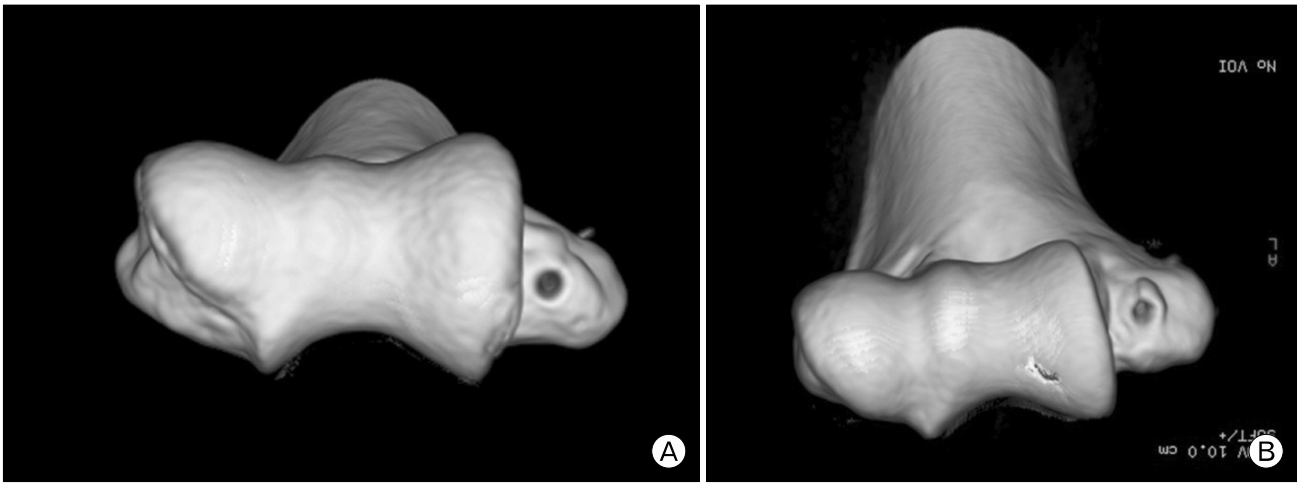

Fig. 1. Images of three dimensional reconstructed computed tomography showing the starting point of the humeral tunnel: (A) inferior point, (B) anteroinferior point.

approach was used to preserve the flexor-pronator origin. The tunnels for the ulna were made anterior and posterior to the sublime tubercle with a diameter of 3.2–3.5 mm. For starting location of the humeral tunnel, two different points were selected. One was inferior point which was located on the inferior tip of the medial epicondyle, and the other was anteroinferior point which was on the anatomical footprint of the MCL. Creation of the entry of the humeral tunnel started using a 2.8-mm drill bit, and the tunnel was dilated up to 4.0 or 4.3 mm sequentially. Then, a 2.0-mm kirschner wire was introduced to the tunnel to make the proximal exit (posterior exit) in front of the intermuscular septum. Another proximal exit (anterior exit) was made 5 mm apart on the anterior surface of the medial epicondyle. Firstly, the graft tendon was passed through the ulnar tunnel. One side limb of the graft that had sutures already in place was introduced to the entry of the humeral tunnel, and the sutures were pulled out through the posterior exit. While the sutures were pulled tightly for secure docking of one side limb of the graft, the length of remnant graft was estimated with the elbow in 30^{o} of flexion, supination and varus state. The measured tendon was sutured by a Krackow fashion and the excess graft was excised immediately above the stitch. The sutures of the other side limb of the graft was pulled out through the anterior exit and maintained tightly. To place the graft securely in the humeral tunnel, cyclic loading was performed while maintaining appropriate tension on the graft tendon, and then the two sets of the sutures were tied over the bony bridge on the humeral epicondyle. After closure of the operative wound, the elbow was placed in in the hinged brace at 30^{o} of flexion with the forearm in neutral position.

3. Postoperative rehabilitation

The operative elbow was maintained in a hinged brace at 30^{o} of flexion with the forearm in a neutral position for 5 weeks, at which time passive range of motion (ROM) exercises were initiated. The brace was set to allow 30^{o}–100^{o} of elbow flexion for 3 weeks. After 9 weeks, full ROM was permitted with the arm in the brace. The brace was removed at 12 weeks, at which time the patient was permitted to start a strengthening program. At 4 months postoperatively, an interval throwing program was initiated and at 6 months, patients could begin to pitch at half-speed. They were expected to return to preinjury levels of play at 9 months.

4. Radiological assessments

Before the surgery, plain radiographs including anteroposterior, lateral (extension and flexion), and valgus-stress radiograph, and magnetic resonance image were performed. Valgus-stress radiographs were taken in both arms with the elbow flexed at 30^{o}, under the general anesthesia at the time of the operation. 3D-CT scan was performed at 3 months with a 64-channel multi detector-row CT system (Light Speed VCT XT; GE Medical Systems, Chicago, IL, USA).

The angle of the humeral tunnel measured in this study was the angle of the humeral tunnel with respect to the longitudinal

axis of the humerus in the sagittal plane (Fig. 2). To evaluate the length and angle of humeral tunnel, the iso-surfacing by marching cubes algorithm were applied[13].

The postoperative ultrasonography for evaluation of the graft status was taken at 3 months in all patients and 12 months in 15 patients in the involved arm with the elbow flexed at 30° under valgus stress. A specialized radiologist with 10 years of experience on musculoskeletal ultrasonography performed all of the follow-up examinations using HDI 5000 system or IU-22 system (both from Philips Healthcare, Bothell, WA, USA).

5. Clinical assessments

Three outcome measures were used in this study: the visual analog scale (VAS) for pain, ROM and the Conway scale. The ROM consisted of flexion, extension, supination and pronation of the elbow joint. The Conway scale is divided into four categories based on the level of competition, and details are as follows: excellent, able to compete at the same or a higher level for more than 12 months; good, able to compete at a lower level for more than 12 months; fair, able to play regularly at a recreation level; and poor, unable to participate in sports.

6. Statistical analysis

Comparisons between the two groups were performed using paired and unpaired Student t-tests for continuous data and the chi-square test for categoric data. Statistical analysis was performed using SPSS ver. 13.0 software (SPSS Inc., Chicago, IL, USA). The level of significance was set at $p<0.05$.

Results

1. Demographics

This study consisted of 19 consecutive patients with surgical reconstruction of MCL using the docking technique (Table 1). Regarding the starting point of the humeral tunnel, inferior point was used in nine patients (group NA) while anteroinferior point was used in 10 patients (group A). There were all males with a mean age of 21.2 years (range, 17–29 years) at the time of surgery. The right elbow was involved in 16 patients and the left elbow in three. The mean follow-up period was 24.9 months (range, 24–36 months). All patients were baseball players, consisting of high school (n=8), collegiate (n=6), professional

Table 1. Demographics

Variable	Group NA* (n=9)	Group A† (n=10)
Age (yr)	21.9 (17–28)	20.8 (18–29)
Side (right : left)	7 : 2	9 : 1
Follow-up (mo)	25.1 (24–36)	24.6 (24–32)
Grade‡	5, 2, 2	3, 4, 3
Position§	7, 1, 1	8, 2, 0
Arthroscopic spur resection	5	4

Values are presented as mean (range) or number.
*Group of nonanatomical location on the inferior edge of the medial epicondyle; †Group of anatomical location on the original footprint of the medial ulnar collateral ligament; ‡High school, college, and professional team; §Pitcher, fielder, catcher.

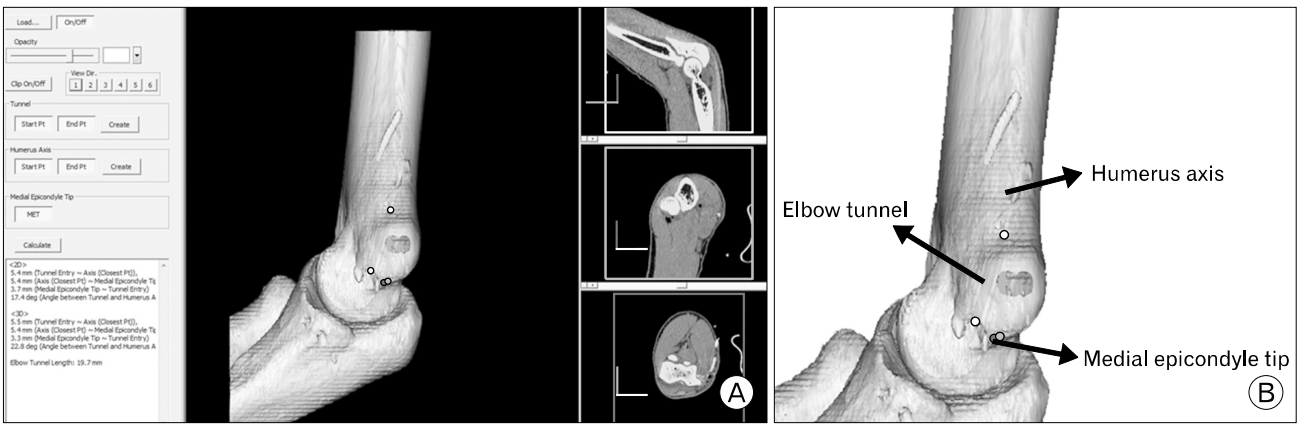

Fig. 2. A photograph of screenshot showing measuring process of the length and angle of the humeral tunnel using the iso-surfacing by marching cubes algorithm (A) and formation of angle with humeral axis (B).

(n=5) team players. The majority of them (15/19) were pitchers, three were fielders and one was a catcher. Arthroscopic spur resection for the posteromedial impingement was performed in nine of 19 patients (47%) before the MCL reconstruction.

2. Radiological outcomes

The mean angle of the humeral tunnel was 12.4° (range, 8.9°–28.4°), and the mean length of the humeral tunnel was 14.9 mm (range, 11.4–20.2 mm). The angle of the humeral tunnel was measured 12.2° (range, 7.9°–25.2°) in the group NA and 15.5° (range, 9.8°–30.4°) in the group A ($p<0.05$). The mean length of humeral tunnel is measured 16.3 mm (range, 11.7–20.1 mm) in the group NA and 15.2 mm (range, 10.3–19.1 mm) in the group A ($p<0.05$). Serial ultrasonography revealed the well-maintained grafts and intact flexor-pronator muscle at 3 and 12 months in all of the players.

3. Clinical outcomes

MCL reconstruction brought substantial improvement in pain and function. However, between-group comparison revealed no statistical differences in all outcome measurements. (Table 2). VAS for pain was 6.0 (range, 3–8) preoperatively and 0.5 (range, 0–4) postoperatively ($p<0.05$). Preoperative mean extension was 2.1° (range, 0°–10°), which was improved to 0.3° postoperatively (range, 0°–5°; $p<0.05$). Mean flexion was improved from 132.6° (range, 120°–140°) preoperatively to 136.3° postoperatively (range, 130°–145°; $p<0.05$). The overall rate of return to play was 90.0% (17/19). According to the Conway scale, 16 out of 19 players (84.2%) were classified excellent with same or higher level compared to pre-injury state, while two players could not return to competitive plays as graded fair to poor. Ulnar nerve symptom occurred in two patients in the NA group. They complained temporary tingling sensation in their fourth, fifth fingers, which subsided within 3 months postoperatively.

4. Complication

Heterotopic ossification occurred in one player postoperatively. He had small size (15 mm×2 mm) ossification at the inferior pole of the medial epicondyle and underwent MCL reconstruction and cubital tunnel release concomitantly. At 1 year postoperatively, excision of the heterotopic ossification and low dose radiotherapy were performed. At final follow-up (2 years postoperatively), he nearly returned to the preinjury state and felt slight discomfort when pitching more than six innings.

Discussion

The purpose of this study was to compare the structural and clinical outcomes of the MCL reconstruction according to the humeral entry point in baseball players. This study revealed statistically significance in the angle and length of the humeral tunnel between the patients with anteroinferior entry point and inferior entry point. Technical consideration of making humeral entry has not been main focus of the investigations on surgical reconstruction of the MCL[14-17]. Studies on the docking technique usually reported fixation methods, follow-up graft status and related clinical outcomes. However, the docking technique which adapted creation of the humeral tunnel without ulnar nerve anterior transposition demands technical competency. When a surgeon is to make the humeral entry point in anatomical position (anteroinferior point) without ulnar nerve anterior transposition, following two aspects should be considered: (1) relatively short

Table 2. Clinical outcomes

Variable	Group NA* (n=9)	Group A† (n=10)	p-value
Preoperative VAS for pain, mean (range)	6.0 (3–8)	6.3 (3–8)	NS
Postoperative VAS for pain, mean (range)	0.5 (0–4)	0.4 (0–3)	NS
Preoperative range of motion‡	3.3/132.1/77.8/64.4	1.0/133.0/80.0/72.5	NS
Postoperative range of motion	0/137.2/80.0/73.3	0.5/135.5/79.0/76.0	NS
Conway scale§	7, 1, 1, 0	9, 0, 0, 1	NS

VAS: visual analog scale, NS: not significant.
*Group of nonanatomical location on the inferior edge of the medial epicondyle; †Group of anatomical location on the original footprint of the medial ulnar collateral ligament; ‡Range of motion consisted of extension, flexion, pronation and, supination; §Conway scale divided into four grades: excellent, good, fair, and poor.

tunnel length and (2) risk of bone breakage with more anteriorly located entry point. Therefore, surgeons who are not familiar with surgical technique may intend to make the humeral entry point more posteriorly. However, if the humeral entry point locates more posteriorly, there would a risk of ulnar nerve complications. Therefore, comparing the outcomes based on two different entry points would provide useful information on these aspects. With enrolled 19 baseball players, the data did not support our hypothesis; that is, the differences in pain and function, level of return to play did not reach statistical significance. With small number studied, this investigation found only two player with ulnar nerve symptom, who had inferior humeral entry point. It might be conceivable to suppose that a less-experienced surgeon may have a higher chance of making ulnar nerve injury with the inferior entry point.

Rohrbough et al.[7] firstly introduced the docking technique to avoid several disadvantage of the Jobe procedure such as the detachment of the flexor origin, ulnar nerve anterior transposition, three large drill holes in the medial epicondyle and the possible complication of an epicondyle fracture. They preliminary reported on 36 cases of MCL reconstruction with 92% rate of return to play. As subsequent studies on the docking technique showed high success rate of over 90% of return to play, the docking technique has been regarded as one of optimal surgical methods for MCL insufficiency[10]. Although with these successful outcomes, clinical investigations have not clearly demonstrated relation between the humeral entry point and outcomes. Although we failed to correlate clinical outcomes and tunnel placements evaluated on computed tomography, this study demonstrated that the average length and angle of the humeral tunnel with inferior entry point was longer than those with anteroinferior entry point. Therefore, based on this finding, we recommend that surgeons who are not familiar to the docking technique use inferior entry point although there is a risk of temporary ulnar nerve complication.

There were several limitations that warrant review. First, small number of enrolled patients makes it difficult to fully evaluate the correlation between the clinical and imaging outcomes. Larger populations would be required to validate our findings. Second, patients were not randomized into each group. This limitation was partially inevitable that making anteroinferior humeral tunnel was difficult in patients with small medial epicondyle. Therefore, the decision on the entry point of the humeral tunnel was dependent on surgeon's technical ability. In addition, the humeral tunnel length may be also influenced by patient's physical characteristics such as height and arm length. Although this study found statistical difference in the humeral tunnel length according to the starting point, this difference may be more obvious if the length of the humeral tunnel was normalized to the entire humeral length or the height.

In conclusion, the MCL reconstruction using the docking technique provided favorable clinical outcomes in baseball players. Although the humeral tunnel angle and length were different depending on the humeral entry points, clinical differences between the two entry points were not found.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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