Triceps Tendon Fascia for Collateral Ligament Reconstruction About the Elbow: A Clinical and Biomechanical Evaluation

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Abstract

In this article, we report on a cohort of patients who underwent elbow ligament reconstruction using triceps tendon fascia (TRI) and compare this alternative graft to a standard, the palmaris longus tendon (PL).

The biomechanical properties of 8 TRI grafts were compared with those of 8 PL grafts, and 10 patients with TRI elbow ligament reconstructions were retrospectively clinically evaluated.

Compared with PL, TRI had significantly more creep, but significantly less cross-sectional area and ultimate failure stress. Ultimate failure load and stiffness did not differ between grafts. Median (SD) postoperative Patient-Rated Elbow Evaluation score (0 = worst, 100 = best) was 79.3 (52). There was no statistical difference between preoperative and postoperative motion. All 10 patients had full triceps strength, and 9 of 10 elbows were stable on examination.

With different graft morphology taken into account, PL had a statistically smaller cross-sectional area and double the ultimate failure stress. When compared using the proportions that would be used during surgical reconstruction, however, the grafts were comparable in ultimate failure strength and stiffness. It is unclear whether the statistically significant 0.8-mm difference in creep translates into clinical relevance. Clinically, patients reported good functional outcomes, motion, strength, and stability.

The traditional graft material for elbow ligament reconstruction has been the palmaris longus tendon (PL).[1-3] Advantages of PL use include convenient harvest and minimal morbidity.[4] The prime disadvantage is congenital absence in up to 25% of the population.[5,6] Reports from Europe have documented use of triceps tendon fascia (TRI) for reconstruction of collateral ligaments in recurrent ulnohumeral elbow instability.[7,8]

There are numerous advantages in using a strip of autogenous triceps tendon as the source of graft material for these ligament reconstructions. The graft is available in all members of the population, graft harvest and ligament reconstruction can be performed through a single incision, there are no nerves adjacent to the tendon, and graft material can be harvested in a variety of sizes and lengths. Several investigators have examined the biomechanical properties of individual tendons, but few studies have provided comparative anatomical and biomechanical information for potential graft sources. To our knowledge, there are no reports on the biomechanical properties of triceps tendon grafts.

In this article, we describe a study in which we examined the biomechanical and morphologic properties of a TRI graft and compared these properties with those of a standard, the PL graft. We also describe an alternative surgical technique, postoperative management, and the results of a cohort of patients with chronic elbow instability treated with elbow collateral ligament reconstruction with TRI.

Material and Methods

Biomechanical and Morphologic Study

With prior approval from the Human Organ Procurement Exchange (HOPE) program, we obtained organ donor graft material taken no later than 14 hours after death and immediately frozen to –80°C. TRI strips 7 mm wide distally by 10 mm long proximally were harvested from the central aspect of each tendon, from the insertion at the olecranon to 15 cm proximally. The PL was harvested open from the palmar aponeurosis to the muscle belly. The tissue, obtained from 5 male organ donors, yielded a total of 18 grafts (10 TRI, 8 PL). One donor had bilateral congenitally absent PLs. Mean age of donors was 22 years (range, 16-37 years).

Two of the 18 samples were excluded from analysis. The first, a TRI graft, had more than 50% of its width cut during harvesting and, with this degree of

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Table I. Biomechanical and Morphologic Data for Triceps Tendon Fascia and Palmaris Longus Graft Testing

	Graft			
	Triceps Fascia		Palmaris Longus	
Property	Mean	SD	Mean	SD
Failure strength, N	289	57	272	50
Cross-sectional area, mm^2	11.8	2.4[a]	5.4	0.8
Stress, N/mm^2	25.4	2.2	51.2	9.3[a]
Stiffness, N/mm	61.2	11.8	64.3	7.6
Total creep, mm	0.93	0.3[a]	0.17	0.05

[a]Statistically significant ($P<.05$).

fiber interruption, was thought to be inappropriate for mechanical testing. The second, also a TRI graft, slipped in the grasping clamps during the dynamic creep–testing portion of the protocol. With these 2 grafts excluded, a total of 16 grafts (8 TRI, 8 PL) was left for analysis.

On day of testing, the tissues were thawed. Vicryl 3-0 was used to tubularize the TRI grafts to fit through a 4.5-mm drill hole, corresponding in size with the bony tunnels used in a collateral ligament reconstruction procedure. Both PL and TRI were maintained in a moistened state with a phosphate-buffered saline solution throughout the testing protocol.

Each graft was mounted on a materials testing system (MTS TestStar II, Minneapolis, Minnesota) to ensure that a minimum graft length of 50 mm (range, 50-78 mm) was left between the upper and lower cryo soft-tissue grips. The cryo soft-tissue grips, designed in our laboratory, have chamfered edges that minimize risk for failure at the grip–graft interface. Tension of 5 N was applied to the grafts while cross-sectional area (CSA) measurements were taken 18 mm from each clamped end and at the central portion of each graft.[9] The mean of these 3 measurements was recorded as the CSA for each graft.

The biomechanical analysis was then performed. Creep properties were measured in the toe region of the stress–strain curve.[10] To identify the toe region for these grafts, we conducted a pilot study using 4 cadaveric TRIs and 4 PLs. Mean (SD) ultimate failure strength of the 8 cadaveric grafts was 189.2 (43) N. The toe region for these cadaveric grafts was found to range from 20% to 30% of ultimate failure strength.

Each graft was cycled 30 times at 0.5 Hz from 0% to 30% of failure force, and dynamic creep was measured. Each specimen was then held at 30% failure stress for 120 seconds, and static creep was measured. Total creep was calculated as the sum of static and dynamic creep. The specimens were then loaded to failure at a rate of 35 mm/s. Stiffness was calculated from the slope of the load elongation curve from 40 N to 120 N, the most linear region of the load elongation curve. Ultimate failure strength was also standardized for CSA and reported as ultimate failure stress.

Ultimate failure strength, ultimate failure stress, stiffness, creep, and CSA were compared between the TRI and PL grafts using a 2-tailed *t* test. Statistical significance was set at $P<.05$.

Table II. Sites of Graft Failure

	Graft	
Site	Triceps Fascia	Palmaris Longus
Midsubstance	6	4
Clamp	2	4

Clinical Study

The Office of Medical Bioethics at the University of Calgary, Calgary, Canada, approved the research protocol (Ethics ID 18793). We then reviewed the charts of con-

PATIENT-RATED ELBOW EVALUATION

Name ______________________ Date____________

*The questions below will help us understand the amount of difficulty you have had with your elbow in the past week. Please describe your **average** elbow symptoms **over the past week** on a scale 0-10.*

1. PAIN

*Rate the average amount of pain in your elbow **over the past week** by circling the number that best describes your pain on a scale from 0-10. A **zero** (0) means that you **did not have any pain** and a **ten** (10) means that you had **the worst pain you have ever experienced. Rate your pain:***

When it is at its worst	0 1 2 3 4 5 6 7 8 9 10
At rest	0 1 2 3 4 5 6 7 8 9 10
When lifting a heavy object	0 1 2 3 4 5 6 7 8 9 10
When doing a task with repeated elbow movement	0 1 2 3 4 5 6 7 8 9 10
How often do you have pain?	0 1 2 3 4 5 6 7 8 9 10 Never … Always

2. FUNCTION

A. SPECIFIC ACTIVITIES

*Rate the **amount of difficulty** you experienced performing each of the items listed below, over the past week, by circling the number that best describes your difficulty on a scale of 0-10. A **zero** (0) means you did not experience any difficulty and a **ten** (10) means it was so difficult you were unable to do it at all.* 0= No Difficulty 10=Unable To Do

Comb my hair	0 1 2 3 4 5 6 7 8 9 10
Eat with a fork or spoon	0 1 2 3 4 5 6 7 8 9 10
Pull a heavy object	0 1 2 3 4 5 6 7 8 9 10
Use my arm to rise from a chair	0 1 2 3 4 5 6 7 8 9 10
Carry a 10lb object with my arm at my side	0 1 2 3 4 5 6 7 8 9 10
Throw a small object, such as a tennis ball	0 1 2 3 4 5 6 7 8 9 10
Use a telephone	0 1 2 3 4 5 6 7 8 9 10
Do up buttons on the front of my shirt	0 1 2 3 4 5 6 7 8 9 10
Wash my opposite armpit	0 1 2 3 4 5 6 7 8 9 10
Tie my shoe	0 1 2 3 4 5 6 7 8 9 10
Turn the doorknob and open a door	0 1 2 3 4 5 6 7 8 9 10

B. USUAL ACTIVITIES

*Rate the **amount of difficulty** you experienced performing your **usual** activities in each of the areas listed below, over the past week, by circling the number that best describes your difficulty on a scale of 0-10. By "usual activities", we mean the activities that you performed **before** you started having a problem with your elbow. A **zero** (0) means you did not experience any difficulty and a **ten** (10) means it was so difficulty you were unable to do any of your usual activities.*

1. Personal activities (dressing, washing)	0 1 2 3 4 5 6 7 8 9 10
2. Household work (cleaning, maintenance)	0 1 2 3 4 5 6 7 8 9 10
3. Work (your job or everyday work)	0 1 2 3 4 5 6 7 8 9 10
4. Recreational activities	0 1 2 3 4 5 6 7 8 9 10

Figure 1. Patient-Rated Elbow Evaluation (PREE).

Table III. Patient Characteristics

Pt	Age,y	Sex	Dominant Hand	Elbow Injury	From Injury to Reconstruction	Reconstruction Operation	Previous Elbow Operation(s)	Follow-Up, mo
1	53	F	R	R radial head fracture	21 mo	MCL, radial neck	ORIF, radial head excision	8
2	34	M	R	L dislocation, radial head fracture	10 mo	LCL	EUA, arthroscopy, debridement, capsular release arthroplasty	12
3	51	F	R	R traumatic throwing -type injury	33 mo	MCL	EUA, arthroscopy, debridement, anterior capsular release	6
4	19	M	R	L dislocation	48 mo	MCL, LCL	EUA, arthroscopy	12
5	19	F	R	R supracondylar fracture with recurrent instability and locking symptoms	96 mo	MCL	LCL reconstruction	12
6	32	M	R	R fall with recurrent instability	14 mo	MCL, LCL	EUA arthroscopy, debridement	12
7	35	M	L	L recurrent dislocation	24 mo	LCL	None	6
8	51	F	R	R dislocation	60 mo	LCL, reattachment of extensor tendon origin	None	6
9	18	M	R	R dislocation, medial epicondyle fracture	~7 y	MCL	ORIF medial epicondyle	20
10	21	M	R	R traumatic throwing injury	10 mo	MCL (contralateral side graft)	MCL repair	6

Abbreviations: EUA, examination under anesthetic; LCL, lateral collateral ligament; MCL, medial collateral ligament; ORIF, open reduction and internal fixation.

secutive patients with chronic elbow instability managed with elbow collateral ligament reconstruction using a TRI autograft. This population did not include throwing athletes. Patient demographics, mechanism of injury, time to surgery, type of surgery, preoperative and postoperative elbow active range of motion (ROM), varus/valgus stability, and strength were recorded. A single investigator measured ROM, stability, and strength. Preoperative and postoperative measurements were compared using *t* test, and statistical significance was set at $P<.05$. Complications noted in the chart were collected. Each patient was contacted and asked to complete the Patient-Rated Elbow Evaluation (PREE) questionnaire, a valid outcome scale with sections investigating pain and function using 10-point categorical scales (Figure 1).[11] All scores were converted to a 100-point scale with 0 equating to worst score possible and 100 to best score possible.

Figure 2. Harvesting central slip of triceps tendon.

Surgical Technique

The patient is placed in a supine position with the hand attached to a limb positioner (Tenet Medical, Calgary, Canada). A midline posterior incision is made and the triceps tendon isolated. A 7-mm-wide central slip of TRI is harvested from the tip of the olecranon to 6 cm proximally (Figure 2). The distal aspect of the tendon graft is thicker in the anteroposterior plane. The proxi-

Table IV. Response Values[a] for Patient-Related Elbow Evaluation

Section	Response Value: Median	Mean	SD
Pain	66.0	62.2	16.4
Function	85.3	88.8	17.6
Total	**79.3**	**75.6**	**52**

[a]0 (worst) to 100 (best).

Figure 3. Anteroposterior radiograph of suture anchor placement.

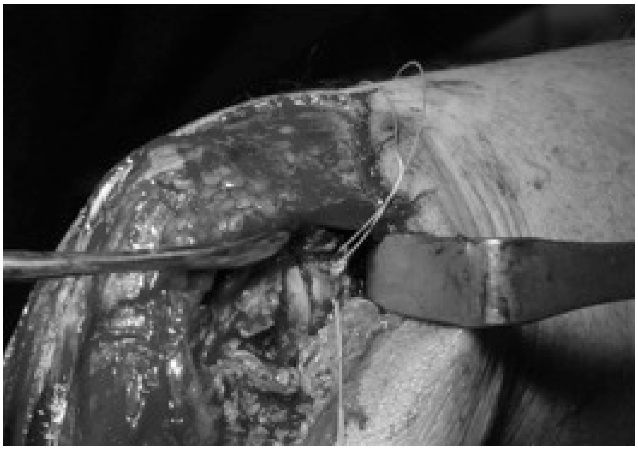

Figure 4. Suture anchor placement in sublime tubercle of coronoid.

Figure 5. Multiple interrupted nonabsorbable No. 2 sutures connecting 2 limbs of graft.

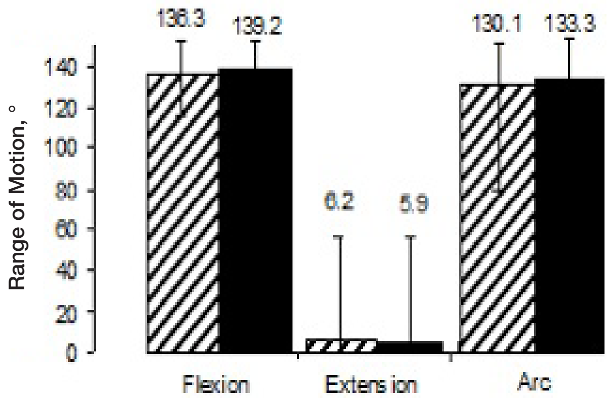

Figure 6. Measurements of active range of motion before surgery (striped area) and after surgery (solid area). Arc indicates sum of flexion and extension range of motion.

mal four-fifths of the graft is a sheet that is made into a tube that fits through a 4.5-mm drill guide.

For lateral collateral ligament (LCL) reconstructions, a lateral fasciocutaneous flap is made, and the Kocher interval between anconeus and extensor carpi ulnaris is developed. A 4.5-mm hole is drilled in the LCL insertion at the lateral epicondyle of the humerus. The hole is started on the inferior portion of the epicondyle; a second hole is drilled 2 cm proximal. These holes are drilled 30° to the long axis of the humerus and then connected with a sharp towel clip. Two 2.5-mm suture anchors are placed at the crista supinator just posterior to the radial head. The thicker distal end of the graft is sutured down to the ulna with the suture anchors. The graft is then passed through the humeral tunnel, inferior to superior, and brought back onto itself in the interval between the humerus and the ulnar insertions, and multiple interrupted nonabsorbable No. 2 sutures are used to bring together the 2 limbs of the graft. The Kocher interval is repaired and the wound closed.

For medial collateral ligament (MCL) reconstructions, a medial fasciocutaneous flap is developed. The ulnar nerve is identified and protected posterior to the medial epicondyle. A split is made in the flexor-pronator origin between the flexor carpi ulnaris and the PL, unless there is a nonunion of the medial epicondyle, which is taken down. The sublime tubercle on the coronoid is identified, and 2 suture anchors are placed around the tubercle (Figures 3, 4). A 4.5-mm diameter hole is drilled in the anteroinferior aspect of the medial epicondyle. The tunnel is then drilled to exit the posterosuperior aspect of the medial epicondyle. The graft is placed in the hole at the anteroinferior aspect of the medial epicondyle, pulled through the drill hole, and then doubled back over itself in the area between the humerus and the ulna. Multiple interrupted nonabsorbable No. 2 sutures are used to bring together the 2 limbs of the graft (Figure 5). The ulnar nerve is left in the cubital tunnel unless the medial epicondyle nonunion is taken down, and then a subcutaneous anterior transposition is performed and the wound closed. Isometry is not checked for either graft.

The limb is immobilized with a posterior plaster splint with the elbow at 90° of flexion, forearm in neutral rotation, and wrist in neutral position. Between 7 days and

10 days after surgery, a hinged elbow orthosis is used full-time with a 30° extension block. The patient removes the splint 4 times a day for forearm ROM exercises (elbow at 90° of flexion) and for skin care. At 2 months, the patient discontinues wearing the splint and starts stretching exercises and strengthening of the biceps and triceps with the elbow at the side. Strengthening exercises with the elbow away from the side are started 4 months after surgery. Full activities are allowed by 6 months after surgery.

Results

Biomechanical and Morphologic Study

All the biomechanical and morphologic data for TRI and PL graft testing are presented in Tables I and II. Although Table I reports only total creep, TRI had significantly more mean creep than PL did—statically (0.31 vs 0.08 mm, respectively), dynamically (0.62 vs 0.09 mm, respectively), and in total. The total mean (SD) creep for TRI and PL was 0.93 (0.32) mm and 0.17 (0.05) mm, respectively.

Clinical Study

In the clinical study, a consecutive group of 15 potential patients was identified. Three patients were excluded—one because the elbow was rehabilitating when the study began, another because of an existing upper extremity peripheral nerve palsy, and the third because of a total elbow arthroplasty. Ten of the remaining 12 potential patients completed the PREE. Demographics of the final group are listed in Table III.

Overall, the median (SD) PREE score for all 10 patients was 79.3 (52) (Table IV). Patients reported lower median (SD) scores for pain, 66 (16.4), than function, 85.3 (17.6). Patient 1, who underwent an MCL reconstruction in addition to a radial neck excision, recorded scores of 12 (pain), 18 (function), and 33 (total). These results were discordantly lower than those of the other 9 patients. Total median (SD) PREE score for those 9 patients was 87.0 (33.1), broken down into pain, 78.0 (14.6), and function, 90 (19.6). Active ROM measurements are shown in Figure 6. There was no statistical difference between preoperative and postoperative flexion, extension, or total arc. After surgery, each patient's triceps strength was graded 5/5, or normal. All patients had stable elbow to varus/valgus stress testing, except for patient 1, who scored the lowest on the PREE. This patient had so much pain that an examination was not possible.

Discussion

To our knowledge, this article is the first report on the biomechanical properties of TRI grafts. In another biomechanical study of ligaments, Carlson and colleagues[12] compared length, area, and volume of PL, pronator teres (PT), and extensor digitorum longus (EDL). They found PT (334 mm) and EDL (325 mm) to be twice as long as PL (161 mm). CSA of PL was 3.1 mm^2, CSA of PT was 1.4 mm^2, and CSA of EDL was 3.3 mm^2. They also examined stiffness: EDL (47.8 N/mm) and PL (42.0 N/mm) were stiffer than PT (25.5 N/mm). There was no significant difference in the modulus of elasticity between tendons. The ultimate failure strengths of the tendons were not determined in this study. Mean PL stiffness in the present study was 64.3 N/mm, which is appreciably more than the 42.0 N/mm reported by Carlson and colleagues. This difference may reflect the young age of the donors in the present study. Tissue age may also account for a difference in CSA. Mean CSA of PL in the present study was 5.4 mm^2, or slightly larger than the 3.1 mm^2 to 4.1 mm^2 reported in earlier studies.[12,13] Alternatively, CSA measurement methods may account for the discrepancy.

Regan and colleagues[14] reported on the stiffness and ultimate failure load of ligaments about the elbow. They biomechanically assessed the major ligaments around the elbow and compared them with PL. Mean CSA of PL was 4.05 mm^2. They found the anterior band of the MCL to be the strongest and stiffest ligamentous structure about the elbow, with a mean ultimate failure load of 260 N. They also found that PL had a larger ultimate failure load, 357 N, compared with that of the anterior band of the MCL. These results are comparable with the mean ultimate failure loads reported in the present study for TRI (289 N) and PL (272 N) grafts. Although numerous studies, such as those by Carlson and colleagues[12] and Regan and colleagues,[14] have examined the biomechanical properties of different individual tendons, our study represents the first to investigate the biomechanical properties of the TRI graft.

In the present biomechanical study, some properties differed between grafts. With different graft morphology taken into account, PL had a statistically smaller CSA and double the ultimate failure stress. When compared using the proportions that would be used during surgical reconstruction, however, the grafts were comparable in ultimate failure strength and stiffness. The larger TRI is not an issue when performing reconstruction about the elbow, as holes 4.5 mm in diameter can be drilled to pass grafts for MCL or LCL reconstructions. However, in areas where graft size becomes an issue, the PL graft can provide double the ultimate strength for a given CSA.

The other notable difference is in the viscoelastic properties of the 2 types of grafts. The structural properties of ultimate failure and stiffness were comparable between TRI and PL grafts, but there was significantly less total creep for PL (0.17 mm) than for TRI (0.93 mm). There are several potential explanations for creep difference. First, compared with TRI grafts, PL grafts may be slightly more resistant to creep. Second, tubularization of TRI grafts causes collagen fibers within the fascia to become slightly twisted or spiralized, so the creep behavior of TRI may be in part related to an untwisting of the TRI graft when loaded in the graft material, the suture material, or both. Third, during harvesting, some midsubstance fibers of TRI grafts may become inadvertently interrupted. Total creep was 0.17 mm for PL and 0.93 mm for TRI. Although the 0.8-mm difference is statistically significant ($P<.05$), the clinical relevance of creep of 0.8 mm in an elbow ligament may be negligible. Until we are certain of its in vivo creep performance, TRI may not be ideal for some high-load groups, such as overhead throwing athletes.

There were limitations inherent in the design of the biomechanical component of this study—the effect of tubularization of TRI graft, duration of creep testing, and testing in isolation rather than testing the reconstructed construct in a cadaveric specimen. The effect of tubularization had been tested in a pilot study, with no difference found in ultimate failure between tubularized grafts and nontubularized grafts. However, discussion regarding tubularization is somewhat irrelevant, as graft tubularization is part of the surgical technique, and we attempted to simulate the in vivo environment as much as possible. Another limitation is that, during creep testing, a complete plateau was not achieved. Testing was performed for 30 cycles dynamically and 2 minutes statically. Although the creep rate decreased at the end of static testing, it did not completely plateau.

Conclusions about the equality of ultimate failure strength between grafts ignored the larger CSA required for TRI to equal PL. In fact, PL had twice the ultimate failure stress. Similar results have been described when PL was biomechanically compared with other ligaments about the elbow.[14] Although ultimate failure strength ignores the effect of CSA, it accurately reflects graft strength in the form used during the described surgical reconstruction.

This study also has several strengths. First, it represents the only biomechanical and morphologic comparison of TRI and PL grafts. Second, we were fortunate to obtain young organ donor tissue, which mimics as closely as possible the patient population that will be undergoing these ligament reconstruction procedures about the elbow. Third, obtaining both PL and TRI grafts from each individual donor reduced the variability resulting from use of unmatched sources. Fourth, we characterized the low-load (creep) and high-load (stiffness, ultimate strength) properties of these grafts.

With respect to clinical performance, 2 other investigator groups have described using TRI grafts for elbow collateral ligament reconstruction. Olsen and Søjbjerg[8] reported outcomes for 19 patients treated for recurrent posterolateral instability of the elbow between 1993 and 2000. Eighteen of the 19 patients were followed up for a minimum of 14 months. Mean time from injury to surgery was 35 months (range, 5-96 months). Before surgery, all patients were clinically evaluated for stability. After surgery, 14 (78%) of the 18 patients had a stable elbow. There were no further dislocations, but 4 (22%) of the 18 patients had persistent apprehension to the pivot shift test. Only 1 patient reported instability or laxity. Fifteen patients did not experience any ROM loss, defined as more than 5° of extension or any degree of flexion. Fifteen of the 18 patients (83%) returned to preaccident levels of activity. According to Mayo elbow performance scores, 16 patients (89%) had an excellent or good postoperative result, and 2 (11%) had a fair result. Seventeen patients (94%) were satisfied with the outcome. None developed an infection or neurologic deficit after surgery.

Eygendaal[7] described using the triceps to reconstruct either the MCL or the LCL in a series of 12 patients who underwent LCL reconstruction. The patients were evaluated with stability tests, a visual analog scale (VAS) for pain, and an elbow functional assessment after a mean of 23 months (range, 17-28 months). Eleven of the 12 patients perceived the elbow as stable. Six lost 5° to 10° of extension; flexion loss was not apparent. Twelve patients rated at-rest postoperative pain a mean of 9.3 on the 10-point VAS, where larger values represent better outcomes. Mean pain with activity was 8.6. Another series of patients (n = 14), who required MCL reconstruction, were followed up for a mean of 21 months (range, 12-49 months). Their mean at-rest pain score was 9.7, and their mean activity score was 9.1.

Some of our clinical results parallel those published by Eygendaal[7] and Olsen and Søjbjerg.[8] The PREE data demonstrate good subjective patient-centered outcomes. Interpreting the PREE data without a preoperative comparison is difficult because there is no consensus on what questionnaire value represents a favorable clinical result. There are also no normative PREE data allowing comparison. Mechanical stability examination correlated with functional PREE scores in that all but 1 patient had a stable examination. The 1 patient who reported poor functional stability did not have an adequate elbow examination because of pain. There was no statistical difference between preoperative flexion, extension, or total arc active ROM values. Given the functional ROM parameters of 30° to 130° (defined by Morrey and colleagues[15]), only 1 of 9 patients with a preoperative function range lost it after surgery. An obvious concern from harvesting a section of triceps tendon is that it will lead to site-specific strength deficits. Both Eygendaal[7] and Olsen and Søjbjerg[8] did not comment on postoperative strength. In our study, all patients maintained full triceps strength after surgery. Nevertheless, any conclusions from the clinical component of this study are limited by the retrospective design, small sample size, short-term follow-up, and lack of preoperative subjective patient center outcome data.

Conclusion

In this article, we describe a method of reconstructing unstable elbow ligaments with a TRI graft as an alternative to a standard, the PL. The biomechanical data provide evidence that these graft sources are comparable in ultimate failure strength and stiffness when compared on the morphology used during the reconstruction surgery. However, because PL had a smaller CSA, its strength per unit area, ultimate failure stress, was double that of TRI. There was a significant difference in viscoelastic properties between grafts, but its clinical significance was unclear.

The clinical component adds to what limited clinical information exists in that harvesting from the triceps tendon does not appear to decrease strength after surgery. The remainder of the clinical results indicates that patients reported good subjective outcomes, maintained preoperative ROM, and regained mechanical stability after surgery.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.