Non-Biological Reconstruction of the Ulnar Collateral Ligament of the Metacarpophalangeal Joint of the Thumb: A Retrospective Case-Control Study

Reconstrucción no biológica del ligamento colateral cubital de la articulación metacarpofalángica del pulgar: Un estudio retrospectivo de casos y controles

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Abstract

Objective The present retrospective analysis compares postoperative results of non-biological ligament reconstruction (NBLR) for chronic injuries involving the first metacarpophalangeal joint (MCPJ) and ulnar collateral ligament (UCL).

Materials and Methods A total of 18 patients with MCPJ injury underwent static non-biological ligament reconstruction and were included in this retrospective case-control analysis. Preoperative, postoperative, and contralateral thumb measurements (clinical, radiological, and subjective outcome questionnaires) were compared over a mean follow-up of 38 months.

Results For the NBLR, the average postoperative ranges of motion of the MCPJs and the interphalangeal joints were of 0 to 57.5° and 0 to 71° respectively. The average grip strength was of 103.3%, and the average pinch strength was of 88.7% relative to the unaffected hand. The subjects demonstrated stability with a firm endpoint comparable to unaffected thumb. The average score on the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire among all patients was of 11.9 for the disability/symptom module, 0 for the sports module, and 16.5 for the work module. Stiffness was reported in four patients, and no wound issues or other complications were registered.

Conclusions The NBLR of the UCL of the thumb yields acceptable short-term outcomes, which may enable a faster recovery and reincorporation into daily activities compared with biological repairs.

Keywords
- thumb
- ligament
- metacarpophalangeal joint
- reconstruction

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Resumen

Objetivo El objetivo de este análisis retrospectivo fue cotejar los resultados posoperatorios de la reconstrucción ligamentosa no biológica (RLNB) para lesiones crónicas que involucran la articulación metacarpofalángica (AMCF) y el ligamento colateral cubital (LCC) del primer dedo.

Materiales y Métodos En total, 18 pacientes con lesión de la AMCF fueron sometidos a una reconstrucción ligamentosa estática no biológica y se incluyeron en este análisis retrospectivo de casos y controles. Se compararon las mediciones preoperatorias, posoperatorias y del pulgar contralateral (evaluación clínica, radiografías y cuestionarios de resultados subjetivos) durante una media de 38 meses de seguimiento.

Resultados Para la RLNB, la media de rangos de movimiento posoperatorios de las AMCF y de las articulaciones interfalángicas del pulgar fueron de 0 a 57,5° y de 0 a 71°, respectivamente. Las fuerzas promedio de agarre y pinza, en relación con la mano no afectada, fueron de 103,3% y 88,7%, respectivamente. Todos los pacientes demostraron estabilidad con un punto final firme en relación con el pulgar no afectado. La puntuación media en la versión corta del cuestionario de Discapacidades Rápidas de Brazo, Hombro y Mano (Quick Disabilities of the Arm, Shoulder and Hand, QuickDASH, en inglés) entre todos los pacientes fue de 11,9 para el módulo de discapacidad/síntoma, 0 para el módulo de deportes, y 16,5 para el módulo de trabajo. Se informó rigidez en cuatro pacientes, y ningún paciente sufrió problemas relacionados con la herida u otras complicaciones.

Conclusión La RLNB del LCC del pulgar genera buenos resultados a corto plazo, lo que puede permitir una recuperación y rehabilitación aceleradas.

Palabras clave

- pulgar
- ligamento
- articulación metacarpofalángica
- reconstrucción

Introduction

The ulnar collateral ligament (UCL) of the first metacarpophalangeal joint (MCPJ) is among the most injured ligaments of the hand.[1,2] If ligament healing is improper, it will likely advance to a chronic MCPJ-UCL injury. The resultant instability can provoke pain, weakness in grasping, pinching, and, ultimately, MCPJ osteoarthritis.[1,3–6] There are several treatment options for chronic UCL lesion, including simple suture repair, dynamic and static techniques, and arthrodesis, to mention a few.[1,2,5,7,8] Static biological ligament reconstruction (BLR) with a free tendon graft is the most common technique for the chronic instability of the first AMCF.[9–12]

Despite the fact that conventional reconstruction procedures result in joint stability,[1,7,13] this is often at the cost of joint flexion and the need to correct normal strength.[5,14] Acknowledged contributing factors for this complication are excessive tension in the graft and the generally required prolonged postoperative immobilization, which delays rehabilitation for 4 to 7 weeks.[7,15,16]

Non-biological increase with Suture Tape has recently been introduced as a new idea in ligament repair; the concept is that of an un InternalBrace to the BLR to accelerate restoration and patients' return to everyday activities and sports.[11,12,17–19] Despite data limited to short-term outcomes,[20] InternalBrace as an augmentation to CCL repair suggests some level of biomechanical superiority compared to repairs without InternalBrace.[21]

Despite promising results for non-biological ligament reconstruction (NBLR),[19,20] it still lacks a standard clinical application for chronic thumb MCPJ-UCL injuries.

This study aimed to analyze and compare X-ray imaging and clinical results among patients with chronic thumb MCPJ-UCL injuries undergoing NBLR. Our initial hypothesis is that NBLR would have acceptable results and avoid the high technical complexity and donor-site morbidity of the standard therapeutic option, being a reliable alternative.

Materials and Methods

Patients

From January 2002 to December 2019, we conducted a retrospective chart review of 72 patients treated for symptomatic chronic UCL injuries of the thumb MCPJ. Patients were included in the analysis if they met all the inclusion and none of the exclusion criteria. The inclusion criteria were: a) an isolated, complete, and symptomatic chronic thumb MCPJ-UCL injury; b) treatment with NBLR using FiberTape (Arthrex, Inc., Naples, FL, United States); and c) a postoperative follow-up of at least 24 months. The clinical criteria for a complete rupture were: a) radial MCPJ deviation greater than 30° or additional laxity greater than 15°, compared with the healthy thumb at 30° of flexion; and b) the lack of a robust stop on the injured thumb when compared with the intact thumb.[2] Chronic injury was defined as an instability for more than 6 weeks despite the conservative (non-surgical) treatment. Patients were excluded if: a) they had an additional or

previous thumb or hand injury; b) arthritis data in the first AMCF in the preoperative radiographs; c) UCL reconstruction performed using a technique other than NBLR; or d) if the patien"s clinical records were unavailable for review.

The patients were operated on by the same hand surgeon from a regional hand surgery institution. The surgeon's decision to reconstruct or repair the ligament relied on UCL quality, which was considered based on the ligament's consistency and capacity to hold sutures and whether it could be mobilized enough to be reattached in its anatomic position. The UCL was repaired if the ligament conditions were as those previously mentioned.

Surgical Technique

Approach

An S incision was made on the ulnar side of the AMCF of the thumb. The dorsal branches of the superficial radial nerve were identified, separated, and secured.

The adductor aponeurosis was opened so that it could be repaired afterward. An incision was made at the junction of the dorsal capsule with the ligament, looking for evidence of osteoarthrosis in the articular cartilage.

The UCL tissue was examined to determine if repair or reconstruction was needed. An anchor was used to reinsert it into the anatomical origin if a repair was necessary. Alternatively, when reconstruction was preferred, the remaining ligament was dissected to expose the MCPJ. Once the reconstruction was completed, the remaining ligament was sutured to the FiberTape. The reconstruction configuration used was triangular with a proximal apex. Two distal points were marked 3 mm from the MCPJ on the proximal and ulnar side of the phalanx at the two and five o'clock positions when viewed from the side of the right thumb. The proximal point was in the metacarpal neck at the nine o'clock position, proximal to the fossa of origin of the UCL typically initiates, distant 7 mm from the articular cartilage (►**Fig. 1**).

Three 1.35-mm guidewires were placed. Two of the Kirschner wires (K-wires) were placed on the proximal ulnar side of the phalanx in a convergent orientation, where the UCL is inserted. This method guarantees sufficient spacing between each hole after drilling, preventing any intraoperative complications such as fractures. The third K-wire was placed proximal to the origin of the UCL, 6 to 8 mm from the MCPJ, in the dorso-ulnar part of the metacarpal (MTC).

Drill over the guide wires using a cannulated 3.0-mm drill bit, 1 cm into the bone, as limited by the depth limit. The central zone of 2.0-mm FiberTape was then loaded onto a forked-tip, fully-threaded, twist-in, knotless 3.5-mm DX SwiveLock anchor (Arthrex, Inc.) and afterward inserted into the MTC hole (►**Fig. 2**). Then, the volar tape of the FiberTape was brought distally, loaded onto the forked eyelet of a second 3.5-mm DX SwiveLock anchor, and inserted into the volar hole at the base of the proximal phalanx while holding the joint reduced in neutral position to prevent excessive tension on the repair. Finally, the dorsal tape of

Fig. 1 Proximal fixation point in the metacarpal neck at the 9 o'clock position.

Fig. 2 Loading of FiberTape with a 3.5-mm DX SwiveLock anchor into the drill hole at the metacarpal neck.

the FiberTape was brought distally, loaded onto the forked eyelet of a third 3.5-mm suture anchor, and inserted into the dorsal hole at the proximal phalanx, while maintaining the MCPJ at 30 degrees of flexion to avoid excessive tension on the repair (►**Fig. 3**). Positioning small, curved forceps underneath the FiberTape while introducing the implant into the phalanx holes helps prevent excessive tension on the repair. The entire range of motion (ROM) of the first digit, optimal balance, and tension to radial deviation of the MCPJ were verified before closing. The dorsal capsule was repaired with sutures using the UCL remanent, and then the adductor aponeurosis was repaired. Sterile bandages and a spica plaster splint were used.

After surgery, the splint was maintained for one week, and thumb interphalangeal joint (IPJ) ROM exercises were started directly. During the next 6 weeks, a removable orthosis was

Fig. 3 Final triangular configuration of FiberTape with 3.5-mm DX SwiveLock anchor.

used. During this time, the patients completed active and passively-assisted movements and employed their hand for routine everyday activities. All activities were allowed after nine to ten weeks.

Assessments

Postperatively, every patient was assessed by an experienced hand surgeon at 3, 6, and 12 months; then, once a year until the final follow-up. At each visit, patients were assessed both clinically and radiographically.

The primary objective outcomes were RDM and strength of the MCP and interphalangeal joints, measured in the injured and healthy hands. In addition, the stability of the injured and contralateral MCPJ to radial stress was measured in full extension and 30° of flexion. Each patient's ROM (extension and flexion) was recorded in degrees, to the nearest 5°, using a goniometer. Grip, key, and tip clamp strength were registered in kilograms using traditional dynamometers (Jamar dynamometer, Sammons Preston, Bolingbrook, IL, United States). A modification aspect for hand dominance was employed for all subjects, assuming that the dominant limb was 10% stronger than the non-dominant one.

At the final follow-up, a subjective evaluation was conducted employing the score on the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire (0: no disability; 100: full disability) to assess function, and the 10-point visual analog scale (VAS) to rate pain (0: no pain; 10: severe pain). The patients were asked about their overall satisfaction with the results, including adaptation to daily activities, return to work, and if they would undergo the same surgery if needed. A previously-described[5] grading method was employed to acquire an overall outcome per subject (►**Table 1**).

Every subject had X-rays taken before and after surgery and of the nonaffected side to evaluate the MCF laxity and degenerative changes. Static posteroanterior (PA), stress PA with the MCPJ at 30° of flexion, and lateral views were obtained. A total of 31 patients agreed to undergo preoperative and postoperative magnetic resonance imaging (MRI) to assess degenerative changes in the MCPJ, which were graded using the Kellgren-Lawrence classification system.[22] All images were evaluated by two independent senior musculoskeletal radiologists blinded to the type of operation performed. Complications and operative time were recorded.

Statistical Analysis

The categorical variables were expressed as frequencies and percentages, and the continuous variables, as mean, standard deviation (SD), minimum, and maximum values. As appropriate, we examined within-group differences regarding previous and surgical results using the paired Student *t*-test or the Wilcoxon nonparametric test. For comparisons between the operated and non-operated hand, standards were compared using the independent Student *t*-test. Exact *p*-values (two-sided) were calculated for Wilcoxon two-sample test statistics, as our sample size was small and standard asymptotic methods assume sufficiently large sampling distributions. Statistical significance was accepted at levels of $p \leq 0.05$.

Results

Demographic data are shown in ►**Table 2**. Of the 18 patients, 13 were actively working and had high-demanding daily activities, while 5 had low-demanding activities. All 18 were able to return to work and resume daily activities, including sports. The average surgical time was of 33 (±6,4; range: 25–40) minutes.

Per the Kellgren-Lawrence arthritis classification system, all subjects had a fully conserved MCPJ at baseline and postoperatively, with no proof of radiological changes of osteoarthrosis at the final follow-up.

Range of Motion

The pre- and postoperative measurements for the thumb ROM are shown in ►**Table 3**. The ROM did not change significantly in either joint between the preoperative and final assessments. At the final follow-up, there were no significant differences in movement between the operated and intact thumbs.

Table 1 Grading System

Grade	Stability (laxest degree)	MCP ROM (% loss)	Pain	Activity limitations	Pinch (% loss)
4 (excellent)	≥ untreated thumb	≤ 15	None	None	≤ 15
3 (good)	0–10°	15–30	Mild: intermittent, caused by heavy use	Only heavy use avoided	15–30
2 (fair)	11–20°	31–50	Moderate: caused by light activity	Moderate limitations in ADLs	31–50
1 (poor)	> 20°	> 50	Severe: pain at rest	Severe limitations in ADLs	> 50

Abbreviations: ADLs, activities of daily living; MCP, metacarpophalangeal; ROM, range of motion.
Note: The patients were assigned a grade from 1 to 4 in each category, and the total scores were rated as follows: excellent – 18 to 20 points; good – 14 to 17 points; fair – 8 to 13 points; and poor – 0 to 7 points.

Table 2 Demographic Data

	NBLR
Number	18
Age (years)	Mean: 43.5
	SD: ± 12.58501
	Range: 22–65
Preoperative time (months)	Mean: 8.416667
	SD: ± 2.483277
	Range: 4–13
Follow-up (months)	Mean: 24.55556
	SD: ± 8.096639
	Range: 13–40
Sex (n)	Male: 12
	Female: 6
Affected side (n)	Right: 13
	Left: 5
Dominant side (n)	Right: 14
	Left: 4
Dominant side affected (n)	Non-dominant side: 5
	Dominant side: 13

Abbreviations: NBLR, non-biological ligament reconstruction; SD, standard deviation.

Table 3 Range of Motion (ROM)

NBLR group	IPJ: preoperative ROM	IPJ: postoperative ROM	IPJ: contralateral ROM	MCPJ preoperative ROM	MCPJ: postoperative ROM	MCPJ: total contralateral ROM	Thumb total preoperative ROM	Thumb total postoperative ROM	Thumb total contralateral ROM
	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)
Mean, SD +/-, Range, %	66.7	68	72.5	68.3	67.2	71.1	135	135.9	143.6
	±6.9	±6.7	±4.3	±12.5	±12.9	±14.8	±11.6	±12.1	±13
	55–80	55–80	65–80	50–90	45–85	50–90	120–155	110–155	125–165
	91	94.50	100	96	94	100	93.50	94	100
	$p = 0.6$	$p = 0.37$		$p = 0.6$	$p = 0.41$		$p = 0.74$	$p = 0.36$	

Abbreviations: IPJ, interphalangeal joint; MCPJ, metacarpophalangeal joint; NBLR, non-biological ligament reconstruction; SD, standard deviation.

Strength Measurements

The pre- and postoperative measurements of grip and pinch strength are shown in ►**Table 4**. A significant advance was noted before and after surgery, with general gains of 57%. In the last follow-up, none of the strength measurements between the operated and non-operated thumb presented a significant difference.

Stability

The pre- and postoperative measurements regarding clinical (MCPJ) and radiological stability are shown in ►**Table 5**. Significant clinical and radiological improvements were noted postoperatively, and there was no significant disparity in the clinical and radiological measurements for the treated and untreated thumbs.

Subjective Measures

The pain decreased significantly after the operation, and significant progress in the QuickDASH score also was noted. Using the Glickel grading system,[7] every patient experienced an excellent satisfaction rate, a good return to work rate, and would repeat the same type of surgery if necessary.

Complications

On the last in-person follow-up, no complications from the surgery were observed. The 3.5-mm anchors in the radiographic reviews did not reveal bone erosion data.

Table 4 Strength measurements

NBLR group		Preoperative tip pinch	Post-operative tip pinch	Contralateral tip pinch	Preoperative key pinch	Postoperative key pinch	Contralateral key pinch	Preoperative grip	Post-operative grip	Contralateral grip
		(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)
Mean, SD +/−, Range, %		3	4.8	5.2	5.2	8.7	9.1	15.5	28.6	29.2
		±0.9	±1.2	±1.1	±0.9	±0.3	±0.3	±0.8	±1.4	±1.6
		2–5	3–7	3–7	4–7	7–11	7–11	11–24	19–38	22–42
		62	92	100	60	96	100	54	98	100
		$p < 0.05$	$p = 0.5$		$p < 0.05$	$p = 0.42$		$p < 0.05$	$p = 0.44$	

Abbreviations: NBLR, non-biological ligament reconstruction; SD, standard deviation.

Discussion

In the sample of the present study, NBLR using 1.3-mm SutureTape (Arthrex, Inc.) achieved excellent short-term results in terms of MCPJ stability, ROM, and pain, while reducing the technical demands and donor-site morbidity associated with other surgical techniques.

The current trend of direct ligament augmentation repairs with 1,3-mm SutureTape has yielded promising results.[19,20] Biomechanical studies in hand surgery and other fields of orthopedic surgery have demonstrated excellent outcomes with this approach to ligament or tendon repair using Suture Tape augmentation.[11,12,17–19,23,24] De Giacomo and Shin[20] and Lee et al.[19] have reported their approach to direct repair to treat acute and chronic thumb UCL injuries using Suture Tape augmentation, and stated that the use of Suture Tape provides strength and greater shape stability, enabling accelerated rehabilitation, and a faster recovery to daily, professional, and recreational activities. No data has been published on chronic MCPJ-UCL reconstruction using SutureTape or other NBLR techniques.

Although employing static BLR for chronically-injured thumb MCPJ-UCL has demonstrated excellent clinical outcomes in terms of stability and strength,[10,13] it is often at the expense of flexion.[5,25] Time to ligament healing and osseointegration of the tendon graft is a limiting step in recovery, as the thumb is often immobilized for this period, thereby delaying rehabilitation for 4 to 7 weeks.[16] We believe this highlights a critical advantage of NBLR over BLR, as FiberTape is implanted and requires no time to heal, so the MCPJ may be mobilized as early as seven days after surgery.

Another crucial technical issue is that the dorsal band of an RLB could limit the flexion of the AMCF if it becomes too tight. With the NBLR, we fixed the MCP insertion first, which enabled us to recreate two independent bands of the collateral ligament (►**Figs. 4A,B**). Thus, we achieved stability and prevented dorsal subluxation of the MCPJ without sacrificing flexion. This is comparable to the outcomes achieved using simulated reconstruction with the Glickel[9] technique, which has been documented to yield outcomes superior to other techniques.

Looped-suture biomechanical tests demonstrate that number-5 FiberWire number 5, 0.799 mm diameter (Arthrex, Inc.) has tensile properties like those of the palmaris longus tendon.[25]

With the NBLR, we used 2.0-mm FiberTape, which is stiffer than 1.3-mm SutureTape, 0.799-mm FiberWire, and the palmaris longus tendon. Therefore, we hypothesize that the stability and strength attainable in performing NBLR using 2.0-mm FiberTape satisfy acceptable biomechanical standards. One primary concern with NBLR is the issue of long-term durability. However, although the FiberTape is a synthetic device that must withstand radial and dorsal forces, it continued to provide satisfactory results during our average follow-up period of three years, and some patients for more than four. Beyond that time, it is possible that additional joint stability can be provided by other native structures, like the capsule and adductor aponeurosis, as they adapt and lose any extra elasticity. Previous studies have reported that the dorsal

Table 5 Clinical and Radiological Stability

NBLR group	Clinical: preoperative 0° stress	Clinical: postoperative 0° stress	Clinical: contralateral 0° stress	Clinical: preoperative 30° stress	Clinical: postoperative 30° stress	Clinical: contralateral 30° stress	Radiological: preoperative 30° stress	Radiological: postoperative 30° stress	Radiological: contralateral 30° stress
	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)	(degree)
Mean, SD +/−, Range, %	38	6.7	5.3	38.9	7.2	6.1	36.4	7.2	6.1
	±5.5	±3.7	±3.7	±6.2	±3.4	±3.6	±5.2	±3	±3.3
	30–45	0–10	0–10	30–50	0–10	0–10	30–45	0–10	0–10
	$p < 0.05$	$p = 0.44$		$p < 0.05$	$p = 0.35$		$p < 0.05$	$p = 0.32$	

Abbreviations: NBLR, non-biological ligament reconstruction; SD, standard deviation.

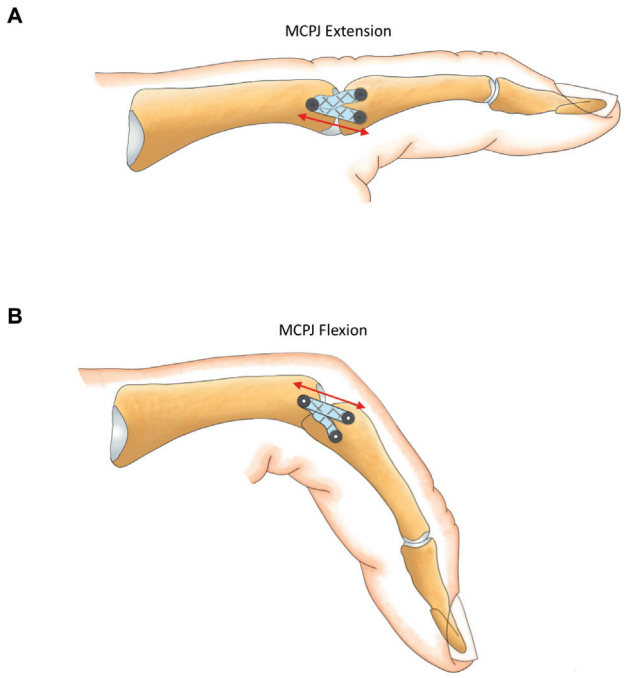

Fig. 4 Variation in strain for the two independent bands of the FiberTape. (**A**) the volar band becomes taut during extension; (**B**) the dorsal band becomes taut during flexion. **Abbreviation:** MCPJ, metacarpophalangeal joint.

capsule is essential to stabilize the MCPJ.[26,27] Capsulorrhaphy of the remnant UCL was performed routinely in all patients and seemed to be related to adequate joint alignment in all cases.

From a technical perspective, NBLR is simpler than BLR. The morbidity associated with obtaining the autograft[28,29] is eliminated with the non-biological technique. Another advantage of this technique is that it does not require additional K-wire immobilization, eliminating all risks related to the needles.[7,15]

To know the prevalence and importance of osteoarthrosis related to RLNB of the CCL, larger studies and greater follow-up are needed.

The current study has limitations, among them, the need for long-term results. This is particularly important, since we are dealing with a novel application of UCL reconstruction with Internal Brace. The durability of this construct has proven promising short-term outcomes; however, mid- and long-term outcomes still need to be discovered. Ideally, a prospective, randomized controlled study with more extended follow-up and a more significant sample is required to ascribe the benefits of FiberTape in reconstructing chronic MCPJ-UCL lesions.

Conflict of Interests

The authors have no conflict of interests to declare.

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