Modified Eaton-Littler's Reconstruction for Traumatic Thumb Carpometacarpal Joint Instability: Operative Technique and Clinical Outcomes

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Abstract

Keywords

- Eaton-Littler's ligament reconstruction
- operative technique
- prospective study
- outcome measures
- thumb carpometacarpal joint instability

Background Injuries to thumb carpometacarpal joint ligaments lead to instability. Eaton-Littler's ligament reconstruction traditionally uses a strip of flexor carpi radialis to stabilize the CMC joint.

Study Description We have modified this technique to reproduce the direction of active action of the anterior oblique ligament by reconstructing both the volar and dorsoradial ligaments. In this prospective study, we evaluated patients with confirmed traumatic thumb CMC joint instability who underwent modified Eaton-Littler's reconstruction. Strength analysis, Michigan Hand Outcome Questionnaire, QuickDASH, and subjective outcome measures were collected pre- and postoperatively with minimum 3 years of follow-up. Eleven patients were included in the final analysis, with mean age of 29 years (range: 16–52) and average follow-up of 6.2 years (range: 3–11). There was a statistically significant improvement in all outcome measures.

Clinical Relevance Our modified technique helps to simultaneously address both volar and dorsal ligaments and yields satisfactory clinical outcomes at medium term follow-up.

Level of Evidence Level IV, case series.

The thumb carpometacarpal (CMC) joint or the trapeziometacarpal joint is a complex joint resembling two reciprocally opposed saddles whose transverse axes are perpendicular.¹ This morphology offers the CMC joint three planar motions; flexion–extension, abduction–adduction, and pronation–supination or opposition–retropulsion.¹ The asymmetric height of the radial and ulnar condyles of the trapezium articulating surface provides a degree of intrinsic stability.² This stability is reinforced principally by the joint capsule and the five ligaments of the thumb CMC joint. These are the volar oblique ligament, dorsoradial ligament, intermetacarpal ligament, posterior oblique ligament, and the ulnar collateral ligament.³ The volar oblique ligament from the trapezium to the volar beak of the thumb metacarpal provides the primary restraint

to dorsal subluxation.^{4,5} However, this has been questioned by biomechanical and anatomical studies in support of the thin dorsal oblique ligament reinforced by the expanded insertion of the abductor pollicis longus (APL) as a primary restraint.^{6–10}

Injuries to the thumb CMC joint ligaments lead to varying degrees of instability from dorsally dislocated thumb with complete rupture to thumb instability from partial rupture or attenuation.^{1,2,6,11,12} Persistent instability has been reported in 50% of patients following closed reduction and percutaneous Kirschner wire fixation of acute CMC dislocations so significantly better results with early ligament reconstruction were obtained.^{11–13} Commonly used techniques for ligament reconstruction are described by Eaton-Littler^{4,14} and Brunelli.¹⁵

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The well-established Eaton-Littler's ligament reconstruction traditionally uses a strip of flexor carpi radialis (FCR) tendon through an extraarticular drill hole in the thumb metacarpal base and secured to the FCR tendon itself to stabilize the CMC joint.^{4,14} We have modified this technique to reproduce the direction of active action of the anterior oblique ligament by reconstructing both the volar and dorsoradial ligaments, thus providing global stability to the thumb CMC joint. The aim of this study was to describe the surgical technique and present our clinical outcomes with medium term follow-up.

Materials and Methods

Study Design

We performed a prospective consecutive study of all patients aged over 16 years who underwent modified Eaton-Littler's reconstruction for thumb CMC joint instability at our unit with minimum 3 years of follow-up. The study protocol was approved by the local research and clinical effectiveness departments.

Patients

The data of all patients with confirmed traumatic thumb CMC joint instability who underwent modified Eaton-Littler's ligament reconstructions were collected prospectively. We excluded patients who had wrist fractures, scaphoid fractures, lunate/perilunate dislocations, and those with open injuries. All patients had plain radiographs of the wrist, magnetic resonance arthrography, or diagnostic arthroscopy confirming the diagnosis.

When assessing patients for thumb CMC instability, we routinely follow a stepwise approach consisting of first, the provocative test described by Takewale et al.¹⁶ The thumb is first abducted in a palmar direction and pronated; in this position, the capsule of the joint tightens and the APL lies in front of the joint to become a secondary, extrinsic stabilizer. The joint is therefore stable when forward pressure is applied to the base of the metacarpal of the thumb and there is no forward movement of the metacarpal in relation to the trapezium. The thumb is then gradually abducted radially, supinated, and extended. In this position, it is only the anterior oblique ligament, which will aid the stability of the joint. Forward pressure is then applied to the now supinated and repropulsed thumb. If the beak ligament is deficient, there will be forward movement of the metacarpal in relation to the trapezium reproducing the symptoms of instability. If equivocal, we proceed with a lignocaine test. This involves injecting local 1% plain lignocaine locally and assessing temporary relief of instability symptoms. All patients would then undergo MRI arthrogram to confirm the clinical diagnosis. If, however, the diagnosis is still in doubt following MRI arthrogram, we proceed with a diagnostic arthroscopy. In addition, all patients were assessed for any degenerative changes on plain radiographs using the Eaton and Littler classification system.⁴ Patients with any degenerative changes were excluded.

All patients underwent routine preoperative anesthetic assessment and received a general anesthetic with arm tourniquet.

Outcome Measures

We collected demographic data, including age, hand dominance, occupation, and mechanism of injury. Once the thumb CMC traumatic instability was confirmed by either MRI arthrogram or diagnostic arthroscopy, preoperative strength analysis was performed for both injured and unaffected sides. The Michigan Hand Outcome Questionnaire (MHQ)¹⁷ and The Disabilities of the Arm, Shoulder, and Hand Score (QuickDASH)^{18–20} data were collected preoperatively. At final follow-up, we recorded any complications and performed postoperative strength analysis, MHQ, and QuickDASH outcome measures. We also administered a patient satisfaction questionnaire at final follow-up asking the patients to subjectively rate their outcome as "good," "moderate," or "poor."

Operative Technique

The thumb CMC joint is approached through an anterior curvilinear incision (i.e., Wagner incision) along the lateral margin of the thumb metacarpal, curving ulnar toward the distal wrist crease as far as the flexor carpi radialis tendon. The superficial sensory branches of the radial nerve, palmar cutaneous branch of the median nerve, and the superficial branch of the radial artery are identified and protected. The thenar muscles are then reflected extraperiosteally from the metacarpal and the trapezium to expose the thumb CMC joint. The anterior oblique ligament is then identified and inspected as well as the dorsoradial ligament. Arthrotomy of the joint is then performed to inspect the articular surfaces (**► Figs. 1–3**).

A separate 1-cm transverse incision is then made proximally in the forearm to harvest a 10-cm long FCR tendon slip using Carroll's tendon forceps. An extra-articular bone tunnel is then made through the dorsum of the thumb metacarpal placed 7 to 8 mm distal and parallel to the thumb metacarpal articular surface.

In the traditional Eaton-Littler's technique, the FCR slip, based distally, is released in continuity till its insertion on the index metacarpal. It is then rerouted through a drill hole in the base of the thumb metacarpal, under the APL insertion, and secured on the radial side of the joint.

We have modified this classical technique by restricting the release of FCR slip 2 to 2.5 cm short of its insertion. This slip is then directed in an oblique manner to reproduce the direction of action of the anterior oblique ligament. A couple of sutures, polydioxanone (PDS) 3–0, are placed at this bifurcation point of the FCR slip to prevent further splitting of the slip toward the insertion of FCR on the index finger (**► Fig. 1**). The FCR slip is routed through the extra-articular bone tunnel and sutured in a taut position back on itself. The routed FCR slip covered both the dorsal (dorsoradial ligament) and volar aspect (volar beak ligament) of the CMC joint by passing under the APL tendon. An appropriate tension is created in the routed FCR slip by wrist tenodesis maneuver to avoid thumb contracture. The joint capsule is then repaired in an end-to-end fashion using 4–0 PDS interrupted sutures. Wound is then closed and a thumb spica applied for 6 weeks.

Hand therapy was commenced after removal of the plaster to allow active and passive mobilization of the thumb

Fig. 1 Anatomical illustration demonstrating the technique and our modification. (A) Traditional Eaton-Littler's technique. (B) Modified Eaton-Littler's technique (Loh's modification).

Fig. 2 Intraoperative clinical photographs demonstrating the operative technique. (A) Wagner incision. (B) FCR tendon exposure at distal wrist crease level (FCR above McDonald's Dissector). (C) Subperiosteal thenar muscle dissection to reveal a tear in the anterior oblique ligament of the capsule of the CMC joint of the thumb. (D) Inspection of the articular surfaces of the thumb CMC joint. (E and F) Harvesting a FCR tendon slip using Carroll's tendon forceps. CMC, carpometacarpal; FCR, flexor carpi radialis.

Fig. 3 Operative technique (continued). (A) Bone tunnel completed. (B) Modified Eaton's reconstruction with the FCR tendon slip through the bone tunnel (size: 2.8 mm), under the APL tendon and FPL tendon itself and terminating at the capsule of the thumb CMC joint using PDS 3-0 sutures for tendon junctions and PDS 4-0 for joint capsule. Further distal bifurcation of the FCR tendon slip from the main FCR tendon is prevented by suturing at the site of bifurcation (see ► Fig. 1 for illustration). (C) Completed reconstruction after appropriate tendon tensioning. (D) The skin closure with subcuticular Monocryl 4-0. APL, abductor pollicis longus; CMC, carpometacarpal; FCR, flexor carpi radialis; PDS, polydioxanone.

under hand therapist's supervision. Follow-up was performed regularly at 3 monthly intervals for 12 months.

Statistical Analysis

The values of all parameters are presented as percentages. The paired *t*-test was considered significant for *p*-value less than 0.5. SPSS 16.0 software (SPSS Inc., Chicago, IL) was used for descriptive statistical analysis.

Results

We included 14 patients in the study, 3 were lost to follow-up; 1 patient migrated overseas, 1 patient relocated to the United Kingdom and was unable to attend clinical assessment, and 1 patient was lost to follow-up. We therefore included 11 patients who met our inclusion criteria with minimum 3 years of follow-up. There were six females and five males with mean

Table 1 Demographic data, mechanism of injury, and diagnosis of all patients

Pt.	Age at injury	Sex	Dominance	Occupation	Mechanism
1	17	M	RHD	Gardner	Sporting injury
2	34	F	RHD	Unemployed	Left thumb kicked by horse
3	28	F	RHD	Insurance	Fall on pavement
4	17	F	RHD	Student	Fall on wet floor
5	18	F	RHD	Student	Fall from standing height
6	52	M	RHD	Mechanic	Road traffic accident
7	36	F	RHD	Carer	Fall down stairs
8	36	M	RHD	Laborer	Fall at work
9	48	M	RHD	Manager	Fall on pavement
10	18	F	RHD	Student	Fall at home
11	16	M	RHD	Student	Fall from height

Abbreviations: F, female; M, male; RHD, right hand dominance.

Table 2 Clinical outcomes of all patients pre- and postoperatively

Pt.	FU (y)	Pre-QDASH	Post-QDASH	Pre-MHQ	Post-MHQ	Pre-pinch kg force (contralateral)	Post-pinch kg force (contralateral)	Pre-grip kg force (contralateral)	Post-grip kg force (contralateral)	Outcome
1	3	59	11	38	79	4.5 (11)	9.3 (12)	10 (52)	44.0 (51.0)	Good
2	5	43	14	48	92	3.0 (8.1)	7.2 (8.0)	9.0 (22)	19 (21.5)	Good
3	5	84	16	54	96	2.3 (6.0)	5.5 (6.2)	7.2 (23.3)	21.5 (23.1)	Good
4	6	64	11	43	87	1.8 (3.3)	5.2 (7.7)	6.0 (20.7)	18.3 (20.7)	Good
5	6	57	20	57	78	3.2 (5.2)	4.5 (4.7)	12 (27)	18.0 (20)	Good
6	6	80	23	27	83	4.0 (6.7)	4.0 (8.7)	13.3 (31.3)	12.7 (30.7)	Moderate (pain, stiffness)
7	6	73	29	38	79	2.7 (7.3)	6.8 (7.2)	7.5 (19)	17 (18.5)	Good
8	7	82	41	38	62	1.1 (3.7)	2.1 (3.9)	1.3 (18)	5.4 (19.8)	Poor
9	7	73	14	33	76	4.7 (8.3)	7.3 (8.4)	25 (39.4)	35.5 (39)	Good
10	8	52	9	29	96	2.3 (7.5)	7.7 (7.8)	9.5 (20)	17.8 (19.5)	Good
11	9	66	7	37	96	4.6 (7.9)	8.3 (7.8)	27 (34.2)	41.3 (35.3)	Good

Abbreviations: FU, follow-up; QDASH, The Disabilities of the Arm, Shoulder, and Hand Score (QuickDash); MHQ, Michigan Hand Outcome Questionnaire; contralateral, measures for the contralateral unaffected side.

Table 3 Analysis of the Disabilities of the Arm, Shoulder, and Hand Score (Quick-DASH) and Michigan Hand Outcome Questionnaire

N = 11, mean (SD)	Preoperative	Postoperative at final FU	p-Value ^a
Q-DASH (0 = no disability)	67 (13)	18 (10)	<0.01
MHS (100 = normal)	40 (9)	84 (10)	<0.01

Abbreviations: FU, follow-up; SD, standard deviation.

^aPaired t-test, $p < 0.01$ is significant.

age of 29 years at the time of injury (range: 16–52) and average follow-up of 6.2 years (range: 3–11). All patients were right hand dominant; the mechanism of injury was that of low-energy injury with seven patients injuring their dominant wrists (► **Table 1**).

There was a statistically significant improvement in all outcome measures comparing preoperative and postoperative scores of both MHQ and QuickDASH (► **Tables 2 and 3**). Strength analysis also was statistically improved postoperatively for thumb pinch and hand grip (► **Table 4**). Patients had satisfactory radiographs at final follow-up (► **Figs. 4 and 5**). However, complications were encountered in two patients; one had pain and stiffness with “moderate” outcome, and one patient had “poor” outcome due to pain and limited hand function (► **Figs. 6 and 7**).

Discussion

Stability of the biconcave thumb CMC joint is provided by five ligamentous structures during static pinch and grasp: (1) the anterior oblique ligament, (2) the dorsoradial ligament, (3) the first intermetacarpal ligament, (4) the posterior oblique ligament, and (5) the ulnar collateral ligament.² The traditional view of Eaton and Littler has been that the anterior oblique ligament, also known as the beak or volar ligament, is the key stabilizer of the joint, which prevents radiodorsal subluxation of the thumb metacarpal during key and dynamic pinch.^{4,13,14} Other cadaveric studies seem to favor the dorsoradial ligament complex to be the primary restraint to dorsal dislocation and responsible for thumb stability.^{6,8}

Table 4 Strength analysis of thumb pinch and hand grip (kg force)

N = 11, mean (SD)	Preoperative	Postoperative	p-Value ^a
Thumb pinch			
Operated hand	3.11 (1.21)	6.17 (2.12)	<0.01
Unaffected hand	6.82 (2.20)	7.49 (2.13)	–
Hand grip			
Operated hand	11.62 (7.79)	22.77 (12.15)	<0.01
Unaffected hand	27.90 (10.55)	27.19 (10.57)	–

Abbreviations: SD, standard deviation.

^aPaired t-test, $p < 0.01$ is significant.

Fig. 4 Posterior–anterior and lateral radiographs of (patient 7) at final follow-up with satisfactory clinical and radiological outcomes.

A variety of ligament reconstruction techniques are available to stabilize the CMC joint, most notably Eaton-Littler^{4,14} and Brunelli¹⁵ reconstructions. Eaton-Littler's reconstruction is a well-established procedure with good clinical outcomes.^{12,14,16,21} The harvested portion of FCR is used as a substitute for the anterior oblique ligament; the FCR slip, based distally, is released in continuity till its insertion on the index metacarpal. It is then rerouted through a drill hole in the base of the thumb metacarpal, under the APL insertion, and secured on the radial side of the joint. This traditional reconstruction is protected with Kirschner wire to be removed after few weeks.

Our reservation on this traditional reconstruction is the fact that it does not provide sufficient dorsal stability, particularly for patients with concurrent injury to the dorso-radial ligament. We have, therefore, modified this technique by (► **Fig. 1**) restricting the release of FCR slip to 2 to 2.5 cm short of its insertion suturing the slip at its bifurcation creating a stable base. Then by directing this slip obliquely, it reproduces the direction of AOL. It is then routed through the extra-articular bone tunnel and sutured in a taut position back on itself. By doing so in this oblique manner and passing under the APL tendon, the FCR slip travels volar–dorsal–volar

Fig. 5 Posterior–anterior and lateral radiographs of (patient 9) at final follow-up with satisfactory clinical outcomes and some mild narrowing of thumb CMC joint and negative grind test. CMC, carpometacarpal.

Fig. 6 Posterior–anterior and lateral radiographs of (patient 6) at final follow-up with unsatisfactory clinical outcomes with stiffness, moderate pain, and early degenerative changes.

back on itself, thereby simultaneously ensuring a reinforcement of the volar and dorsoradial ligaments. We believe this modification helps to achieve global stability to the joint.

Akmaz et al¹¹ reported their outcomes in a series of seven male patients with traumatic instability of the thumb CMC joint following Eaton-Littler's reconstruction with average follow-up of 23 months. They reported that the patients' grip

strength and pinch strength increased by a mean of 40.4% (range: 31–50%) and 75.4% (range: 62–100%), respectively. Van Giffen et al²² reported mean postoperative DASH score of 23.2 in 18 evaluated patients. Nyszkiewicz et al²³ reported on eight patients with average follow-up of 12.27 months and average postoperative DASH score of 22.92. Lane et al,²¹ on the other hand, with a larger series of 35 patients and average

Fig. 7 Posterior–anterior and lateral radiographs of (patient 8) at final follow-up with poor clinical outcome without significant radiographic changes.

follow-up of 5.2 years, reported that 67% had excellent results, 30% had good results, and all patients had good stability and improved pinch strength.

This small series is of a single surgeon (W.Y.C.L.) who devised the modification. Our clinical results are comparable to those published in the literature with longer than average reported follow-up. In our series, both MHQ and QuickDASH have significantly improved postoperatively 84.06 (100 = normal) and 17.76 (0 = no disability), respectively. At final follow-up, the thumb pinch and hand grip have also significantly improved to 82 and 83.74% of the unaffected side, respectively.

Two of our patients did not achieve satisfactory functional outcomes. Both were laborers with high functional demands, although one had developed early degenerative changes at final follow-up (→Figs. 6 and 7). It remains to be seen whether longer follow-up would reveal further changes. Therefore, counseling patients with high functional demands and heavy manual jobs is of paramount importance to manage their expectations with less satisfactory outcomes through ligament reconstruction.

In conclusion, thumb CMC joint traumatic instability is a challenging injury that requires early recognition and prompt management. Emerging evidence is challenging the traditional view that the volar oblique ligament is the primary restraint in favor of the dorsoradial ligament. We believe the stability is derived from both volar and dorsal ligaments. Our modified technique helps to simultaneously address both volar and dorsal ligaments and yields satisfactory clinical outcomes at medium term follow-up.

Note

This study was performed at the Department of Trauma and Orthopaedics at Southport and Ormskirk Hospital NHS Trust, Southport, United Kingdom. The study protocol was approved by the local research and clinical effectiveness departments.

Conflict of Interest

None.

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