Box-loop technique in the management of complex elbow instability: a prospective controlled trial

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Summary

Introduction: Chronic elbow instability is a disabling complication. This prospective study reports our experience with the box-loop reconstruction technique, compared with traditional Lateral Collateral Ligament (LCL) and eventual Medial Collateral Ligament (MCL) reconstruction, showing its functional outcome at 12-month follow-up.

Methods: From January 2013 to February 2017, 27 patients with complex elbow instability were recruited. Group-A patients were managed using box-loop technique; in Group-B patients LCL reconstruction was performed and MCL lesions were always intraoperatively tested, under fluoroscopy, and eventually treated. Clinical evaluations were performed at baseline (T0) and at 1-month (T1), 6-month (T2) and 12-month (T3) follow-up. X-rays were performed at T0 and T3. Intergroup and intragroup variability was assessed.

Results: In all the patients, an improvement of both the range of movement and the joint stability was observed after surgery. The mean increase in

flexion-extension arch was 52° in Group-A patients at 12-month follow-up. A significant improvement ($p < 0.05$) of Mayo Elbow Performance Score, Oxford Elbow Scores and Visual Analogue Scale was observed at 12-month follow-up in both groups.

Conclusion: Box-loop technique revealed safe and effective in the management of multidirectional elbow instability.

Level of evidence: IV, Cases Series.

KEY WORDS: *elbow chronic instability, box-loop reconstruction technique, elbow dislocation, circumferential graft technique, lateral collateral ligament, medial collateral ligament.*

Introduction

Elbow dislocations are the second most common major joint dislocations in adults, with a reported annual incidence of 5.21/100,000 people in the USA¹.

Simple elbow dislocations, without associated fractures, account for 50-60% of elbow dislocations and are generally non-operatively managed, with short-term immobilization followed by early functional therapy²⁻⁴. Recent studies, nonetheless, have shown a complex damage of capsuloligamentous even in simple dislocations, thus affecting the whole joint stability⁴⁻⁶.

Elbow chronic instability is a disabling complication, presenting as recurrent joint subluxations or dislocations, which can be observed in elbow dislocations with ligamentous insufficiency^{4,7,8}.

Several reconstructive techniques of the Lateral Collateral Ligament (LCL) complex and the Medial Collateral Ligament (MCL) complex have been described to treat lateral or medial elbow instability, respectively⁹⁻¹³.

In some cases, however, a multidirectional instability can be depicted, thus the reconstruction of both the LCL and the MCL is required. Finkbone and O'Driscoll¹⁴ have recently described the box-loop reconstruction technique, a less invasive method which reconstructs the entire collateral ligament complex, using a single circumferential tendon graft.

This prospective controlled study reports the outcome of the box-loop reconstruction technique, compared with LCL and eventual MCL reconstruction, at 12-month follow-up.

Material and methods

Patients selection

From January 2013 to February 2017, 27 patients referring to our Department with chronic complex elbow instability were recruited.

Patients were then divided into two groups, according to the surgical procedure performed to obtain the elbow stability. Group-A patients were managed using box-loop technique, between September 2015 and February 2017. In Group-B patients, on the other hand, LCL reconstruction was performed, while suspected MCL lesions were always intraoperatively tested, under fluoroscopy, and eventually treated, between January 2013 and August 2015. A 2-0 Fiber-Wire™ (Arthrex, Naples, FL, USA) was used to perform the LCL and, eventually, the MCL complex reconstruction.

Postoperatively, in Group-A patients the elbow was immobilized in a cast for 2 weeks, followed by 4 weeks in an articular brace, in order to allow gentle active and active-assistive exercises. The brace was then progressively dismissed, on the basis of the patient's history and clinical outcome.

In Group-B patients, the elbow was immobilized in extension in a splint for 48 hours, followed by 5 weeks in an articular brace, which was progressively dismissed, depending on the patient's history and clinical outcome.

All the patients gave informed consent before enrolment. The study was conducted according to international standards¹⁵.

Box-loop technique description

All the box-loop reconstructions were performed by the same surgeon (G.V.) according to the technique description by Finkbone and O'Driscoll¹⁴ (Figs. 1, 2). Two different medial and later surgical incisions were generally performed; when concomitant surgery was needed, i.e. radial head fixation or arthroplasty, a posterolateral Kocher approach was used. An autologous gracilis graft was used to perform the circumferential reconstruction.

On the medial side, with the elbow flexed at 90°, the distal dissection is made by splitting, at its origin, the common flexor-pronator tendon. Then, the origin of the MCL, on the anterior-inferior margin of the epicondyle, and its insertion, on the sublime tubercle of the ulna, are depicted. A 3.2-mm drill hole, is performed into the anterior inferior margin of the epicondyle and into the ulna, just a few millimetres distal to the MCL insertion. Care should be taken to not drill deeper, at this side, since the drilling line must be definitively chosen, after the identification of the corresponding lateral point.

On the lateral side, the deep dissection is performed through the anconeus interval; the interosseous vessels are cauterized. The LCL complex, together with the capsule, is splint longitudinally toward the supinator crest tubercle. The isometric point on the lateral condyle, which must be equidistant from the anterior, proximal and distal margins of the capitellum, is assessed. A 3.2-mm drill hole is performed there and into the ulna just a few millimetres posterior to the supinator crest tubercle. Then, a target end of a drill

Figure 1. Box-loop technique, as described by Finkbone and O'Driscoll. AP view; Lateral View; Medial view. The entry point of the drill bit where to make the tunnels are indicated in red.

Figure 2. Preoperative (A, B) and 1-month follow-up (C, D) radiographs of case A1.

guide is placed into the corresponding medial hole and, starting from the lateral side, about 60% of the humerus lateral-medial distance is drilled. The same procedure is made into the ulnar hole and, after that, on the medial side holes.

A split gracilis autograft is prepared using a 2-0 FiberWire™ (Arthrex, Naples, FL, USA) stitch. The graft is passed through the humerus and looped through the ulna twice. Finally, the capsule and the residual ligament tissue are sutured and the graft is tensioned.

Outcome evaluation

Functional outcomes were assessed at baseline (T_0) and at 1-month (T_1), 6-months (T_2) and 12-months (T_3) after surgery, by the OES, the MEPS and the Visual Analogue Scale (VAS).

Clinical examination at each follow-up included: range of motion evaluation; pivot shift test; posterolateral rotatory drawer test, varus and valgus stress tests in complete extension and 30° of flexion. Radiological evaluation, including anteroposterior and lateral views of the elbow, was performed after surgery and at 12-month follow-up (T_3).

Statistical analysis

Statistical analysis was performed using the SPSS® 11.0 software (SPSS Inc., Chicago, IL, USA). The paired t test was used to assess the variability within groups; the unpaired t test was performed to evaluate the intergroup variability. The tests were two-tailed with a confidence level of 5%.

Results

The patients' characteristics are summarized in Table I. Twelve patients (8 males, 4 females; mean age 45.75; range 19-67) were managed with box-loop reconstruction technique (Group-A), whereas 15 patients (10 males, 5 females; mean age 46.93; range 21-65) were treated with traditional LCL and eventually MCL reconstruction (Group-B, Tab. I).

In Group-A patients, radial head arthroplasty (Evolve™ Proline, Wright, Memphis, Tennessee, USA) was previously performed in 3 patients out of

12 (25%), while 1 patient out of 12 (8.33%) had already performed a radial head open reduction and internal fixation (ORIF).

In Group-B patients, radial head arthroplasty (Evolve™ Proline, Wright, Memphis, Tennessee, USA) was previously performed in 3 patients out of 15 (20%), and 3 patients out of 15 (20%) had already performed a radial head ORIF.

Table II shows the clinical outcomes at 12-month follow-up compared with baseline (Paired-t test). In all patients, an improvement of range of motion was observed postoperatively: the mean flexion-extension

Table I. Patient demographics.

Group-A							
Case	Age	Sex	Side	Job	Comorbidities	Diagnosis	Prior surgery
A1	63	Female	Right	Housewife	Hypertension; Hypothyroidism	Chronic instability after terrible triad injury	Radial head arthroplasty Coronoid pull-out
A2	44	Male	Right	Bricklayer	-	Chronic instability with coronoid non- union	-
A3	48	Female	Right	Seamstress	Smoker; Diabetes Mellitus	Chronic instability with coronoid and radial head non- union	Radial head arthroplasty
A4	27	Male	Left	Farmer	Smoker	Chronic instability after multiple dislocations	-
A5	59	Male	Left	Chef	-	Chronic instability after terrible triad injury	ORIF of radial head
A6	38	Male	Right	Farmer	-	Chronic instability after multiple dislocations	-
A7	45	Male	Right	Bricklayer	Smoker; Dyslipidaemia	Chronic instability	-
A8	43	Female	Left	Teacher	Smoker	Chronic instability after terrible triad injury	Radial head arthroplasty Coronoid pull-out
A9	55	Female	Right	Housewife	-	Chronic instability	-
A10	19	Male	Left	Farmer	-	Chronic instability	-
A11	41	Male	Left	Plumber	Diabetes Mellitus	Chronic instability	-
A12	67	Male	Right	-	-	Chronic instability after terrible triad injury	Coronoid pull-out

To be continued

Continue from Table I

Group-B								
Case	Age	Sex	Side	Job	Comorbidities	Diagnosis	Surgery	Prior surgery
B1	21	Male	Right	Student	-	Chronic instability after elbow dislocation	LCL/MCL	-
B2	48	Male	Left	Farmer	-	Chronic instability	LCL/MCL	-
B3	43	Female	Right	Nurse	Smoker; Hypertension	Chronic instability after terrible triad injury	LCL/MCL	ORIF of radial head
B4	54	Male	Right	Teacher	Smoker; Diabetes Mellitus	Chronic instability after multiple dislocations	LCL/MCL	-
B5	65	Female	Right	Housewife	Hypothyroidism; Diabetes Mellitus; Hypertension	Chronic instability after terrible triad injury	LCL	ORIF of radial head Coronoid pull-out
B6	51	Male	Left	Employer	-	Chronic instability after dislocation	LCL	-
B7	44	Male	Right	Physician	-	Chronic instability	LCL/MCL	-
B8	38	Male	Left	Bricklayer	Smoker	Chronic instability after terrible triad injury	LCL/MCL	Radial head arthroplasty
B9	42	Female	Left	Teacher	-	Chronic instability after terrible triad injury	LCL/MCL	Radial head arthroplasty Coronoid pull-out
B10	56	Male	Right	Bricklayer	-	Chronic instability after dislocation	LCL	-
B11	47	Male	Right	Farmer	-	Chronic instability after multiple dislocations	LCL/MCL	-
B12	61	Female	Left	Plumber	Smoker; Hypertension	Chronic instability after terrible triad injury	LCL/MCL	Radial head arthroplasty
B13	55	Male	Right	Employer	-	Chronic instability after terrible triad injury	LCL	ORIF of radial head Coronoid pull-out
B14	32	Female	Right	Hostess	-	Chronic instability after dislocation	LCL	-
B15	47	Male	Right	Policeman	-	Chronic instability after multiple dislocations	LCL	-

Table II. Physical Examination Results: intragroup variability (Paired t-test).

Group-A								
	Preoperative		Postoperative			Stability* (Pre/post)		
	Mean F/E	Mean P/S	Mean F/E	Mean P/S		Varus	Valgus	Posterolateral rotatory
Mean	110.5°/42°	71°/80°	147°/0°	87°/86°	52.5°	2/0	1/0	3/0
p	-	-	0.01	0.01	0.01	0.01	0.01	0.01

Group-B								
	Postoperative		Preoperative			Stability* (Pre/post)		
	Mean F/E	Mean P/S	Mean F/E	Mean P/S		Varus	Valgus	Posterolateral rotatory
Mean	106.4°/40°	70°/80°	145.3°/10°	88°/85°	54.3°	1/0	2/0	3/0
p	-	-	0.01	0.01	0.01	0.01	0.01	0.01

*stability grading: 0, none; 1, mild laxity with end point; 2, moderate laxity with end point; 3, gross instability.

Table III. Functional outcomes: intra-group variability (Paired t-test).

Group-A												
	Baseline			1-month follow-up			6-month follow-up			12-month follow-up		
	MEPS	OES	VAS	MEPS	OES	VAS	MEPS	OES	VAS	MEPS	OES	VAS
Mean±SD	45±12.6	22±6.4	6.5±2	66.2±7.8	31.2±4.7	2±1.8	68.6±5.7	47.4±5.2	1±0.5	72.3±4.5	51.5±3.4	1±0.2
p	-	-	-	0.01	0.022	0.009	0.004	0.006	0.001	0.002	0.003	0.001

Group-B												
	Baseline			1-month follow-up			6-month follow-up			12-month follow-up		
	MEPS	OES	VAS	MEPS	OES	VAS	MEPS	OES	VAS	MEPS	OES	VAS
Mean±SD	44±9.4	23±7.4	5.7±3	64.5±8.5	29.5±7.5	3.4±0.76	66.5±5.4	44.6±4.3	1.2±0.4	65.5±3.4	53.4±4.65	1.3±0.4
p	-	-	-	0.02	0.032	0.005	0.002	0.004	0.001	0.001	0.002	0.001

MEPS: Mayo Elbow Performance Score; OES: Oxford Elbow Score; VAS: Visual Analogue Scale; SD=Standard Deviation

arch improvement was 52.5°, in Group-A patients, and 54.3°, in Group-B patients (Tab. II). All the joints resulted stable after surgery in Group-A, while in Group-B 1 patient out of 15 (6.67%) needed a re-intervention.

Table III summarizes the functional outcomes recorded at each follow-up, compared with baseline in both groups. A significant improvement of OES, MEPS and VAS was recorded at 1-month follow-up in both groups. Two patients out of 12 in Group-A still reported a mild elbow pain at 1-month follow-up; a significant pain reduction, however, was observed at the following follow-ups.

Table IV compares the functional outcomes between the two groups at 12-month follow-up (Unpaired-t-test). No significant differences between groups were observed (Tab. IV).

Radiographs showed no instability signs in all elbow

joints (Fig. 2). In Group-A, only 1 joint out of 12, showed mild degenerative joint changes at 12-month follow-up (Fig. 3).

Discussion

Chronic elbow instability is a disabling pathology, which may cause chronic pain, feelings of instability, recurrent joint subluxation or dislocation and movement limitations, thus seriously affecting the patient's daily routine¹⁶⁻¹⁸. Two different circumferential graft techniques have been recently described by Finkbone and O'Driscoll¹⁴ and by van Riet et al.^{19,20}, to treat the combined medial and lateral insufficiency observed in multidirectional elbow instability.

The box-loop reconstruction technique¹⁴ is a quick, easy and safe procedure; therefore, it has become

Table IV. Functional outcomes: inter-group variability at 12-month follow-up (Unpaired t-test).

MEPS			OES			VAS		
Group-A	Group-B	p	Group-A	Group-B	p	Group-A	Group-B	p
72.3±4.5	65.5±3.4	0.082	51.5±3.4	53.4±4.65	0.0993	1.3±0.4	1.3±0.4	0.985

MEPS: Mayo Elbow Performance Score; OES: Oxford Elbow Score; VAS: Visual Analogue Scale; SD=Standard Deviation

Figure 3. 12-month follow-up radiographs of case A5: note the degenerative changes of the elbow.

our preferred technique for the management of multi-directional unstable elbow. This paper reports our experience with this circumferential grafting technique. This is, to the Authors' knowledge, the first prospective controlled study conducted on patients undergoing the box-loop reconstruction.

In the current study, the box-loop reconstruction revealed effective in the treatment of elbow instability: all the joints appeared clinically stable and no further dislocations were observed during follow-up in Group-A patients. In all the patients treated with box-loop technique, elbow pain, recorded as VAS, significantly reduced at follow-ups, thus allowing a great improvement of the elbow range of motion. All these findings had a positive impact on the patients' activities of daily living, as revealed by the significant improvement of OES and MEPS scores at follow-up (Tab. III).

Similar data were reported in a retrospective study by Finkbone and O'Driscoll¹⁴, who described the outcomes of the box-loop reconstruction technique in 14 patients, with an average follow-up of 64 months. These Authors reported in only 1 patient out of 14 a delayed-onset ulnar neuropathy, which needed an ulnar nerve transposition on postoperative day 12.

Hackl et al.³, in an *in vitro* study, compared the box-loop reconstruction with the conventional MC and

LCL reconstruction techniques. They concluded that circumferential graft technique described by Finkbone and O'Driscoll¹⁴ provides equal elbow joint stability, compared with conventional techniques, but it shows a superior biomechanical profile with respect to graft stiffness. This *in vitro* finding is consistent with the data observed in our study: in all the patients, an increased range of movement was observed, without compromising the whole joint stability. Furthermore, no significant clinical differences between groups were observed at 12-month follow-up in this study.

The sample size is a limitation of this study. Our findings, however, confirm the data reported by Finkbone and O'Driscoll¹⁴, showing the excellent short-term outcomes of box-loop reconstruction technique.

Future studies with larger samples and a longer follow-up will be needed to better define the advantages of this surgical technique. All the patients recruited for the current study will undergo a longer follow-up to assess the long-term efficacy of the box-loop reconstruction technique.

Conflicts of interest

The Authors declare no conflicts of interest concerning this article.

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