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ORIGINAL ARTICLE

Elbow Medial Ulnar Collateral Ligament chronic isolated insufficiency: anatomical M-UCL reconstruction technique and clinical experience in a mid-term follow-up

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Abstract

Purpose This study aims to clinically evaluate, at mid-term follow-up, a group of patients treated by the senior author in the last 6 years with our anatomical double-bundle reconstruction surgical technique for the medial ulnar collateral ligament (M-UCL) insufficiency.

Methods In this study, we included only patients affected by chronic valgus elbow instability, diagnosed with an accurate clinical evaluation combined with an MRI, without associated fractures that had been surgically treated in the past and without additional instability detected during the first checkup and in the preoperative evaluation under anesthesia. The nine patients enrolled were operated by the senior author between 2011 and 2014 (from 16 to 49 years old at surgery, all amateur sportsmen). The average follow-up is 4 years (47.6 months). The values of the range of movement were recorded and compared. Pain assessment was performed using the VAS scoring system. The recovery of daily activities was evaluated through the validated MEPS and Quick-DASH score scales. All patients underwent an X-ray in two standard projections and a preoperative and follow-up MRI.

Results The recovery of the range of motion was complete in six cases. The remaining three patients had minor loss of extension. None of the patients reported flexion deficits nor pronation–supination at follow-up. All patients achieved subjectively perceived stability and clinically objectified stability at follow-up. Five patients referred a total lack of pain at follow-up. Seven patients achieved full marks in the Mayo Elbow Performance Score and an excellent improvement in the Quick-DASH score.

Conclusions Excellent functional results indicate that M-UCL isolated reconstruction with autologous hamstrings described in this study is a reliable and replicable technique with a reduced incidence of complications. Resuming sports is consistently successful in our patients.

Keywords Elbow · Instability · UCL · Reconstruction · Hamstrings

Introduction

The elbow is characterized by an intrinsic high congruity and stability. The physiological range of motion of this joint is 140° in flexion–extension and approximately 170° in pronation–supination. The functional range of motion has been described to be 30°–130° in flexion–extension in order to perform activities of daily living and 20°–130° for throwing patterns [1].

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Elbow stability is strictly dependent on static and dynamic constraints and could be compromised by work or sport activities repetitively exerting the joint. The elbow occupies the second place in major joint dislocation ranking [2], and 15–35% of these acute traumas can lead to instability patterns [3, 4].

The main stabilizers in valgus stress are the Medial Ulnar Collateral Ligament (M-UCL), as a static component, and the flexor–pronator muscles, as a dynamic factor.

The M-UCL consists of three different parts, forming a triangle: the anterior oblique (AOL) and posterior oblique (POL), which originates in the anterior–inferior surface of the medial epicondyle [5], and transverse ligaments.

The AOL is the main valgus stress restraint and the strongest component of the UCL [6–8]. The origin of the AOL is inferior to the rotation axis [9] and inserts medially and 18 mm distal to the coronoid tip, near the sublime tubercle [7, 10].

Two different functional bands have been described in the AOL, the anterior band (AB) and the posterior one (PB). These bundles provide a mutual function in enduring valgus stress through the range of flexion–extension motion [6, 11], and no isometric structures are actually described in this anatomical region.

Loading configuration and degree of elbow flection are strictly linked to variations in magnitude and degree of force transmitted across the elbow [11, 12].

The bony components of the elbow joint are largely the major restraints to transverse or rotational stress from full extension to 20° and/or over 120° flexion [7, 11, 13, 14]; between these two ranges, the UCL complex is the principal one. The AB of the AOL works as a stabilizer from full extension to 85° flexion, whereas the PB is taut beyond 55°. The POL gains a function over 90° of flexion [14, 15]. The elbow reaches the greater valgus laxity at 70° flexion in the presence of an interrupted UCL [7, 16, 17].

This study aims to clinically and radiologically evaluate, at mid-term follow-up, a group of patients with history of repeated microtraumas due to professional or sport-specific repetitive gesture. In our clinical experience, this is the more frequent cause of pure valgus chronic instability; the direct acute valgus trauma, with no rotational component, results quite uncommon. The patients have been treated in the last 6 years with our double-bundle reconstruction surgical technique.

Materials and methods

Population

In this study, we included only patients affected by chronic valgus elbow instability, diagnosed with an accurate clinical evaluation combined with an MRI, without associated fractures that had been surgically treated in the past and without additional instability detected during the first checkup and in the preoperative evaluation under anesthesia (that sometimes appears really fundamental for the definitive surgery planning).

The nine patients enrolled were operated for AOL reconstruction by the senior author between 2011 and 2014. The median age at the time of surgery was 32.8 years: one female patient and eight male patients. They all practiced amateur sports.

Five patients were treated with a semitendinous tendon from the ipsilateral knee, whereas four patients were treated by taking the gracilis tendon, evaluating intraoperatively which tendon to select, according to the diameter and tissue quality.

The average follow-up is 4 years (47.6 months), from a minimum of 32 to a maximum of 76 months (Table 1).

At the time of hospitalization and follow-up, the patients were examined by the same doctor. The values of the range of movement were recorded and compared. In addition, the patients answered a questionnaire, by providing an informed consent. Pain assessment was performed using the VAS scoring system. The recovery of daily activities was evaluated through the validated MEPS and Quick-DASH score scales.

All patients underwent an X-ray in two standard projections and a preoperative and follow-up MRI.

Reconstruction surgical technique

The autologous hamstring is harvested from the ipsilateral knee and prepared with a Krackow suture at the two ends. It has to fit in a 4.5-mm caliper.

A medial, muscle-splitting approach is performed. A 7-mm drill hole is made at the sublime tubercle directed toward the lateral and posterior cortex of the ulna. The

Table 1 Study population

PZ	Age at surgery (years)	Sex	Graft type	Associated procedures	FU
1	16	M	Gracilis	/	54
2	49	M	Semitendinosus	Arthroscopic lysis	37
3	18	M	Gracilis	Open lysis	47
4	43	M	Semitendinosus	/	37
5	46	F	Gracilis	/	36
6	48	M	Semitendinosus	/	46
7	30	M	Semitendinosus	Arthroscopic lysis	46
8	20	M	Gracilis	Ulnar nerve lysis	82
9	25	M	Semitendinosus	/	77

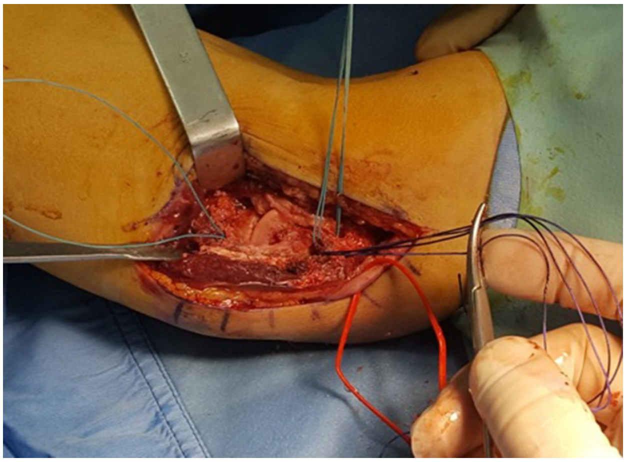

Fig. 1 On the left the ulnar blind tunnel, on the right the humeral convergent ones (one is dark blue and one light blue), the red one is the isolated ulnar nerve

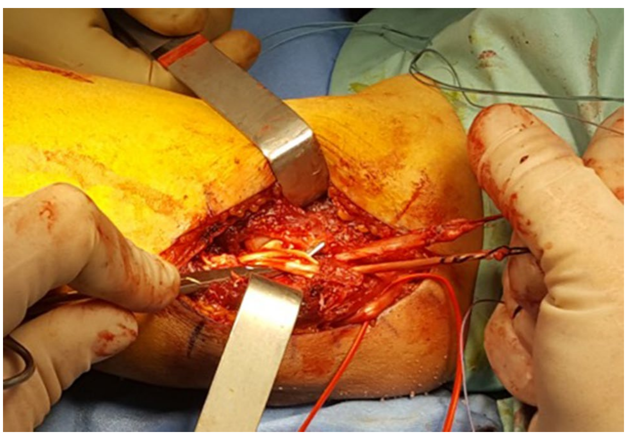

Fig. 2 Passage of the graft: on the right the two bundles in their independent tunnels

graft is folded over onto itself and fixed with a bioabsorbable 6-mm interference screw. At the humeral side, another 7-mm tunnel is prepared. It is a blind tunnel and is oriented anterior–superior, preserving the ulnar nerve. Two more tunnels, 4.5 mm in diameter, are prepared independently converging on the 7-mm one (Fig. 1).

The "two bundles" of the graft are passed with a soft suture passer through the common tunnel and divided in the smaller ones (Fig. 2).

The residual part of every bundle is sutured on itself after tensioning: The anterior bundle is tensioned at 30° of elbow flexion, the posterior bundle at 80° of elbow flexion. This phase is preceded by a "cycling" of the elbow to improve the settling of the tendons into the tunnels and to provide a pre-tensioning.

Isolation of the ulnar nerve is performed but no anteposition is needed.

Postoperative protocol

Rehabilitation following surgical reconstruction of the UCL begins with range of motion and initial protection of the reconstruction, along with resistive exercises to keep the shoulder and core strong. This is followed by progressive exercises for resistive exercise which aims to fully restore strength and muscular endurance in order to ensure a safe return to sport and overhead functional activities.

The early phases of postoperative care for UCL reconstructions involve specific time frames, restrictions, and precautions to protect healing tissues and the surgical fixation.

The knee is maintained in full extension for 2 weeks, and the patient is allowed to bear weights as tolerated with or without two crutches (pes anserinus donor site protection).

The later phases of rehabilitation are presented in a criterion-based progression, in which advancements to subsequent levels are based on strength and control.

The resuming of competitive sports will take 6–10 months. Patients should ice the elbow for 10–15 min after each rehab session to decrease pain and post-op swelling.

These guidelines (Table 2) also include aerobic training throughout the rehabilitation process and, for many patients, a later stage with an interval throwing program.

Results

Clinical results

The recovery of the range of motion (R.O.M.) was complete in six out of nine cases; one case presented a non-painful loss of extension of 5°, one case remained unchanged at a 5° deficit in extension and one recovered up to 5° residual deficit. None of the patients reported flexion deficits nor pronation–supination at follow-up (Table 3; Fig. 3).

All patients achieved subjectively perceived stability and clinically objectified stability at follow-up.

Five patients referred a total lack of pain at follow-up evaluated with the VAS scale, and three patients achieved a remarkable relief of symptoms (Table 4).

One patient reported only a partial improvement in the pain, although the functional evaluation performed obtained good results.

Seven patients achieved full marks in the Mayo Elbow Performance Score (Table 5) and an excellent improvement in the Quick-DASH score (Table 6).

All patients resumed the same work as before surgery, in eight out of nine cases without experiencing any difficulty.

Table 2 Postoperative guidelines in M-UCL reconstruction with hamstrings

	Phase I (3 weeks after surgery)	Phase II (up to 8th week)	Phase III (up to 12th weeks)	Phase IV (up to 20th week)	Phase V (up to 36th week)
Rehabilitation goals	Protect healing tissues Decrease pain and inflammation Prevent muscular atrophy Initiate elbow range of motion	Gradual increase in elbow range of motion to near full range of motion by the 9th–10th week Protect reconstruction during continued healing Improve muscular strength of the arm, shoulder and trunk	Increase overall strength and endurance Achieve and maintain full elbow range of motion Transition to entry level plyometrics	Maximize rotator cuff and scapular strength in throwing positions and postures Initiate education on throwing mechanics Transition to higher level plyometrics	Maximize dynamic neuromuscular control with shoulder and elbow stabilization Develop biomechanically sound throwing mechanics Maximize muscular endurance and strength of the muscles
Precautions	Week 1 = immobilized at 90° of elbow flexion in hard brace Week 2 = functional hinged brace with range of motion from 30°–100° Week 3 = functional hinged brace with range of motion from 15°–110°	Week 4 = functional hinged brace with range of motion from 10°–120° Week 5 = functional hinged brace with range of motion from 5°–130° Week 6 = functional hinged brace with range of motion from 0°–130° Discontinue brace at 6–8 weeks except in unsafe environments. Avoid valgus	There should be no pain while doing the strengthening exercises Post-exercise soreness, should be less than 4/10 and return to baseline within 24–36 h	There should be no pain while doing the strengthening exercises Post-exercise soreness, should be less than 4/10 and return to baseline within 24–36 h	There should be no pain while throwing or doing sport-specific drills Post-throwing soreness, or post-sport-specific drill soreness, should be less than 4/10 and return to baseline within 24–36 h
ROM exercises	Gentle active and active assistive range of motion for the elbow and wrist Gentle and gradual overpressure to meet range of motion guidelines Note: Be sure to avoid valgus force or positioning during exercises	Gentle active and active assistive range of motion for elbow and wrist Passive range of motion should be initiated if needed in a very controlled and gentle fashion way	Range of motion should be full at postoperative week 10, and if not, please consult with the physician well in advance of before week 12 appointment	Range of motion should be full at this point, and if not, please consult with the physician	Range of motion should be full at this point, and if not, please consult with the physician
Therapeutic exercise	Begin week 2 with sub-maximal isometrics for shoulder internal rotation, shoulder abduction, biceps, wrist flexors and extensors Hand gripping Cervical spine and scapular active range of motion	Isotonics with light resistance for shoulder, elbow and wrist Scapularstrengthening and stabilization Hip, lower extremity and core strengthening Cervical spine active range of motion/stretching	Progressive isotonics Initiate eccentric elbow flexion strengthening Assess shoulder mobility and address any imbalances Manual resistance diagonal patterns	Initiate rhythmic stabilization drills for the elbow and shoulder in protected positions Initiate plyometics—2 hand drills only Begin throwing mechanics education—including slow motion “air throws”, posture and position checkpoints	Multi-joint, multi-planar strengthening program Proprioceptive drills Plyometric progressions—transition from 2 arms to 1 arm (sagittal and rotational) Initiate interval throwing program, progressing to a position specific throwing program Initiate sport-specific return program

Table 2 (continued)

	Phase I (3 weeks after surgery)	Phase II (up to 8th week)	Phase III (up to 12th weeks)	Phase IV (up to 20th week)	Phase V (up to 36th week)
Cardiovascular fitness	Walking, stationary bike—brace on No treadmill Avoid running and jumping due to the distractive and compressive forces that can occur at landing	Walking, stationary bike—brace on No treadmill Avoid running and jumping due to the distractive and compressive forces that can occur at landing	Walking, stationary bike—brace off Continue to avoid running and jumping	At week 16 athletes may be running and sprinting at 75% speed, monitoring the environment to minimize the risk of falls	Training should be targeted toward sport-specific energy systems

A patient, a warehouse worker, performed it without restrictions, yet with some occasional discomfort on lifting heavy weights. Sports activities were resumed by all patients, returning to the previous level 6/8 months after surgery. In two cases, there was a reduction in the level of activity, not due to the actual limits or absolute contraindications, but for the choice of the operated patients. No significant differences were detected among the operated patients taking the semitendinosus or the gracilis tendon.

Radiographic results

Compared with the preoperative and postoperative radiographs, in none of the treated cases did follow-up X-rays show a more severe than the initial joint degeneration (Fig. 4).

No newly formed heterotopic ossifications were detected.

The reconstructed ligament was present and identifiable in all MRIs, indicating continuity, in the presence of physiological local fibrosis (Fig. 5).

Discussion

Valgus laxity is difficult to identify in a first clinical examination and the literature reports percentages between 26 and 82% of correct preoperative diagnosis [18, 19]. Sometimes people come to our clinic with a long story of epitrochlear pain treated for months, or years, as an enthesopathy of the flexor muscles without any benefit.

After an accurate diagnostic procedure, a careful evaluation of the history of the patient, of the standard radiology and in high-field magnetic resonance, the acute treatment may consist of functional rest, anti-inflammatory therapy, local ice (packs), and bracing.

The literature reports that only 42–50% of the patients treated with this therapy manage to resume sports levels similar to those prior to the trauma, even after following specific rehabilitation protocols [20, 21]. These are modest results that gear the surgeon toward an invasive approach, particularly in subjects with high functional sports or work demands.

Surgery with end-terminal sutures in case of UCL injuries or with trans-osseous sutures in the event of periosteal lesions were widely employed in the past [22–24].

It is well documented in the literature that the rate of resuming sports is higher in patients treated with ligament reconstruction rather than in patients undergoing fixation of the native ligament [18, 22].

Fixation is currently indicated only in acute phases, in young patients affected by complete M-UCL avulsion injury detected by MRI [25]. In the remaining cases, ligament

Table 3 R.O.M. evaluation

PZ	Pre-op extension	Post-op extension	Pre-op flexion	Post-op flexion	Pre-op prono sup.	Post-op prono sup.
1	0° (complete)	5°	140° (complete)	140° (complete)	170° (complete)	170° (complete)
2	13°	5°	120°	135°	170° (complete)	170° (complete)
3	22°	0° (complete)	112°	140° (complete)	170° (complete)	170° (complete)
4	7°	0° (complete)	140° (complete)	140° (complete)	170° (complete)	170° (complete)
5	0° (complete)	0° (complete)	130°	140° (complete)	150°	170° (complete)
6	20°	0° (complete)	140° (complete)	140° (complete)	170° (complete)	170° (complete)
7	30°	0° (complete)	110°	140° (complete)	140°	170° (complete)
8	0° (complete)	0° (complete)	140° (complete)	140° (complete)	155°	170° (complete)
9	5°	5°	140° (complete)	140° (complete)	160°	170° (complete)
Mean value	10.8° (SD 10.4)	1.7° (SD 2.4)	130.2° (SD 12.1)	139.4° (SD 1.6)	161.7 (SD 10.5)	170° (SD 0)
Mean of improvement	9.1° (SD 11.4)		9.2° (SD 11.8)		9.4° (SD 11.7)	

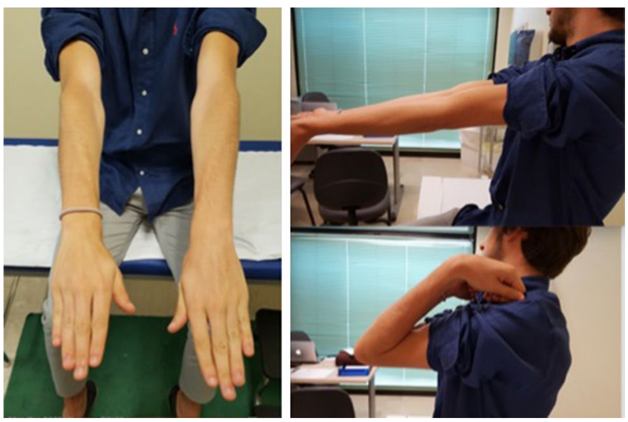

Fig. 3 Clinical 3-year follow-up

Table 5 MEPS improvement

PZ	Pre-op MEPS	Post-op MEPS
1	55	85
2	55	100
3	40	100
4	45	100
5	50	100
6	35	70
7	60	100
8	50	100
9	50	100
Mean value	48.9 (SD 7.4)	95 (SD 10)
Mean of improvement	46.1 (SD 9.1)	

Table 4 VAS score improvement

PZ	Pre-op VAS score	Post-op VAS score
1	7	3
2	8	0
3	9	1
4	8	0
5	8	1
6	9	6
7	7	0
8	7	0
9	8	0
Mean value	7.9 (SD 0.7)	1.2 (SD 1.9)
Mean of improvement	6.7 (SD 1.8)	

Table 6 Quick-DASH score improvement

PZ	Pre-op Quick-DASH score	Post-op Quick-DASH score
1	43.2	9.1
2	50	20.5
3	59.1	2.3
4	56.8	2.3
5	63.6	0.0
6	75	38.6
7	68.2	2.3
8	59.1	4.5
9	75	2.3
Mean value	61.1 (SD 10.1)	9.1 (SD 12)
Mean of improvement	52 (SD 14.4)	

reconstruction is to be considered the recommended operation.

In 1986, Jobe et al. [26] first described an M-UCL reconstruction technique using an autologous palmaris longus tendon transplantation. In the original technique, called "Tommy John," the muscle mass of the flexor–pronators muscles was raised and the ulnar nerve was always placed underneath the muscle tissue. However, Conway et al. [22]

Fig. 4 Three-year follow-up X-rays

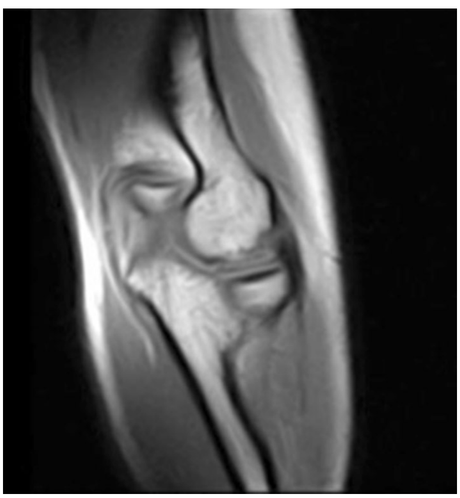

Fig. 5 Coronal MR image showing the new M-UCL at 3 years follow-up

have reported a high incidence of ulnar neuropathies when using this technique (21%) that requiring a subsequent ulnar nerve decompression in more than half of the affected subjects.

In 1996, Smith et al. [27] described a technique ("Modified Jobe") implying only splitting the flexor–pronators, a different positioning of the bone tunnels and a tensioning of the neo-ligament with a supine forearm, flexed at 60° and in varus stress. The transposition of the nerve was not required. Andrews et al. [28] described a similar technique, by simply lifting the mass of the flexor–pronators, without incising it, thus reducing the invasiveness of the procedure.

The "docking technique," described by Althcheck and Rohrbough [29], simplified the procedure, the tensioning and fixation of the ligament: The authors achieved excellent results in 92% of the cases with a complication rate of 5.5% [30].

Ruland et al. [31] carried out a study on cadavers, comparing three different surgical techniques for the reconstruction of the collateral ulnar ligament. By analyzing the resistance to torsion strength, in groups which use the palmaris longus, the torsion strength was statistically lower compared to the native ligament, whereas, in the group which uses the semitendinosus tendon, the score was significantly higher compared to the other two groups.

Conway et al. [22] found an excellent result rate of 68% in patients operated on M-UCL reconstruction based on the Jobe technique. Thompson et al. [19] found an 82% rate of excellent results on 33 patients enrolled for follow-up after reconstructive surgery with the modified Jobe technique.

Out of 100 patients operated with the same technique, Dodson et al. [32] found 90% excellent results with a 3% complication rate. Similarly, on a sample of 12 patients operated with the "docking technique" and eight patients with the modified technique, Koh et al. [33] found 95% excellent results with a complication rate of 5%, without remarkable/relevant differences in the two groups.

Among the new techniques compared to the previous ones, Hechtman et al. [34] proposed a hybrid technique by using anchors for the reconstruction of the UCL; through this study conducted on cadavers, the authors have reported that this technique allows a reliable anatomical reconstruction of the UCL. Long-term results [35] have shown excellent findings in 85% of the cases on 34 operated patients, with a complication rate of 3%.

Chang et al. [36] published a bibliographic review on the various reconstruction techniques of the ulnar collateral ligament, comparing the Jobe technique (both traditional and modified), the "docking technique" and alternative techniques, indicating the docking technique as the one with the evidence of greater solidity and muscular split with the greatest sparing of the ulnar nerve as the best surgical procedure.

Another suggested technique is the DANE TJ hybrid technique [37, 38] in which a single ulnar tunnel is created at the level of the sublime tubercle in which the transplant is fixed with a screw, while, at the humeral level, it is fixed with the traditional "docking technique." The advantage of this technique is the reduced percentage of fractures of the ulnar tunnel with the use of the interference screw. Using this technique, Dines et al. [38] found, on a total of 22 patients, 86% excellent results and 18% complications. Lastly, Savoie et al. [39] reported the results of a retrospective study on the short-term results of 116 patients undergoing UCL reconstruction with cadaver semitendinosus: The result was excellent in 80% of the patients, whereas the complication rate was 6%.

Among the various reviews proposed in literature, most of them compare the many reconstructive techniques. Vitale and Ahmad [40] found that 83% of the patients operated with the Jobe technique or the "docking technique" resumed the same level of preoperative activities. Furthermore, the use of a muscular split approach has led to a 17% increase in excellent results, also supported by the fact that ulnar nerve transposition is not required. Moreover, the same meta-analysis shows that the results of the "docking technique" are better compared to those of the Jobe technique. In another recent review of the literature, Watson et al. [41] have recently compared the clinical and biomechanical findings of all techniques, including the Jobe technique, the "docking technique," the fixation with the interference screw and fixation with Endobutton®. The authors observed a resuming of sports activities in 79% of the cases, while the "docking technique" showed the lowest percentage of complications. From a biomechanical point of view, they also noted that, in the docking technique and in the Endobutton® procedure, the main cause of failure was associated with the suture failure, whereas, in the Jobe technique, the fracture of the tunnel was the main cause of failure. Lastly, in the screw fixing procedure, the cause of the failure is mainly due to the graft itself.

Complications of M-UCL reconstruction surgery are rare. A serious injury, in the case of palmaris longus tendon samples, may affect the median nerve, which has also recently been documented [42, 43].

Therefore, a reconstruction with a hybrid technique as performed in the patients involved in this study seems to have a lower frequency of complications: the extensor muscles splitting is not invasive, the interference screw in the single ulnar tunnel seems to be safer than other fixation systems and the use of a hamstring in place of a palmaris longus or an allograft can reduce the incidence of transplant rupture. Furthermore, good-quality allografts are costly and not always available everywhere. Finally, the double-step fixation of the anterior and posterior bundle of the graft reproduces the biomechanics of the native ligament.

Conclusions

Elbow instability is difficult to be classified and, consequently, to be correctly treated. Recently, Marinelli et al. [44] published a new classification system that appears to be more punctual and comprehensive than others proposed through the years. The AOL reconstruction technique described in this paper could be a solution for simple medial instability (acute or persistent) or a complementary step in the surgical approach to complex instabilities. The excellent functional results indicate that it is a reliable and replicable technique with a reduced incidence of complications. Resuming sports is consistently successful in our patients. If they reduce the activity, it is by their own choice as they are not professional athletes, not due to an absolute contraindication. The treatment of choice can be a reconstruction using both a gracilis or a semitendinosus graft without apparently modifying the results of the operation. The major limitations of this study are the reduced number of cases and the lack of a control group, although the mid- and long-term results reported are clearly objectified.

Considering the various techniques suggested over the years, we can underline some aspects that are worth bearing constantly in mind during an M-UCL reconstruction: minimizing strains on the flexor–pronator muscles, reducing traumas on the ulnar nerve, using bone tunnels positioned to allow an anatomical reconstruction of the two AOL bundles and their independent and controlled tension.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval For this type of study formal consent is not required (retrospective study).

Human and animal rights This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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