How I do it

Ligamentous reconstruction around the elbow using triceps tendon

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ABSTRACT Posttraumatic instability of the elbow joint can be osseous or ligamentous. Ligamentous instability can be in valgus or in posterolateral rotatory direction. Rupture of both the lateral and medial collateral ligament of the elbow can be seen as an isolated injury, or it can be part of a more complex injury such as a dislocation. Persistent insufficiency of the lateral collateral ligament of the elbow results in posterolateral rotatory instability. Insufficiency of the medial collateral ligament, the anterior part in particular, results in valgus instability. Persistent symptoms after nonoperative treatment are an indication for reconstruction. In the past, ligamentous reconstruction at both the lateral and medial side was performed using palmaris tendon graft through bony drill holes.

In this article I describe a new technique using ipsilateral triceps tendon, fixed in drill holes using bioabsorbable interference screws. This technique allows simplified graft tensioning and improved graft fixation, and avoids the risk of fracturing of the bony tunnels. An accelerated rehabilitation protocol can be applied. The final result depends on proper isometric reconstruction, associated lesions or degeneration of the elbow joint and adequate after-treatment. Taking these factors into account, the technique described shows promising short-term results.

Posttraumatic instability of the elbow can be divided into osseous or ligamentous instability. If fractures of the olecranon or coronoid process heal with displacement, there is a risk of chronic instability. This type of osseous instability is generally easily recognized at standard radiography. This is in contrast to ligamentous damage, which is often not recognized in the acute phase and may therefore result in chronic posttraumatic instability. The most common cause of ligamentous injury resulting in instability is elbow dislocation. The incidence of elbow dislocation in the general population is estimated to be 6/100,000. More than 95% of all dislocations occur in a posterolateral direction. Posttraumatic chronic ligamentous instability can be divided further into medial or valgus instability and posterolateral rotatory instability (PLRI). As the signs and symptoms of both entities are often subtle, the examiner must have a high index of suspicion and a thorough knowledge of symptoms and expected findings at physical examination to make the diagnosis.

Persistent insufficiency of the lateral collateral ligament (especially the ulnar part, lateral ulnar collateral ligament (LUCL)) results in PLRI (Figure 1A). Insufficiency of the medial collateral ligament (MCL), in particular the anterior part or AMCL, results in valgus instability (Figure 1B). During posterolateral dislocation, rupture of the ligamentous complex occurs in a circle from lateral to medial, as described by O'Driscoll et al. In stage I, the LUCL is disrupted; in stage II, the other lateral ligamentous structures as well as the anterior and

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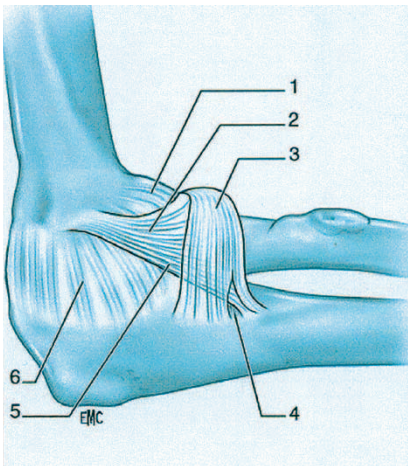

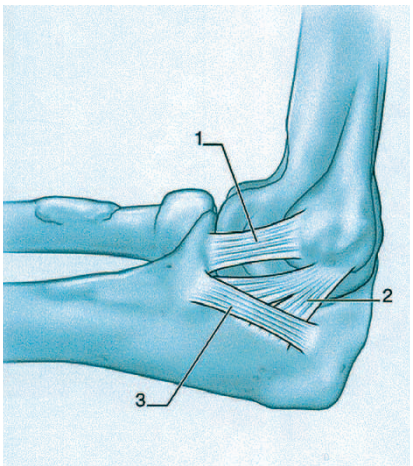

Figure 1A. The lateral collateral ligament complex.
1. Anterior capsule.
2. Radial collateral ligament (RCL).
3. Annular ligament (AL).
4. Triangular space.
5. Lateral ulnar collateral ligament (LUCL).
6. Posterolateral capsule.

B. The medial collateral ligament complex.
1. Anterior medial collateral ligament (AMCL).
2. Posterior medial collateral ligament (PMCL).
3. Transverse ligament.

posterior capsule are disrupted; In stage III, rupture of the MCL occurs. Rupture of the MCL can be partial or complete (O'Driscoll et al. 1991).

Persistent symptomatic instability after non-operative treatment is an indication for reconstruction. Most reports describe a technique that includes a free tendon graft placed in bone tunnels in the humerus and ulna (Jobe et al. 1986, Bennet et al. 1992, Conway et al. 1992). Although good results have been reported, the technique is technically demanding and the risk of fracture of the ulnar tunnel in particular is a concern. Recently, a simplified docking technique was described at the humeral side, using the palmaris tendon. However, at the ulnar side a bone tunnel was used (Rohrbough et al. 2002).

In this report, I describe a new procedure involving a docking technique at both the humeral and ulnar side of the graft, using ipsilateral triceps tendon and bioabsorbable interference screws (Arthrex Inc., USA).

Posterolateral rotatory instability (PLRI)

Disruption of the lateral collateral ligament can be seen after varus stress injury, after posterolateral dislocation of the elbow, or after release of the common extensor tendon to treat chronic lateral epicondylitis. In PLRI, the proximal radioulnar joint is intact. Laxity or avulsion of the ulnar part of the lateral collateral elbow ligament leads to an increase in external rotation of the ulnohumeral joint (Olssen et al. 1996). This increase in external rotation results in a secondary posterior subluxation of the radial head. This secondary subluxation with intact proximal radioulnar joint must be differentiated from isolated posterior head subluxation with disruption of the proximal radioulnar joint and an intact ulnohumeral joint. Patients with PLRI complain about locking and clicking of the elbow, particularly when the elbow is supinated and extended. This pattern of instability can be demonstrated by the so-called pivot-shift test for posterolateral rotatory instability (O'Driscoll et al. 1991) (Figure 2). In case of doubt, evaluation under anesthesia in combination with arthroscopy can be performed.

Imaging

Classically, the elbow appears normal on anteroposterior radiographs, or there is a slight widening of the radiohumeral joint. On lateral radiographs, the radial head may appear to be situated poste-

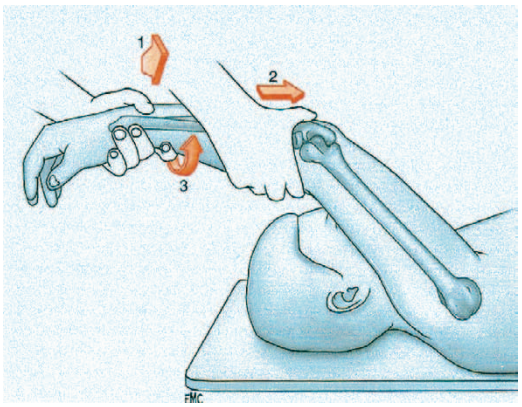

Figure 2. The 'pivot shift' test for posterolateral rotatory instability of the elbow. With the forearm in supination, supination and valgus moments, as well as, axial forces are applied to the elbow. The posterolateral subluxation is visibly and palpably reduced when the elbow is flexed

Figure 3. The radial head is situated posterior to the capitellum on a lateral radiography with the hand in full supination. The arrow indicates the degree of displacement.

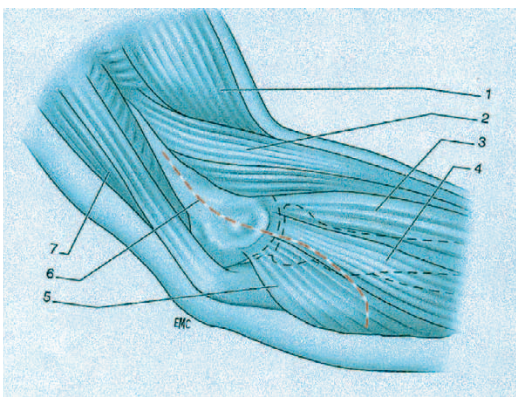

Figure 4. Lateral approach through Kocher's interval made in black, with separation of the anconeus posteriorly from the extensor carpi ulnaris.
1. M. biceps.
2. M. brachioradialis.
3. M. extensor carpi radialis longus is overlying the M. extensor carpi radialis brevis.
4. M. extensor carpi ulnaris.
5. M. anconeus.
6. Line of skin incision.
7. M. triceps.

riorly to the capitellum, especially in full supination (Figure 3). MRI and CT are of no use in the evaluation of integrity of LUCL (O'Driscoll et al. 1991). MRI can be useful for detection of chondral damage to the capitellum secondary to the recurrent subluxation of the radial head (Peiss 1995).

Reconstruction

The patient is placed in a supine position on the operating table, bloodless field is applied and the joint is exposed through Kocher's interval, with separation of the anconeus posteriorly from the extensor carpi ulnaris (Figure 4). The ulnar attachment of the LUCL is palpated at the tubercle of the supinator crest and dissected. On the humeral side, the supracondylar ridge is exposed posteriorly and anteriorly. The entire LUCL can be found to be either stretched or detached from the humerus. The tissue of the LUCL is generally of poor quality, which necessitates reconstruction with an autologous graft. This graft measures about 10 cm in length and 2 cm in width, and is harvested from the middle-third part of the triceps tendon, without damaging the lamina splendens (the muscular septum between the lateral head and medial/long head of the triceps). The graft is folded along its long axis and both ends of the graft are braided with sutures. A 5-mm ulnar drill hole is made just at the tubercle of the supinator crest and the graft is fixed using a bioabsorbable 5.5-mm interference screw (Figure 5). Isometry is determined by holding the graft at the humeral origin of the LUCL during flexion and extension. At the point of isometry, a 5-mm drill hole is made in the distal humerus. With a 1.5-mm drill, two small exit holes separated by 10 mm are created to allow suture passage with a suture retriever from the primary humeral tunnel. The humeral end of the graft is docked in the humeral tunnel, and the suture ends are passed through exit holes to tension the graft (Figure 6). In forced pronation and slight flexion, the graft is fixed with a second bioabsorb-

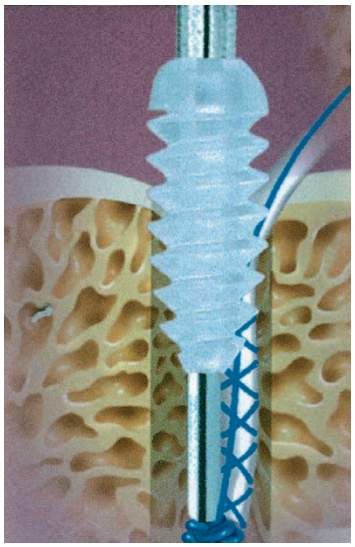

Figure 5. The graft is fixed using an interference screw.

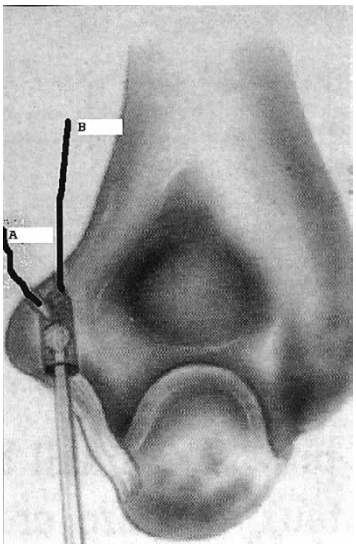

Figure 6. One end of the graft is docked in the humeral tunnel, and the suture ends A and B are passed through separate 1.5-mm tunnels on the humeral side.

able 5.5-mm interference screw, and the two suture ends are fixed to each other over the 10-mm bone bridge. The interval between the anconeus and extensor carpi ulnaris is closed. The tourniquet is deflated, hemostasis is performed as necessary and the skin is closed. The elbow is then placed in a plaster splint with 90° of flexion and maximal pronation for 1 week. Over the following 7 weeks, a brace is used in full pronation which allows full flexion and extension. Muscle building exercises are started under supervision of a physiotherapist after 1 week. Normal activity is allowed 6 months after the operation.

Outcome (Table 1)

In a series of 12 patients (8 men) with an average age of 35 (19–65) years, and with a posttraumatic PLRI (average time after injury 3 (1–7) years), all patients were operated using the procedure described above. The dominant arm was injured in 5. No neurovascular or infectious complications were seen. No ruptures of the triceps tendon were seen. All patients were evaluated after an average of 23 (17–28) months. Physical examination included movement, stability tests for valgus and PLRI instability. The pivot shift manoeuvre was considered to be positive if the patient had apprehension or instability during the manoeuvre. All elbows were assessed using the VAS for pain at rest and during activity, elbow functional assessment (EFA), Broberg & Morrey scoring system and the modified Andrews score (Andrews 1985, Broberg and Morrey 1987). All but 1 patient had a stable elbow according to the patient and according to findings at physical examination. This patient had no further recurrent dislocations but there was a persistent apprehension at the pivot shift test. This patient was the only one with a preoperative cubitus varus deformity and degenerative changes at MRI. 6 patients had a loss of extension of 5–10 degrees. No loss of flexion was seen. All preoperative scores had improved. The modified Andrews score was excellent in 10 cases, good in 2 and moderate in 1 (Table 1).

Valgus instability

Valgus instability may arise due to a single major trauma, resulting in partial or complete rupture of MCL. It may also be a long-term sequel after posterolateral dislocation in which the MCL is ruptured, or it may be the result of chronic overuse in throwing athletes (Eygendaal et al. 2000 a, b). At physical examination, the joint must be tested for valgus instability at 30° and at 90° of flexion

Table 1. Results after reconstruction of LUCL

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	F	19	PLD	R	140/–10	normal	140/–20	9	9	3	8	M	E	M	G	M	G
2	F	50	sublux	L	140/–15	irregular	same	7	9	7	9	M	G	M	G	M	E
3	M	35	PLD	L	140/5	OD cap	140/0	8	10	9	9	E	E	G	E	G	E
4	F	35	PLD	R	150/0	normal	same	5	9	2	9	M	E	G	E	M	E
5	M	50	sublux	R	150/–10	normal	same	8	10	9	9	M	G	M	E	M	E
6	M	29	PLD	L	140/0	normal	same	6	10	3	9	P	E	M	E	M	E
7	M	28	PLD	L	140/–5	normal	140/–10	9	10	4	8	M	G	M	G	G	E
8	M	33	PLD	R	150/0	normal	same	9	10	4	9	G	E	G	E	P	E
9	M	65	PLD	R	140/–20	degen.	140/–30	4	7	2	6	P	M	P	G	P	M
10	M	34	PLD	L	140/–10	normal	140/–20	9	10	6	10	E	E	G	E	G	E
11	M	19	PLD	R	140/0	OD cap	140/10	8	9	5	9	G	E	G	E	G	E
12	F	27	sublux	R	140/0	normal	same	6	9	2	8	M	G	M	G	M	G

A Case
B Gender: M = male, F = female
C Age
D Injury
PLD = posterolateral dislocation
sublux = subluxation of the elbow with spontaneous reduction
E R/L side
F Range of motion preoperatively
G MRI arthrography
OD cap = osteochondritis dissecans of the capitellum
degen. = degenerative changes
irregular = irregular aspect of LUCL
H Follow-up range of motion
I VAS preoperatively at rest
J VAS postoperatively at rest rest
K VAS preoperatively during actitivity
L VAS postoperatively during actitivity
M Elbow functional assessment preoperatively
N Elbow functional assessment postoperatively
O Broberg and Morrey scoring system preoperatively
P Broberg and Morrey scoring system postoperatively
Q modified Andrews scoring system preoperatively
R modified Andrews scoring system postoperatively

P = poor, M = moderate, G = good, E = excellent

and pronation (Eygendaal et al. 1999). Treatment of isolated, acute MCL injury consists of immobilization in a long-arm cast for 4 weeks, followed by an intensive exercise program and avoidance of valgus load for 3–6 months. Patients complain of ill-defined discomfort at the medial side, weakness and clicking of the elbow joint—especially with movements that generate valgus load across the elbow joint. On examination, the elbow often appears normal without swelling (except in acute cases of MCL rupture) with normal motion. An increased ulnohumeral joint opening can be palpated under valgus load, and a comparison with the uninjured side must be made. Chronic valgus instability might result in flexion deformity or cubitus valgus. Physical examination may reveal tenderness to palpation on the MCL complex, depending on the degree of inflammation at the time of examination. Chronic valgus instability can lead to chondral damage of the capitellum and formation of posteromedial compression, and this finally results in osteophytes of the olecranon.

A positive Tinèl sign can be seen either as inflammation, which may irritate the ulnar nerve in the cubital tunnel or significant valgus instability, which can result in traction neuropathy of the ulnar nerve. In cases where there is doubt, evaluation under anesthesia can be performed in combination with arthroscopy. The MCL is not visible at arthroscopy, but a size increase in the ulno-humeral joint of more than 2 mm points to medial instability.

Imaging

Standard radiography may identify ossification within the MCL. Loose bodies, osteophytes around the radiohumeral or ulnohumeral articulations or olecranon, and osteochondrotic lesions of the capitellum may be revealed. Dynamic radiographs under valgus load can be made with a commercially available stress device in which the elbow is flexed 25° and the shoulder abducted 65° (Rijke et al. 1994, Lee et al. 1998) (Figure 7). MRI can contribute to the decision making in medial instability, with a sensitivity of 57% and specificity of 100% for MCL injury (Figure 8) (Mirowitz and London 1992, Schwartz et al. 1995, Nakanischi et al. 1996).

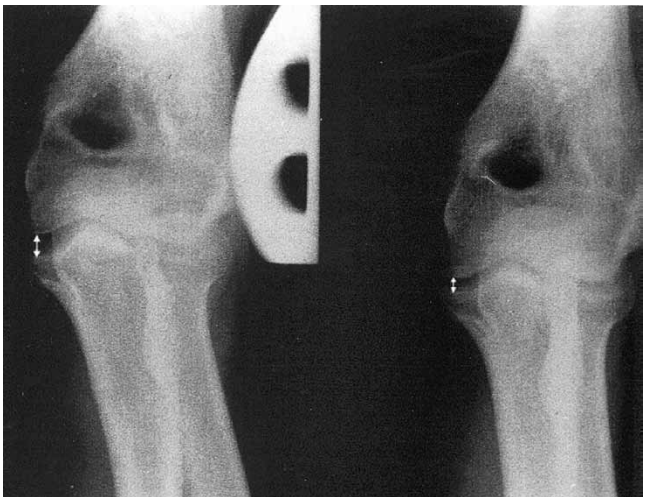

Figure 7. From the radiographs, the distance (d) in mm between the most distal point on the curved contour of the medial condyle and the ulnar coronoid process is measured at zero (d0) and 15 N valgus stress (d15). Medial instability is defined as (d15–d0) of the injured elbow minus (d15 –d0) of the uninjured side and graded as no instability (0–1 mm), partially unstable (1–3 mm), unstable (3–6 mm) or subluxation (> 6 mm), based on previous cadaver studies.

Figure 8. Gadopentetate-dimeglumine enhanced MR-arthrography in a throwing athlete. Rupture of the MCL is visible (white arrow). There is leakage of contrast medium through the ruptured ligament.

Reconstruction

The patient is placed in supine position on the operating table, bloodless field is applied and the skin on the medial side is opened and the ulnar nerve is identified. A standard release is not performed routinely. A longitudinal split is made in the flexor carpi ulnaris (Smith et al. 1996). The sublime tubercle at the proximal ulna and the medial epicondyle of the humerus are completely exposed. Harvesting of the graft and fixation in the ulna is as described above. The point of isometry is determined and at that point, a 5-mm hole and two 1.5-mm exit holes are drilled. This is often close to the clearly visible origin of the existing MCL. During fixation slight flexion, varus stress, and maximal supination is applied. Any remnants of the original ligament are sutured over the graft for additional strength. The flexor and pronator muscles are closed or reattached. The tourniquet is deflated, hemostasis is performed as necessary, and the skin is closed. The elbow is then placed in a plaster splint with 90° of flexion and neutral rotation of the hand for 1 week. Muscle-building exercises are started under supervision of a physiotherapist after 1 week. Valgus stress is avoided for 4 months after the operation.

Outcome (Table 2)

14 patients (7 women) with an average age of 25 (17–46) years and with a valgus instability of the elbow were treated and followed as a prospective cohort (Table 2). The mean interval between trauma and surgery was 21 (12–49) months. The dominant arm was injured in 11 patients. 5 patients had an acute trauma of the elbow during sports. 3 had a posterolateral dislocation of the elbow with persistent symptomatic valgus instability. 6 patients had no history of a traumatic episode; the insufficiency was the result of chronic repetitive microtrauma during overhead throwing. 2 patients had undergone previous surgery, a release for medial epicondylitis. All patients had symptoms that suggested medial instability and showed apprehension or frank valgus instability on physical examination.

Before surgery, all patients underwent plain radiography of both elbows and dynamic radiography under valgus load in a standardized way using a commercially available stress device (Telos, Austin, USA). MRI was performed in all patients, combined with arthrography. Preoperatively, all patients were evaluated in the same way as in the LUCL reconstruction group. No infections or rup-

Table 2. Results after reconstruction of MCL

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	O	R	S
1	F	Volley	31	acute	L	140/0	normal	same	10	10	4	10	G	E	M	G	M	G
2	F	Soccer	17	acute	L	140/0	irr MCL	same	10	10	4	9	G	E	M	G	M	G
3	F	Tennis	21	PLD	L	140/–10	normal	140/–20	8	10	5	9	G	E	G	E	G	E
4	F	Soccer	27	PLD	R	150/0	normal	same	9	10	7	9	E	E	G	E	M	E
5	M	Tennis	17	acute	R	140/–10	OD cap	same	10	10	5	9	E	E	M	E	M	E
6	F	Tennis	37	acute	L	140/0	normal	130/–10	10	10	6	9	E	E	M	E	M	E
7	M	Tennis	46	acute	R	140/–5	rupture	140/–10	9	10	7	10	E	E	M	E	G	E
8	M	Soccer	35	PLD	L	150/–10	rupture	same	10	10	7	10	E	E	G	E	G	E
9	F	Javelin	18	chron	R	140/0	normal	same	10	10	7	9	E	E	G	G	G	G
10	F	Javelin	21	chron	R	140/–10	irr MCL	140/–20	9	10	6	9	E	E	G	E	G	E
11	M	Javelin	24	chron	R	140/0	OD cap	140/–10	8	7	3	5	G	G	M	M	M	M
12	M	Javelin	27	chron	R	140/10	normal	same	6	10	7	10	E	E	M	G	M	G
13	M	Baseball	20	chron	R	140/0	rupture	same	5	10	9	10	E	E	G	E	M	E
14	M	Baseball	18	chron	L	140/0	Irr MCL	same	6	10	9	10	E	E	G	E	M	E

For Abbreviations, see Table 1 and
chron = chronic repetitive microtrauma
acute = acute valgus trauma,
Irr MCL = irregular aspect of MCL

tures of the triceps tendon were seen.

Evaluation took place after an average of 21 (16–34) months and consisted of range of motion and stability tests for valgus instability and the specific elbow tests mentioned above. All elbows were assessed using the VAS for pain at rest and during activity, EFA, the Broberg & Morrey scoring system and the modified Andrews score. Standard radiography of both elbows in neutral position and under valgus load was done.

All but 1 patient had a stable elbow, according to the patient and according to findings at physical and radiographic examination. In 1 patient, there was persistent slight valgus instability at radiography but with no symptoms. 2 patients had transient ulnaropathy, 1 of which required a surgical decompression. 5 patients had a loss of extension of 5–10°. No loss of flexion was seen. All preoperative scores had improved. All but 2 patients were able to return to their previous level of sports.

Discussion

Persistent insufficiency of the LCUL or MCL of the elbow after nonoperative treatment are indications for surgical treatment. Avulsion injuries, which are more likely to occur on the humeral side than on the ulnar side, can be anatomically reduced and secured internally with K-wires or interfragmentary screws. However, in most cases there is a mid-substance rupture of the LUCL or MCL and reconstruction is indicated, using ipsilateral triceps or palmaris tendon graft.

Nestor et al. (1992) described reconstruction for PLRI in 11 patients using palmaris tendon, and achieved stability in 10 patients. Jobe et al. (1986) reported a follow-up study in 71 athletes with valgus instability. 14 patients had a direct repair of the ligament, 56 had a reconstruction of the ligament using the Jobe technique with a free palmaris tendon graft. The result was excellent or good in 10 of 14 patients in the repair group and in 45 of 56 in the reconstruction group. 7 of 14 who had direct repair returned to previous sport activity. 15 patients had postoperative ulnar neuropathy. This was transient in 6 patients, and the other 9 patients had an additional operation for the neuropathy. Postoperative treatment consisted of plaster for 2 weeks, after which the elbow was placed in a hinged brace allowing between 45° of extension and 90° of flexion. Over the next 5 weeks, motion was gradually advanced to full. Rohrbought et al. (2002), who first described the humeral docking technique, had excellent results in 33 of 36 cases. Postoperatively, the arm was maintained in a splint for 1 week, and in a hinged brace with limited flexion and extension for 5 weeks.

The advantage of the technique described here is that the number of drill holes is diminished from three, as has previously been used, to a single hole in the hope of reducing the invasiveness of the procedure as well as the possible complication of an epicondylar fracture. Moreover, graft tensioning is simplified and the improved fixation of the graft allows early training. The use of triceps tendon overcomes the problem of patients with an absent palmaris tendon, and surgical dissection of the wrist is not necessary.

The fascia of the triceps tendon can be absent because the caput longum of the triceps attaches to the lamina splendens, and the insertion of lateral caput, which is the only part of the triceps that attaches to the fascia, starts about 6 cm proximal to the olecranon.

In conclusion, the technique described allows simplified graft tensioning, improved graft fixation, and rapid rehabilitation, and gives good short-term results. All patients will be followed to get insight into the long-term outcome.

No competing interests declared.

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