SUBSPECIALTY PROCEDURES

THE CIRCUMFERENTIAL GRAFT TECHNIQUE FOR TREATMENT OF CHRONIC MULTIDIRECTIONAL LIGAMENTOUS ELBOW INSTABILITY

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Introduction

The circumferential graft technique^{1,2} represents a potential option for the treatment of multidirectional ligamentous elbow instability using a single tendon graft (Video 1).

While early functional treatment can be considered the gold standard for the management of ligamentous or “simple” elbow dislocation, with good clinical results in most patients³, some who have more extensive soft-tissue trauma and/or subsequent dislocations may have gross instability of the elbow. In patients who have persistent disability with insufficiency of both the lateral and the medial collateral ligament complex, ligament reconstruction is warranted in order to restore the joint stability and improve the functionality of the affected arm.

The circumferential graft technique was initially reported in 2006 by van Riet et al.² and separately in a series of 14 patients described by Finkbone and O’Driscoll¹. This technique aims to restore elbow stability by simultaneous reconstruction of the lateral and medial collateral ligaments with a single tendon graft.

Video 1 Illustration of key steps during surgery.

Indications & Contraindications

Indications

- Combined medial and lateral elbow instability
- Ligamentous instability
- Chronic instability
- Intact osseous congruity of the elbow joint
- No or low-grade osteoarthritis

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Contraindications

- Acute ligamentous instability
- Unilateral instability
- Osseous instability
- Osseous deformity
- Advanced osteoarthritis
- Acute or chronic infection

Step 1: Perform a Medial and Lateral Approach

Approach the elbow joint through either a single posterior skin incision or separate lateral and medial incisions.

- Place the patient in the supine position with the arm either across the chest (posterior incision) or placed on an arm rest (bilateral incisions).
- A tourniquet may or may not be used, depending on the surgeon's preference.
- When performing a single posterior incision, mobilize full-thickness flaps medially and laterally.
- Release and protect the ulnar nerve.
- Enter the joint medially through the bed of the ulnar nerve (flexor carpi ulnaris split) or through the common flexor-pronator tendon origin.
- Enter the joint laterally through the Kocher interval between the anconeus and the extensor carpi ulnaris muscle.
- For better visualization, detach the common flexors and extensors from their humeral origin and mobilize them anteriorly. If they are intact, make every effort to preserve them.

Step 2: Drill the Bone Tunnels

Create humeral and ulnar bone tunnels for circumferential graft placement.

- Identify the motion axis of the elbow. When in doubt, a true lateral radiograph can be helpful to identify the motion axis (Fig. 1).
- Identify the sublime tubercle at the medial side of the ulna and the supinator crest at the lateral side posterior to the radial head.
- Create a 2.0-mm drill-hole or place a 2.0-mm Kirschner wire in the distal end of the humerus along the motion axis of the elbow using a target device.
- Create a 2.0-mm drill-hole or place a 2.0-mm Kirschner wire from the sublime tubercle to the supinator crest using a target device (Fig. 2).
- Overdrill both with a cannulated 4.5-mm drill (Finkbone and O'Driscoll¹ found a 3.2-mm drill-hole to be sufficient) (Fig. 3).
- Remove the drills or Kirschner wires.
- Take great care to protect the ulnar nerve at all times.

Fig. 1

Fig. 2

Fig. 3

Fig. 1 Lateral fluoroscopic view of a left elbow showing the tip of a Kirschner wire pointing at the center of rotation.

Fig. 2 Posterior view of a left elbow depicting the humeral and ulnar drill-tunnels. The ulnar nerve has been released and marked with a vessel loop. A single asterisk indicates the humeral Kirschner wire, and a double asterisk indicates the ulnar Kirschner wire. TRI = triceps, and OL = olecranon.

Fig. 3 The primary 2.0-mm drill-holes are overdrilled with a cannulated 4.5-mm drill to establish the definitive bone tunnels.

Step 3: Place the Graft

Use a *plantaris* allograft, which we recommend; however, a *semitendinosus* autograft may also be used.

- Perform a Krakow stitch over a length of 2 cm at both ends of the graft with a number 2-0 FiberWire (Arthrex).
- Shuttle the graft through the humeral tunnel (Figs. 4-A and 4-B) and through the ulnar tunnel (Fig. 5).
- If possible, loop the graft through the bone tunnels once more.
- Before fixation of the graft, close the underlying capsule to avoid leakage of joint fluid.
- Reduce the elbow at 90° of flexion by placing the humerus flat on the operating table and the forearm in a vertical position.
- While one assistant maintains this position, have the other assistant tighten the graft ends by pulling on the FiberWires.
- Suture the overlapping tendon grafts onto each other with a number 2-0 FiberWire using a Krakow stitch at the medial and/or lateral side for secure fixation of the graft (Fig. 6-A).

Fig. 4-A

Fig. 4-B

Fig. 5

Fig. 6-A

Fig. 6-B

Figs. 4-A and 4-B After a Krakow stitch is performed at both ends of the plantaris allograft (**Fig. 4-A**), the graft is looped through the humeral bone tunnel from medial to lateral (**Fig. 4-B**).

Fig. 5 Shuttling of the graft through the ulnar bone tunnels from the supinator crest at the lateral side to the sublime tubercle at the medial side.

Figs. 6-A and 6-B Final fixation of the circumferential graft. **Fig. 6-A** Final fixation is achieved by tying the overlapping limbs of the graft onto each other using a Krakow stitch. **Fig. 6-B** After successful graft fixation, the forearm muscles are reattached to the humeral epicondyles to provide dynamic stability and to cover the graft.

Step 4: Close the Wound

Ensure that meticulous wound closure is achieved as it is key to preventing postoperative complications such as superficial or deep infection and persistent seroma.

- For patients with preoperative ulnar neuropathy, consider anterior transposition of the ulnar nerve.
- If the common flexor and extensor tendons have been dissected at the beginning of the surgery or were traumatically torn off their humeral origin, carefully reattach them to the ulnar and radial epicondyles with transosseous sutures or suture anchors (Figs. 6-B and 7).
- Consider placing a wound drain to prevent hematoma formation.
- Carefully close the forearm fascia at the medial and lateral sides.
- Close the subcutaneous tissue and the skin.
- Apply sterile dressings and a pressure bandage to limit postoperative swelling.

Fig. 7

Figs. 7-A, 7-B, and 7-C Line drawing of the technique, showing the bone tunnel placement. **Fig. 7-A** Anteroposterior view showing the humeral and ulnar bone tunnels. The humeral tunnel is drilled through the center of rotation, and the ulnar tunnel is drilled from the sublime tubercle to the supinator crest. **Fig. 7-B** Medial view of the elbow showing the placement of the graft. **Fig. 7-C** Lateral view showing the placement of the graft.

Results

As multidirectional instability represents a rather rare complication following ligamentous elbow dislocation, clinical data regarding the circumferential graft technique are scarce^{1,2}. From a biomechanical standpoint, we were able to show that this technique may be preferred over conventional reconstruction of the medial collateral ligament and the lateral ulnar collateral ligament⁴. While both reconstruction techniques were found to be inferior to the native collateral ligament complex, the circumferential graft technique withstood cyclic loading better than the conventional technique⁴.

In 2006, van Riet et al. were the first, as far as we know, to describe the circumferential graft technique². They applied this technique in a 13-year-old boy with recurrent elbow dislocation and were able to successfully restore joint stability at a 2-year follow-up². In 2015, Finkbone and O'Driscoll reported what we believe is the largest case series to date regarding treatment of multidirectional elbow instability using the circumferential graft technique, which they termed the *box-loop ligament reconstruction*¹. In their series of 14 patients, they reported a mean American Shoulder and Elbow Surgeons (ASES) score of 81 points and a mean Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score of 13 points¹. None of the patients had recurrent instability at a mean follow-up of 5.3 years¹. One revision surgery for delayed-onset ulnar neuropathy had been performed at the time of the latest follow-up¹.

Pitfalls & Challenges

- Consider the contraindications of this procedure and do not use this technique in patients with osseous instability.
- Be aware of the location of the ulnar nerve and check previous surgical reports for possible anterior transposition of the nerve.
- Consider anterior transposition of the nerve in patients with preoperative ulnar neuropathy.
- Perform careful dissection as posttraumatic scarring, especially in revision surgery, may make it more difficult to identify anatomic landmarks.
- Use a target device for precise creation of the bone tunnels and to avoid multiple drilling with subsequent weakening of the cortical bone.
- Remember that the bone tunnels are not parallel to each other as the ulnar bone tunnel is directed from proximal-medial (sublime tubercle) to distal-lateral (supinator crest).
- Check for adequate tensioning of the graft over the full range of motion before performing fixation.
- Make sure that the elbow is securely reduced when performing graft fixation.
- Carefully reattach the extensor and flexor tendons. They cover the graft to reduce the risk of infection, and they provide active joint stability.
- Meticulously close the forearm fascia to avoid herniation of the forearm muscles, to reduce the risk of infection, and to enhance elbow stability.
- Consider applying an additional hinged external fixator in patients who are noncompliant and overweight (especially in those with a long forearm, which causes a large lever on the joint).

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