

Abstract: Reconstruction of the interosseous membrane is an emerging design to help restore anatomic and biomechanical relationships within the forearm after a longitudinal instability injury. The indication for this reconstruction is proven acute or chronic longitudinal instability of the forearm. This technique uses a synthetic braided graft tied over endobuttons at radial and ulnar tunnels. It can be combined with other procedures such as radial head replacement, wafer procedures, and even ulnar shortening osteotomies for comprehensive management of the condition. Early results indicate that this reconstruction can produce clinical improvement in some patients. Further follow-up is required to determine the long-term durability of the construct, but early results are encouraging in a complex patient population.

Key Words: Essex-Lopresti, radioulnar dissociation, interosseous membrane, longitudinal forearm dissociation, ligament reconstruction

(RECONSTRUCTING THE INTEROSSEOUS MEMBRANE: A TECHNIQUE USING SYNTHETIC GRAFT AND ENDBUTTONS

Marlis T. Sabo, MD, MSc, FRCSC and Adam C. Watts, MBBS, BSc, FRCS (Trauma & Orth)

Technique

Reconstructing the Interosseous Membrane: A Technique Using Synthetic Graft and Endobuttons

Marlis T. Sabo, MD, MSc, FRCSC and Adam C. Watts, MBBS, BSc, FRCS (Trauma & Orth)

HISTORICAL PERSPECTIVE

Although not quite the first to describe acute longitudinal instability of the forearm, Essex-Lopresti described 2 patients with classic features of this injury in 1951. Since that time, many investigators have worked to understand the pathoanatomy and abnormal mechanics created by this injury. The injury disrupts the normal relationship and function of all components of the forearm (Fig. 1). Even if one manages the proximal and distal radioulnar joints appropriately, only the interosseous membrane (IOM) can redistribute the load from the wrist to the elbow in a physiological manner. Certainty of IOM healing cannot be assured, and evidence of accelerated capitellar wear after radial head replacement despite appropriate component sizing in this context suggests that normal function of the IOM is not always achieved with current treatment principles.

Over time, conceptualization of the forearm as a single function unit or joint consisting of the proximal radioulnar joint, IOM, and distal radioulnar joint would suggest that for optimal outcomes for this injury one would need to address each component during treatment. The central band in the focus for many of these techniques because of its consistent anatomy and consistent presence in the many specimens examined in anatomic studies. IOM reconstruction has been extensively studied in the laboratory, and many techniques and graft choices have been tried. These biomechanical studies have demonstrated that load transfer can be restored to near-normal through reconstruction of the IOM. Adams et al have applied their reconstruction technique using bone-patellar-tendon-bone graft to patients with encouraging early results. However, donor-site morbidity can be a concern with many of the described techniques. Use of a new-generation synthetic graft material may offer an advantage to patients by avoiding this. A synthetic graft may also provide greater resistance to elongation compared with a tendon or ligament graft. Our purpose is to describe a reconstruction using synthetic graft [ligament augmentation and repair system (LARS) ligament; Corin Group, Cirencester, UK] and endobuttons to reconstruct the central band of the IOM. The LARS ligament is a second-generation polyethylene terephthalic synthetic ligament designed to allow fibroblastic ingrowth. It has been in use in several countries for >15 years and has been used for various indications including anterior cruciate ligament reconstruction, acromioclavicular joint reconstruction, and rotator cuff reconstruction. Fibroblastic ingrowth has been demonstrated in vitro and significant biological reactions have not been noted. It does not have the Food and Drug Administration approval. We also present short-term results of this technique in the first 4 cases that have been performed for chronic injury.

INDICATIONS AND CONTRAINDICATIONS

Although indications for reconstruction of the IOM are still being defined in the clinical setting, the authors feel that IOM reconstruction has a role in the management of acute and chronic longitudinal forearm instability. Surgeons should consider combining this technique with management of the proximal and distal radioulnar joints for complete management of the pathology. Use of reconstructive techniques in the setting of acute injury has not been well described as yet but is theoretically appealing as a means of addressing the complex pathology and potentially avoiding long-term problems related to load transfer and radius migration seen in chronic cases.

Contraindications include active infection, severe soft tissue scarring/damage, and lack of significant clinical symptoms. Chronic pain syndromes are not necessarily a contraindication to this reconstruction but may detract from the overall outcome of the procedure.

TECHNIQUE

Preoperative Planning

Each patient requires evaluation to determine the specific components required for their reconstruction. This evaluation should address the proximal radioulnar joint, the IOM, and the distal radioulnar joint. This technique will concern the reconstruction of the IOM only. Forearm and wrist radiographs of the affected side, as well as contralateral wrist radiographs can be used to determine the difference in ulnar variances between the normal and affected sides. The forearm radiograph is used to template the position of the radial and ulnar tunnels (Fig. 2). The ulnar tunnel is positioned 6 cm proximal to the ulnar styloid, whereas the radial tunnel is positioned where the line extending from the ulnar tunnel at an angle of 21 degrees
to the ulnar shaft intersect the radial shaft, restoring the anatomy as described by Skahen et al (normally around 12 cm from the tip of the radial styloid). A sterile ruler is used to perform similar measurements from the tips of the ulnar styloid and ulnar tunnel for correct placement intraoperatively.

FIGURE 1. Essex-Lopresti injury. This 59-year-old woman has had a chronic Essex-Lopresti injury. She has previously undergone ligament repair, radial head replacement, removal of the radial head replacement, and ulnar shortening osteotomy. Preoperative elbow (A, B) and wrist (C, D) radiographs demonstrate a valgus tendency at the elbow without the radial head and an ulnar-positive relationship at the wrist.
IOM Reconstruction

Two incisions are required for completion of this technique (Fig. 2C). The first incision is made with the forearm fully supinated and is centered between the radius and ulna at the level planned for the radial tunnel. The incision is approximately 6 to 8 cm long and is taken sharply down to fascia (Fig. 2C). A Henry approach to the radius is performed. The muscle bellies and tendons are bluntly dissected until the IOM is exposed (Fig. 3). A 3.5-mm unicortical hole is drilled in the medial cortex aimed slightly proximal. A 2.5-mm hole is drilled through the lateral cortex of the radius to meet this (Fig. 4). The braided polyethylene graft (Fig. 5) (LARS ligament) has 2 heavy-suture tails integrated into it that are passed through the radial tunnel with a suture passer. The same skin incision is used, and the exit hole in the lateral cortex of the radius is exposed by pronating the forearm to admit the suture passer and thread the endobutton over the graft tails. The graft is passed deep to the flexor muscle bellies by blunt dissection and is then measured against the distance between tunnels and marked. Taking into account the reduced position of the radius with respect to the ulna, the length of the graft should be planned to allow the tip to dock in the ulnar tunnel without “bottoming out” (the graft contacting the far cortex before adequate tension is achieved). A whip-stitch with 2 No. 2 Orthocord (DePuy Mitek Inc., Norwood, MA) sutures is placed in the graft and the graft is cut to length. Orthocord is a proprietary suture type produced by DePuy Mitek Inc. It is a nonabsorbable suture with a polydioxanone component designed to perform similar functions to other high-tensile sutures. The sutures are then passed through the tunnel in similar manner and an endobutton is passed over the ends (Fig. 7).

FIGURE 2. Preoperative templating for the reconstruction. The position of the ulnar tunnel is measured 6 cm proximal to the distal ulna (A, B). From this point, a 21-degree angle is drawn and the line extended until it intersects with the ulnar side of the radial shaft (A, B). The distance from either the radial styloid or the sigmoid notch is used to determine the radial tunnel position (A, B). The skin incision is then plotted to center over the radial tunnel position, placed in the midline of the forearm (C). In this particular patient, the radial tunnel is planned to be 14 cm proximal to the sigmoid notch (C).
After ensuring the graft has docked in the ulnar tunnel, an assistant applies longitudinal traction to the radius by flexing the elbow to 90 degrees, stabilizing the arm above the elbow and pulling on the thumb and index with the forearm in neutral rotation, whereas a second assistant applies traction to one of the Orthocord sutures. Once the surgeon is satisfied that maximal reduction has been achieved, the first Orthocord suture is tied over the button, followed by the second (each is tied independently over the button). Traction is released, and fluoroscopy is undertaken to verify the reduction. Reduction is judged on the basis of the ulnar variance, with ideal being 0 mm, which is assessed with fluoroscopy. Depending on the chronicity of the injury, full restoration of length may not be possible, and additional procedures can be undertaken to avoid impingement of the ulna on the carpus.

Once satisfied, all sutures are trimmed, and closure is undertaken with subcuticular absorbable suture. A sugar-tong cast is placed.

Accompanying Procedures
Surgeons should be aware that other procedures may need to be combined with this reconstruction for optimal restoration of anatomy and biomechanics. These can include radial head replacement or revision radial head replacement to restore the proximal cam of the forearm joint, ulnar shortening osteotomy or wafer procedure, or removal of preexisting hardware. The surgeon should be prepared for the fact that the chronically malreduced forearm may not fully reduce during the IOM reconstruction and that residual ulnar-positive variance may require management at the same time. This can be accomplished with an ulnar shortening osteotomy distal to the ulnar tunnel (space permitting) or a wafer procedure.

Rehabilitation
The patient is observed overnight in hospital with high elevation and then managed as an outpatient. The initial sugar-tong splint is left for 2 weeks, at which point the wound is reviewed and physiotherapy continues. Elbow motion is permitted immediately, but forearm rotation is limited for approximately 2 weeks. At that time, active motion is permitted without restriction.

Complications
Depending on the previous history of the patient, any or all of the complications that attend a multiply operated limb with a complex injury can occur (infection, neurovascular injury,
CRPS, and wound problems). Although the senior author has not encountered any complications with this technique, there are several potential pitfalls and complications that could be anticipated.

**Heterotopic Ossification**
By definition, this technique involves exposure and instrumentation of the interosseous space. Bony debris is also created during tunnel creation. Although the senior author does not routinely apply prophylaxis for heterotopic ossification postoperatively, copious irrigation is used intraoperatively. Should a significant rotational block develop, it is conceivable that the reconstruction could require revision during excision of the bone.

**Fracture**
With any endobutton technique, there is a risk of fracture adjacent to the graft tunnels. This technique is no exception. Ensuring central placement of the tunnels within the radius and ulna should prevent fracture. Should it occur, the reconstruction may need to be abandoned and the fracture managed appropriately.

**Anterior Interosseous Nerve Injury**
This technique does not specifically incorporate exposure of the anterior interosseous nerve. The risk of encountering a clinically evident nerve injury is quite low, given the innervation of the deep flexors is proximal within the forearm. However, in cases of anatomic variation, the nerve could potentially be at risk.

**Graft Elongation or Failure**
The LARS ligament is a relatively new technology with favorable mechanical behavior in vitro. As a result, chronic failure of the graft is also a low risk. However, long-term in vivo performance is still being assessed. As with any graft failure, the procedure could be revised in future with fresh graft material.

**PATIENT OUTCOMES**
At this time, this procedure has been implemented in 4 patients with chronic longitudinal forearm instability. Table 1 shows
the specific patient information. All have had prior surgical treatment for this injury, and 2 were already being treated by a chronic pain team before this reconstruction. Radiographic outcomes are favorable with a difference in graft length of 1.4 to 1.7 mm between first postoperative and most recent radiographs, within measurement error and rotational differences between films.

SUMMARY

IOM reconstruction is a newer procedure designed to help restore the anatomic and biomechanical relationships within the forearm after a longitudinal instability injury. At this time, the patients who have undergone this procedure have had multiple procedures for treatment of a chronic Essex-Lopresti injury, and as a result, some have preexisting chronic pain complicating their situation. The alternative treatment in these patients is creation of a 1-bone forearm, which carries significant functional implications. The technique presented avoids difficulties with donor-site morbidity and provides a robust graft choice. Early results are mixed in this very complex group of patients, but not all patients will improve given the comorbid chronic pain issues that can be present. Future directions will include acute reconstructions in the hopes of preventing long-term consequences of the pathomechanics and pathoanatomy and also longer follow-up of the patients with reconstruction after chronic instability.
TABLE 1. Patient Characteristics and Early Outcomes of Interosseous Membrane Reconstruction

<table>
<thead>
<tr>
<th>Patients</th>
<th>Prior Treatment</th>
<th>Preop Quick DASH</th>
<th>Preop Elbex</th>
<th>Postop Quick DASH</th>
<th>Postop Elbex</th>
<th>Other Procedures (Same Session)</th>
<th>Follow-Up (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>47-year-old F</td>
<td>Radial head replacement, ulnar shortening</td>
<td>N/A</td>
<td>88</td>
<td>41</td>
<td>66</td>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>43-year-old F</td>
<td>Radial head replacement, radial head removal, ulnar shortening osteotomy</td>
<td>96</td>
<td>123</td>
<td>91</td>
<td>123</td>
<td>Radial head replacement, ulnar shortening</td>
<td>11</td>
</tr>
<tr>
<td>57-year-old F</td>
<td>Sauvé-Kapandji, radial and ulnar head replacements</td>
<td>77</td>
<td>113</td>
<td>91</td>
<td>121</td>
<td>None</td>
<td>8</td>
</tr>
<tr>
<td>59-year-old F</td>
<td>Radial head replacement, radial head removal, ulnar shortening osteotomy</td>
<td>N/A</td>
<td>N/A</td>
<td>18</td>
<td>5</td>
<td>Revision radial head replacement, wafer procedure</td>
<td>6</td>
</tr>
</tbody>
</table>

Higher scores represent greater symptoms and poorer function. Elbex indicates Wrightington Elbow Score; F, female; N/A, not available; postop, postoperative; preop, preoperative.

REFERENCES