10 Ultrasound of the Interosseous Membrane of the Forearm

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10.1 Introduction

The interosseous membrane (IOM) is stretched between the two bones of the forearm. It participates in the dynamic stabilization of the antebrachial frame, in the transverse but also longitudinal plane. It can be torn by a longitudinal shear mechanism and, in this case, combined with a fracture-impaction of the radial head and a tear of the triangular fibrocartilaginous complex (TFCC) of the wrist resulting in Essex-Lopresti syndrome (Fig. 10.1) [1]. Incomplete tears can also occur in distal radioulnar dislocation (isolated or associated with fracture of the radius: Galeazzi-type lesion) or proximal radioulnar dislocation (in Monteggia-type lesion) (Fig. 10.2).

In the acute phase of trauma to the forearm, the diagnosis of rupture of the IOM is sometimes evident before the displacement of the radius from the ulna, but often the diagnosis is missed at the initial stage. IOM rupture induces major destabilization of the antebrachial framework, and this diagnosis will affect surgical management: contraindication to isolated resection of the radial head, stabilization of the radial ulnar joint, and ligamentoplasty of the forearm [2].

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Two imaging tests are proposed to explore IOM: ultrasound [3–5] and magnetic resonance (MRI) imaging [6, 7]. The purpose of this chapter is to describe the use of ultrasound as a means of exploring the IOM.

10.2 Anatomo-pathological Reminders

Anatomy and Biomechanics: The IOM consists of two layers of fibers, the most important of which are oriented up and out (radial) (Fig. 10.3). Some of these fibers are rather strained in supination and others in pronation. This positional fiber recruitment allows continuous operation of the IOM regardless of the rotation of the forearm without impeding the rotation of the radius around the ulna. The orientation of the fibers explains the double stability of the IOM: transverse (prevents the two bones from moving away) and longitudinal/vertical (prevents the relative ascent of the radius relative to the ulna). In addition to the IOM, longitudinal stability of the forearm is ensured by the TFCC (which also participates in transverse stability) and by the radial head (which prevents the rise of the radius by buttressing against the humeral capitellum) [8].

Anatomical studies distinguish three different parts of the IOM: proximal, medial, and distal. The middle portion is the strongest and most

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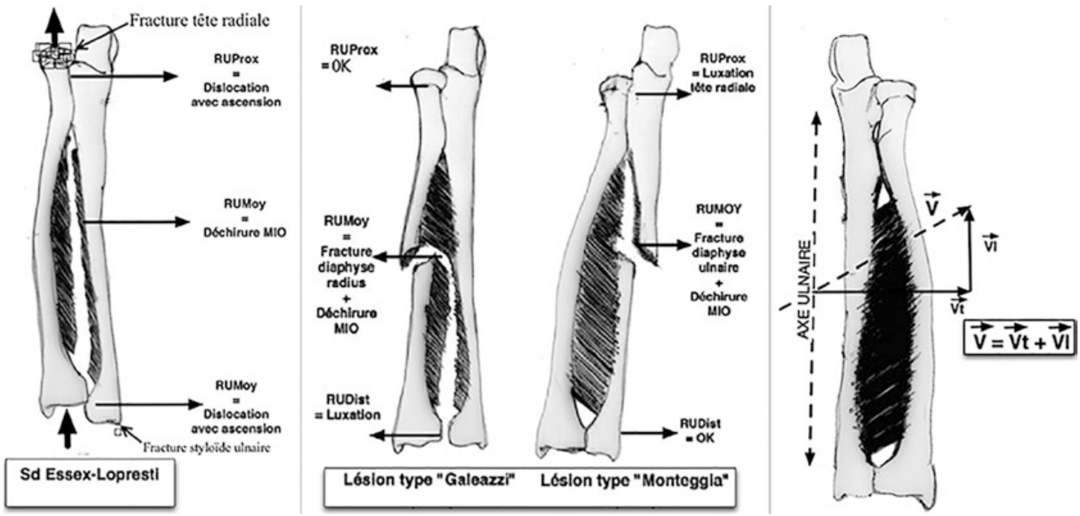

Fig. 10.1 Essex-Lopresti syndrome in its complete form: IOM tear, radial head fracture, ascension of the radius with inversion of the radioulnar index

functionally important. It occupies the widest portion of the interosseous space and stretches rather in neutral rotation. In pronation it is relaxed because the two bones are crossed, and the interosseous space is reduced.

10.3 Traumatic Lesions of the IOM

IOM tears can be partial or complete (full height) and are the result of indirect mechanisms of longitudinal translation/separation of both forearm bones. It appears that the rupture occurs preferentially in the middle of the interosseous space, where the IOM is finer. Three names are to be remembered to describe the traumatic lesions of the IOM: Essex-Lopresti, Monteggia, and Galeazzi.

Essex-Lopresti Syndrome is the complete form with longitudinal and transverse destabilization. Standard radiographs always have the same lesion association: fracture of the radial head usually comminuted and inversion of the distal radioulnar index, which in summary corresponds to a proximal migration of the radius relative to the ulna. This ascent is due to the transmission of stresses from the carpus to the radius at the time of a fall on the palm. Because the IOM is completely ruptured, it no longer holds the proximal migration of the radius. Subsequently, this ascent is maintained by the action of muscles and especially the biceps brachii. Naturally the radius does not "go down," and the evolution is toward a limitation of pronosupination (proximal radioulnar injury as a result of fracture of the radial head +/distal radioulnar dislocation), wrist pain (distal radioulnar damage and ulnocarpal impingement: long pseudo-ulna), and elbow (proximal radioulnar injury).

Lesions of the "Monteggia" type conventionally associate a fracture of the ulna with a complete dislocation of the proximal radioulnar joint. In the manner of Maisonneuve fractures of the leg, the lesion necessarily implies a partial tearing of the proximal part of the IOM: in fact it is impossible to completely dislocate the proximal radioulnar without damage to the IOM.

Galeazzi-type lesions associate a fracture of the radius with a distal radioulnar dislocation. Again, distal radioulnar dislocation is not possible without tearing of TFCC and IOM.

It is accepted that the IOM cannot heal spontaneously for two mechanical reasons. First, the IOM is composed of elastin fibers, and once severed, there is an immediate retraction to its radial and ulnar bone inserts that prevents spontaneous

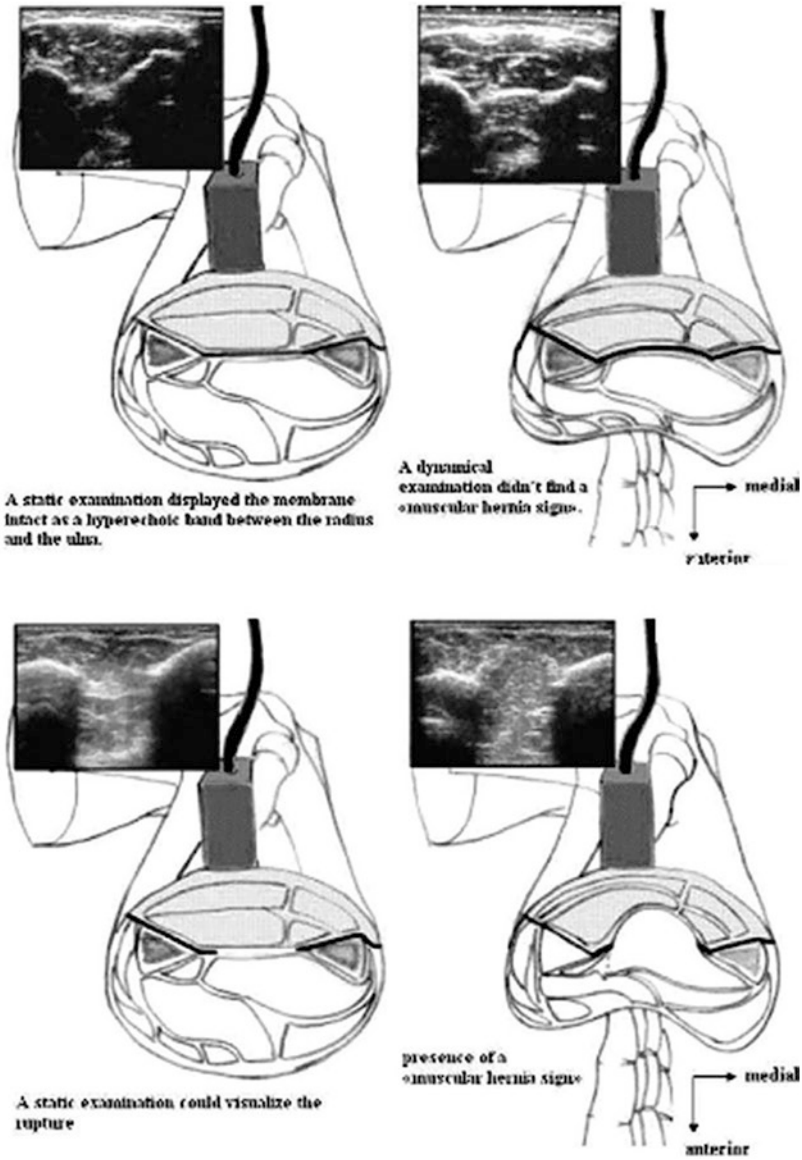

Fig. 10.2 The two classical lesion syndromes depending on whether the IOM tear is associated with an injury of the proximal (Monteggia) or distal (Galeazzi) radial ulnar

re-confrontation of the ruptured banks. Secondly, the surrounding muscles (deep flexors) naturally tend to enter the IOM gap and thus a mechanical obstacle to the confrontation of the banks. The natural evolution is therefore toward a lack of IOM healing while the interosseous space is filled with cicatricial fibrosis that no longer has the mechanical properties of the native IOM ("ligament elongation callus"). In addition, scar processes lead to a gradual fixation of the radius in the upper position relative to the ulna.

Diagnostic means of IOM rupture: X-ray examinations, computed tomography (CT), and standard radiographs don't allow you to see the satellite lesions of IOM rupture: fracture of the radial head, ascent of the radius, and fracture of the ulnar styloid. In some cases, these signs are not visible at the outset, which may lead to the omission of the diagnosis. Direct observation of IOM is possible only with MRI and ultrasound. MRI has the advantage of providing functional information (tissue edema) and not being a

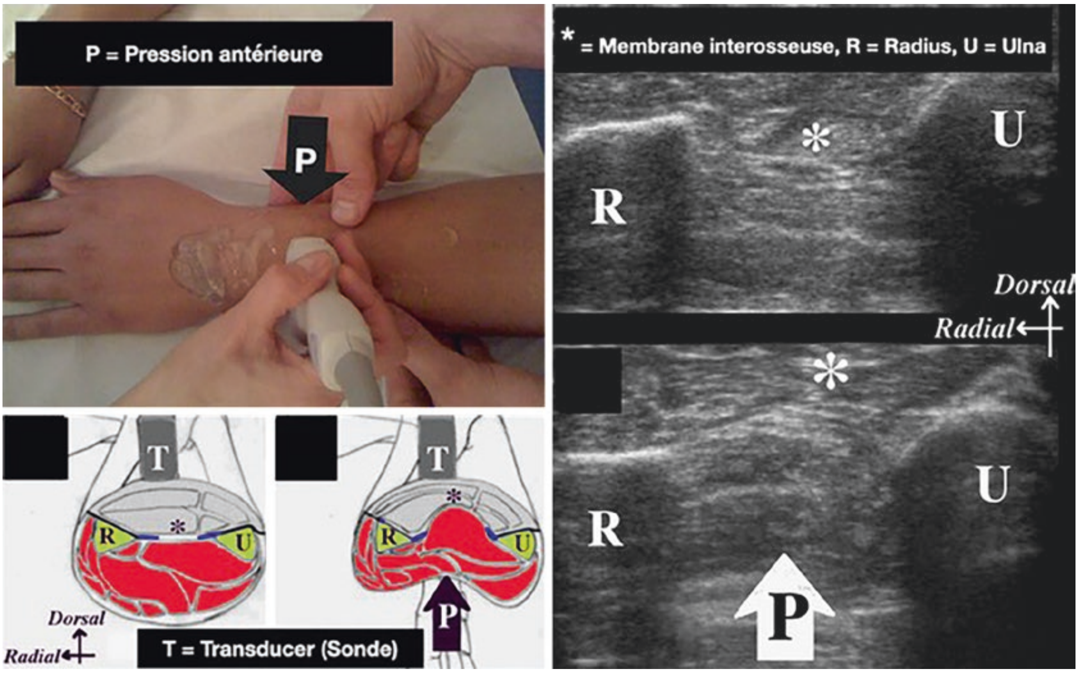

Fig. 10.3 The most important fibers in the IOM are oriented from the ulna to the radius and from the bottom to the top. Thus the force vector corresponding to them can be broken down into a horizontal vector (transverse stability: prevents the separation of the two bones) and vertical vector (longitudinal stability: prevents the rise of the radius)

dependent operator. However, it also has several limitations in this context: difficult to access in emergency, degraded images from the moment the metal material (osteosynthesis plates, screws, radial head prosthesis) was implanted, no dynamic examination possible, and high cost. In the acute phase, MRI can show the interruption of the membrane in T1 and T2 sequences as well as edema in the soft parts surrounding the IOM, signaling the reality of an acute traumatic process [7]. In the chronic phase, its interpretation is more complex because the inflammatory process has disappeared, and if there is no fiber healing with effective length, scar tissue can fill the rupture bank without ensuring the normal function of the IOM ("ligament elongation callus").

Treatments and issues of diagnosis of IOM rupture: All authors conform to the fact that chronic phase treatment has poor functional outcomes [9]. One of the reasons is that once the rise of the radius is "frozen" at the chronic phase, it is technically almost impossible to descend the radius. The ulna should usually be shortened by osteotomy to correct the distal radioulnar index. Confirmation of a complete IOM rupture indicates that the radial head has become the site of significant longitudinal stresses, which can be considered a risk factor for failure of head osteosynthesis. Carrying out arthroplasty will then be preferable. For the same reasons, isolated resection of the radial head would be contraindicated. Finally, the diagnosis of complete rupture could be an argument for the complementary execution of an IOM ligamentoplasty to stabilize the forearm.

10.4 Ultrasound of the Interosseous Membrane

10.4.1 When to Perform an Ultrasound of the IOM?

After trauma to the forearm, in the acute or chronic phase, and in the presence of the satellite lesions described above (fracture of the radial head, inversion of the distal radioulnar index, ulnar styloid tearing), a lesion of the IOM should be evoked and ultrasound performed. Ultrasound can also be performed after surgery even if metal equipment has been implanted.

10.4.2 What Is the Normal Ultrasound Appearance of the IOM?

When the IOM is intact, it is very easy to visualize in ultrasound: it appears as a hyperechogenic structure stretched between the interosseous edges of the two bones. When the forearm rotates, the interosseous space opens and closes, the IOM stretching and relaxing accordingly. The upper part of the IOM is narrower and deeper and therefore harder to observe, but its functional importance is less. The medial part is the most important and is ideally observed in neutral rotation where it is stretched. The distal portion is rather tense in supination. The ideal is to position yourself in front of the patient who is sitting with both elbows on the examination table, in neutral rotation of the forearms. This allows easy access to both forearms.

10.4.3 What Is the Ultrasound Appearance of the Disrupted IOM?

The review must be bilateral and comparative. It is necessary to begin with a morphological examination and then to conduct a dynamic evaluation. In the acute phase, asymmetry can be seen, a continuity solution signaling the tear or the presence of a hematoma in the interosseous space. In the chronic phase, it is much more difficult to diagnose the rupture on the morphological examination alone because scar (nonfunctional) fibrous tissue usually takes place in the interosseous space and gives an appearance of continuity of the fibers between the two bones. This scar is usually a little thicker and may even mistakenly suggest that the IOM is more resistant on the lesioned side.

We recommend performing dynamic IOM testing using the dynamic "muscle hernia sign." We initially described this test on the basis of anatomical work, and it was originally intended for acute ruptures. However, in the chronic phase there is an asymmetry between the two sides. The principle is very simple and is based on the fact that when there is a rupture, one can pass part of the deep flexor muscles through the rupture, toward the posterior compartment of the forearm. The operator places the probe on the back side of the forearm and presses the anterior side at the same time. If the IOM is intact, then the flexor muscles cannot pass through the interosseous space. If the IOM is broken, one manages to generate a real muscle hernia through the interosseous space (test for provoked muscle hernia [3]).

10.5 Conclusion

There is an important stake in making a diagnosis of IOM rupture. Ultrasound is a valuable tool, especially since the lesion will be recent. The surgeon will be able to visualize the rupture, especially by testing for the provoked muscle hernia.

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