

Alleviating Pain: The Role of Embolization for Musculoskeletal Injuries

Mechanisms, imaging-based patient selection, treatment gaps and opportunities, and future directions of embolization in sport-related and degenerative MSK pain.

With Yuji Okuno, MD, PhD



Over the past decade, embolization has transitioned from oncologic and hemorrhage control to treating chronic pain and degenerative joint disease. What are the most compelling mechanisms explaining why reducing abnormal hypervascularity

improves pain and function in musculoskeletal (MSK) disorders?

A key concept underlying MSK embolization is that vascular ingrowth is inherently disadvantageous for most MSK tissues. Although skeletal muscle requires rich vascularization to meet high metabolic demand, many MSK structures—such as articular cartilage (avascular) and tendons (hypovascular)—are physiologically adapted to function with minimal or no blood supply.

Importantly, this is not incidental. Chondrocytes and tenocytes actively secrete antiangiogenic factors, maintaining a controlled avascular or hypovascular state. This defense exists because vascular invasion is biologically unnecessary and potentially harmful: Neovessels advance by degrading extracellular matrix through mediators such as matrix metalloproteinases, which compromises the structural integrity of dense connective tissue.

When inflammation develops, as in tendinopathy or degenerative joint disease, this tightly regulated balance is disrupted, and pathologic neovascularization occurs. Rather than facilitating effective tissue repair, such vascular ingrowth is associated with persistent inflammation, nociceptive nerve co-ingrowth, and pain generation.

Therefore, restoring the physiologic hypovascular environment by reducing abnormal hypervascularity represents a rational therapeutic strategy. Consistent with this concept, prior experimental and clinical studies have demonstrated that inhibition of angiogenesis leads to improvement in arthritis and tendinopathy, supporting

embolization as a mechanism-based intervention targeting pain generators rather than structural degeneration alone.

Other important mechanisms include evidence that reduction of inflammatory vessels leads to decreased infiltration of inflammatory cells, as well as findings showing that embolization reduces afferent stimulation to the dorsal horn of the spinal cord. We believe these mechanisms also play a significant role in the therapeutic effects observed.

For sports-related overuse injuries, what imaging or clinical markers best identify candidates likely to benefit from embolization versus continued conservative management?

Imaging assessment plays a crucial role in patient selection for embolization therapy in practice of overuse sports injuries. In particular, patients who demonstrate strong imaging findings associated with neovascularization are good candidates for embolization. This is because prominent neovascularization reflects a higher degree of inflammation, and such patients are less likely to improve with other conservative treatments.

Ultrasound findings related to neovascularization include increased color Doppler signals and tendon thickening. On MRI, characteristic findings include edema on fat-suppressed T2-weighted sequences, peritendinous fluid or effusion, and high signal intensity within the bone marrow at the tendon insertion site. In addition, contrast-enhanced MRI demonstrating enhancement is a particularly important finding closely associated with neovascularization.

Patients who exhibit these imaging features typically have more severe inflammation and often show little or no improvement with conservative therapy. Many of these patients also fail to respond to other treatment options, such as platelet-rich plasma (PRP) therapy or extracorporeal shockwave therapy (ESWT). For this reason, such patients represent excellent candidates for embolization, and embolization should be actively considered in this population.

Previous evidence regarding embolization for Achilles tendinopathy has shown that patients with abundant Doppler signal within the Achilles tendon substance tend to have higher response rates to embolization therapy.

What is the role of embolization in patients with chronic tendinopathies unresponsive to regenerative medicine therapies? Do you foresee embolization becoming first-line therapy?

There are many patients with chronic tendinopathy who do not respond to regenerative therapies such as PRP therapy, and among these patients, a substantial proportion show clinical improvement after embolization. For this reason, patients who have failed PRP therapy represent good candidates for embolization.

In the future, we believe that embolization has the potential to become a first-line treatment, provided that comparative studies demonstrate its superior efficacy over PRP. Establishing such evidence through well-designed comparative or randomized studies will be essential to defining the optimal treatment strategy for chronic tendinopathy.

What treatment gaps does embolization for sports-related overuse injuries address? Where do current standard treatment methods fall short for patients?

At present, available conservative treatments are minimally invasive or noninvasive; however, their reliability is limited. In other words, some patients respond while others do not, and predicting treatment response remains difficult. For example, PRP injections are often criticized as being akin to a “coin toss,” reflecting the unpredictability of their clinical outcomes.

Ineffective treatment merely results in a loss of time, which is a significant disadvantage for athletes and recreational sports participants who wish to return to activity as soon as possible.

As a consequence, patients who do not respond to conservative therapy often lose approximately 6 months before being forced to decide whether to proceed with surgery. However, surgery is associated with substantially greater invasiveness, prolonged time to return to sport, and the risk of tissue stiffening. These factors may prevent patients from regaining their preinjury optimal performance level, particularly in overuse-related conditions.

Thus, when the only available options are conservative treatments with low invasiveness but unreliable efficacy or surgery with high invasiveness and no guarantee of full performance recovery, the therapeutic gap between these two approaches is considerable.

MSK embolization therapy can be performed promptly once a condition is judged to be relatively severe or unmanageable with conservative treatments. Light training can often be resumed shortly after the procedure,

and the likelihood of achieving clinical benefit is high. In this sense, we believe embolization therapy effectively bridges the gap between conservative management and surgical intervention.

Regarding MSK embolization in general, what study designs or endpoints will most effectively persuade the orthopedic and rheumatology communities regarding MSK embolization?

From a study design perspective, we believe that randomized controlled trials (RCTs) comparing embolization with PRP therapy or ESWT, as well as RCTs comparing embolization with surgical intervention, would be highly informative.

Regarding outcome measures, safety is a critical endpoint. Notably, tendon rupture after embolization procedures has never been reported to date. In our own experience, we have treated more than 2,000 cases of tendinopathy, and no cases of tendon rupture have occurred. This safety profile represents an extremely important outcome measure.

Time to return to sport and the rate of return to preinjury best performance are particularly important clinical endpoints. These outcomes are highly relevant for athletes and physically active individuals and should be prioritized when evaluating the clinical value of embolization therapy.

Which sports-related injuries have you successfully treated with embolization at this point? Which MSK indications hold the most promise for embolization over the next 5 years?

To date, we have treated the majority of overuse-related sports injuries using embolization therapy, and most of these conditions can be considered good indications for this approach. Among them, tendinopathy and enthesopathy appear to be the most promising indication. However, embolization is not limited to tendinopathy/enthesopathy; stress fractures are also an excellent indication, and we have achieved favorable clinical outcomes. In cases of stress fractures, we have observed clear promotion of bone union, suggesting that embolization may offer benefits beyond subjective pain relief. Importantly, emerging evidence indicates that embolization enables not only improvement in pain but also enhancement of bone healing, representing a novel and clinically meaningful concept. ■

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