

# A NOVEL MULTISITE PERIPHERAL NERVE STIMULATION APPROACH FOR CHRONIC HIP PAIN IN AVASCULAR NECROSIS: A CASE REPORT

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**Background:** Avascular necrosis (AVN) is a progressive disease, commonly leading to joint collapse and severe pain. Peripheral nerve stimulation (PNS) to the lumbar plexus and articular nerves innervating the hip can be a viable option for treatment of hip pain in patients who are not eligible for surgery.

**Case Report:** A patient with AVN-induced hip pain received bilateral lumbar plexus PNS at the level of L2, resulting in a > 90% relief of bilateral posterolateral aspects of the hip and 50% to 60% reduction in overall hip pain, respectively, at his 2-week follow-up. He subsequently underwent PNS placement to the articular branches of the femoral nerves bilaterally, resulting in improved coverage of the anterior groin leading to a 75% reduction in overall bilateral hip pain.

**Conclusions:** Our case supports the utility of PNS to the lumbar plexus and articular nerve branches innervating the hip joint as a safe and novel treatment for chronic hip pain, despite limited evidence available for lumbar plexus neuromodulation.

**Key words:** Case report, peripheral nerve stimulation, chronic hip pain, avascular necrosis, neuromodulation

## BACKGROUND

Avascular necrosis (AVN) of the bone, also known as osteonecrosis, is a disease process characterized by cellular death due to subchondral ischemic interruption, ultimately resulting in joint collapse and severe pain (1). AVN most commonly affects weight-bearing joints of men between the ages of 30-65, with common risk factors, including cellular toxicity (smoking, chemoradiation), trauma, extraosseous venous abnormalities or stasis, chronic corticosteroid use, intraosseous intravascular occlusion (coagulation disorders and sickle cell disease), and alcohol use disorder (1,2). The femoral head is the most common joint affected, with 70% of atraumatic femoral head AVN cases affecting the bilateral hips (1). Management of hip AVN depends primarily on

disease progression, as classified by the Ficat and Arlet classification system (2). Nonoperative management for early-stage AVN is aimed at delaying disease progression and preserving the joint; however, this is somewhat controversial, with use of core decompression being the most promising treatment (1,3). In younger patients with femoral head collapse, or in patients over the age of 40 years old with irreversible etiologies of femoral head AVN, total hip arthroplasty (THA) has been found to be the most reliable long-term treatment for pain and hip stability (1-3). Patients who are not eligible for operative intervention, however, may require alternative treatment options and interventions.

Foundations for peripheral joint innervation were pioneered by anatomist Nikolaus Rüdinger in the mid-

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19th century and further expanded upon by Ernest Gardner in the mid-20th century, setting the framework for peripheral joint interventional pain and surgical denervation procedures utilized today (4-6). Since its foundation, recent studies (6) have further investigated hip capsule innervation to extrapolate primary pain generators of the hip. Hip sensation has been described to be primarily mediated by articular branches of the lumbar plexus, including the femoral nerve (anterior capsule), obturator and accessory obturator nerves (anteromedial capsule), superior gluteal and sciatic nerves (lateral to posterolateral capsule), and the nerve to the quadratus femoris (posterior capsule) (4,6). Nociceptive and mechanoreceptive-rich areas have also been found to be in higher density over the anterior portions of the hip, thus concluding that the femoral and obturator nerves act as the primary pain generators of the hip; therefore, these nerves are common target sites for radiofrequency ablation (RFA) for treatment of chronic hip pain today (4,6).

Alternatively, peripheral nerve stimulation (PNS) has been an emerging therapy for refractory chronic neuropathic pain, particularly when conservative or less-invasive interventions have failed. The mechanism of PNS is thought to be due to modulation of peripheral nerve activity resulting in improved interplay between A $\beta$  fibers and C fibers leading to decreased central sensitization and local nociceptive signaling (7).

An international study from 2023 (8), regarding perception and utility of PNS for neuropathic pain management, demonstrated that many interventional pain physicians and leaders in professional pain societies consider PNS as a secondary treatment option following failed conservative management and use of RFA for chronic neuropathic pain. Current guidelines (4,9) from the American Society of Pain and Neuroscience (ASPN) support the use of lower extremity peripheral nerve targets, including, but not limited to, the sciatic, femoral, and obturator nerves (Level I Evidence, Grade B); however, ASPN also encourages thorough patient screening for appropriate PNS candidates.

Despite available evidence of focused anatomical coverage with targeted femoral/obturator PNS for antero-medial hip pain, lumbar plexus PNS can be considered an additional site for stimulation for broader pain coverage (4,9). Due to hip innervation derived proximally from the lumbar plexus, PNS can be used for poorly localized hip pain with the rationale of providing broader hip capsule coverage by targeting multiple articular

branches proximally (10). Lumbar plexus blockade and articular branch RFA have been utilized as treatments for chronic hip pain; however, there is limited evidence for the utilization of PNS to the lumbar plexus, specifically in AVN, thus highlighting lumbar plexus PNS as a novel approach for chronic hip pain management (11). In patients who have experienced inadequate regional coverage of symptoms in the hip following lumbar plexus PNS, additional targeted PNS leads to the anterior femoral and/or obturator nerves can be utilized, specifically if the primary area of inadequate coverage occurs at the anteromedial portions of the hip joint capsule. We present a patient with chronic bilateral hip pain secondary to AVN who received significant lasting pain relief from bilateral lumbar plexus (at the L2 level) PNS and bilateral anterior femoral nerve PNS. Signed informed consent was obtained by the patient prior to preparation of the report.

#### **CASE PRESENTATION**

A 32-year-old man with a past medical history of tobacco and alcohol use disorder presented with chronic bilateral hip pain due to bilateral hip AVN. His chronic bilateral hip pain was refractory to activity modification, corticosteroid injections, and acetaminophen. He was unable to utilize anti-inflammatory medications due to a kidney injury acquired from suspected alcohol-induced hypovolemic shock. He was unable to complete a course of physical therapy, given the severity of pain and functional limitations. Plain radiograph imaging demonstrated degenerative changes of the bilateral hips with femoral head collapse. After failed conservative management, he presented to 2 separate orthopedic surgeons who recommended THA; however, the patient was deemed a poor surgical candidate due to smoking status, and he was unable to maintain smoking cessation for the 6 weeks required for the elective surgery. He was subsequently referred to the interventional pain clinic for further management.

After initial evaluation, he underwent bilateral hip intraarticular local anesthetic injections with 3 mL of 0.25% bupivacaine under fluoroscopy and reported > 80% pain relief in his bilateral hips for the duration of the local anesthetic, approximately 6 hours. The patient then underwent a bilateral anterior femoral and obturator RF nerve ablation with inadequate pain improvement at his 2-week follow-up. He additionally endorsed the desire to defer future surgical intervention, given the success of these procedures and his

interest in pursuing other nonoperative interventions for further improvement of his bilateral hip pain.

The patient underwent a bilateral lumbar plexus PNS trial with SPRINT (SPR Therapeutics, Cleveland, OH) at the level of L2. He had a > 90% reduction in bilateral posterolateral hip pain (posterior hips, buttocks, and lateral legs), with a reported 50% to 60% reduction in overall bilateral hip pain following lumbar plexus PNS at his 2-week follow-up. Due to inadequate reduction of pain in the bilateral anterior groin and medial thigh, the patient elected to undergo additional PNS lead placements for additional bilateral anteromedial pain. He underwent a bilateral anterior femoral nerve PNS trial with SPRINT (SPR Therapeutics, Cleveland, OH). He reported an additional 50% reduction in bilateral anteromedial hip pain, resulting in an overall 75% reduction in his bilateral hip pain following the addition of an anterior femoral nerve PNS at his 2-week follow-up. The patient also endorsed improvement in his ability to tolerate activities of daily living and discontinued use of all pain medicines.

## CONCLUSIONS

PNS, targeting the articular branches of the lumbar plexus, appears to be a safe and effective treatment for patients with chronic hip pain, particularly those with femoroacetabular joint collapse due to AVN who are not eligible for operative intervention and have failed conservative management, including other interventional procedures. Our findings support PNS as a viable option for pain reduction, functional improvement, and enhanced daily activity participation for chronic hip pain. Due to the lumbar plexus PNS targeting multiple articular branches proximally, it can be utilized for broad coverage of diffuse or poorly characterized hip pain. Our findings suggest that the addition of targeted PNS to the femoral and/or obturator nerves may improve coverage to the anteromedial compartment of the hip if lumbar plexus stimulation were to provide inadequate coverage. Given the limited existing data, further investigation and comparative studies with targeted peripheral nerve PNS would prove beneficial to determine a potential role for lumbar plexus PNS in managing chronic hip pain.

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