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Case Report

Spinal Cord Stimulation for the Treatment of Chronic Knee Pain Following Total Knee Replacement

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Background: Chronic pain after total knee replacement is common but remains poorly understood. Management options for patients with this condition are traditionally limited to pharmacological approaches.

Objective: This article presents a case of using spinal cord stimulation in the management of chronic knee pain following total knee replacement.

Design: Case report

Setting: Pain management clinic

Methods: A 68-year old patient presented with a 3-year history of persistent knee pain following total knee replacement. After failing to respond to medications and nerve blocks, a trial of spinal cord stimulation and subsequent permanent implantation of a spinal cord stimulator (SCS) were performed. The Oxford knee score (OKS) was used to assess her pain and functionality before and after SCS implantation.

Results: The patient reported improvement in her pain and function. Her baseline OKS was 39 and fell to 26 one year post implantation of an SCS representing a reduction of pain and disability from severe to moderate.

Limitations: A case report.

Conclusion: Spinal cord stimulation might be an option in the management of refractory knee pain following total knee replacement.

Key Words: total knee replacement, knee pain, spinal cord stimulation

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Total knee replacement (TKR) is an accepted and effective treatment for advanced, painful degeneration of the knee joint. TKR has been shown to dramatically decrease pain and improve function in appropriately selected patients (1,2). The indications for TKR include functional limitation of the affected joint, persistent knee pain, radiographic evidence of joint degeneration and a lack of improvement with non-surgical therapies. Disease processes most commonly associated with TKR include osteoarthritis, rheumatoid arthritis, juvenile rheumatoid arthritis, and osteonecrosis. It is one of the most commonly performed orthopedic procedures worldwide. In 2003, more than 400,000 primary total knee replacements were performed in the United States and it is estimated that 3.4 million operations will be performed by the year 2030 in the United States alone (3).

Despites its success, a significant percentage of patients suffer from persistent knee pain following TKR

(4). The persistence of pain is a major determinant of patient satisfaction following TKR (5). In fact, up to 15% of patients evaluated 5 to 8 years after TKR have significant pain and functional limitation (5). Some of the proposed factors contributing to a less than satisfactory outcome following TKR include post-operative infection, prosthetic malfunction, surgeon and institutional experience, the need for revision, and preoperative co-morbidities (6). Additional factors that might play a role in patient dissatisfaction following TKR include low socio-economic status, poor pain coping strategies, and a failure to meet patient expectations (7). Once prosthetic integrity has been confirmed, the etiologies of chronic pain following TKR are poorly understood (8).

Total knee arthroplasty has long been recognized as a very painful operation. Effective perioperative analgesia has been associated with improvement in knee range-of-motion, physical rehabilitation, and reduction in the incidence of chronic pain (9-11). However, objective findings such as range of motion do not correlate with patient satisfaction which is based on reduction of pain and enhanced physical function (12). In addition, a recent prospective, one-year follow-up of a randomized, triple-masked, placebo-controlled trial comparing extended-duration continuous femoral nerve block with ropivacaine to saline, failed to demonstrate an improvement in pain and functionality following TKR (13). Unfortunately, there are no multi-modal acute pain management strategies, or rehabilitative modalities that consistently affect the outcomes of pain and function after TKR.

Furthermore, there is little data from an evidence based approach to guide treating physicians on the management of chronic pain post TKR. Pharmaceutical agents consisting of a combination of antiepileptics, antidepressants, and analgesics are the first line of management (14). However, though uncommon in clinical practice, even a multimodal approach may fail to bring satisfactory relief. Local injections into a focal area of tenderness to treat a suspected neuroma usually render short-term relief with a potential risk of infection to the prosthetic joint. More often, patients with chronic post –TKR pain have diffuse pain involving the joint area making peripheral neural blockade an impractical long-term strategy.

In this case presentation, we present a patient with persistent knee pain following revision TKR who failed to respond to conservative therapies for her pain. She experienced significant improvement in her symptoms following spinal cord stimulator implantation. The Oxford knee score was used to assess the outcome of spinal cord stimulation for post-TKR. It is a single score derived from a validated 12-item questionnaire designed specifically for knee surgery patients to evaluate pain and functional ability (15).

Spinal cord stimulation (SCS) is a Food and Drug Administration (FDA) approved therapy for persistent back and leg pain following lumbar spine surgery and has demonstrated success in a variety of chronic intractable conditions (16). This case report illustrates the use of spinal cord stimulation for the neuropathic component of chronic knee pain following TKR.

Case Description

The patient is a 68-year-old female with a past medical history of osteoarthritis who underwent partial left knee replacement in 2003. Due to persistent pain in the left knee joint, she underwent a total knee replacement in 2005. After her repeat operation, she continued to suffer from a deep burning and searing pain to the left knee located mostly inferior to her patella (Fig. 1). This pain occurred constantly and was made worse

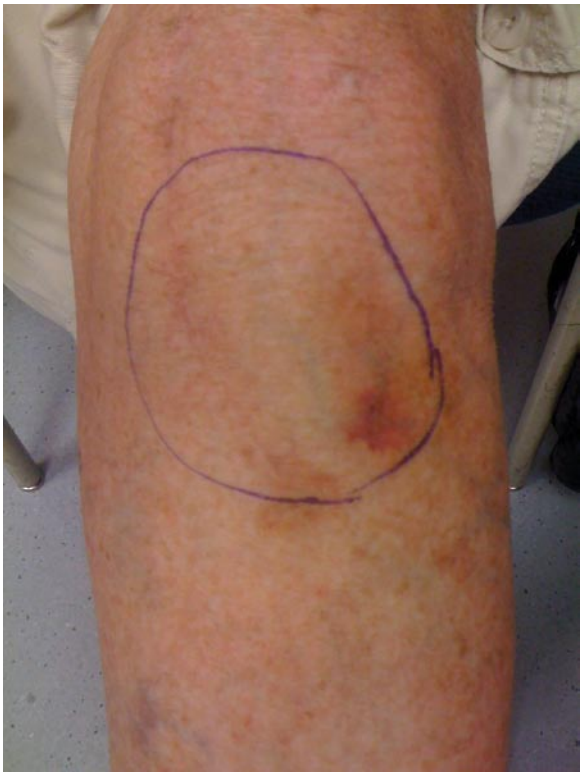

Fig. 1. *The area of chronic knee pain following total knee replacement is demarcated.*

with activities such as prolonged walking or dancing. She denied any radiation, back pain, numbness, tingling, edema, sweating, skin color changes, and bowel or bladder incontinence.

Prior to her consultation, she tried a variety of treatments for her persistent knee pain including aspirin, acetaminophen, ibuprofen, naproxen, diclofenac, celecoxib, lidocaine patch, pregabalin, bupropion, mexiletine, oxycodone, and transdermal fentanyl — all with minimal relief. She underwent physical therapy, TENS unit therapy, scar injection, femoral nerve block, transforaminal epidural steroid injections, and pulsed-mode radiofrequency lesioning of the left L3 and L4 nerve roots. These interventions were also met with limited success. She was referred to our clinic for further evaluation and treatment.

Her physical exam was significant for a fit appearing female. There was a well-healed left knee incision with slight tenderness to very firm palpation over the inferior aspect of the incision. There was no hyperalgesia or allodynia over her scar and her range of motion of the left knee joint was 120 degrees. The strength of her knee flexors and extensors was 5/5. The prosthesis was clinically and radiographically intact. There was no sensory loss to pinprick in the painful region outlined in Fig. 1. In addition, there was no edema, skin color change, and skin temperatures (Novatemp TM, Novamed, Elmsford, NY, USA) were similar: 31.2°C (left) and 31.4°C (right). Her Oxford knee score (OKS) prior to spinal cord stimulator implantation was 39. The highest score on the OKS is 60 and represents maximum disability (15). A score that ranges from 40 to 60 represents a suboptimal outcome with respect to pain and function (5).

Because of the poor characterization of chronic post-TKR pain, and to screen more definitively for the presence of neuropathic pain, the patient completed a 10-item neuropathic pain diagnostic questionnaire (DN4). Sensory descriptors and bedside sensory examination that render a score of 4/10 or greater has a positive predictive value of 86%, sensitivity 82.9%, and a specificity of 89.9% (17). Our patient had a score of 6 on the DN4 which implies that there is neuropathic pain as a component of the chronic pain complaint.

Given our patient's failure to respond to a variety of medications, physical therapy, and interventional modalities, and the presence of neuropathic pain, a trial of spinal cord stimulation was offered. She was evaluated by our pain psychologist who felt there were no psycho-social issues that would lead to a poor outcome from spinal cord stimulation. She underwent a one week trial period after implantation of a single 8 contact electrode to T10 preferentially directed to the left of mid-line (Fig. 2). Permanent implantation of an epidural spinal cord stimulator system (Precision TM; Boston Scientific Neuromodulation, Valencia, CA, USA) was performed one week later after the patient reported greater than 50% relief in her knee pain during the trial period.

After permanent implantation, the patient reported significant improvement in her left knee pain. Figure 3 demonstrates the area of paresthesia superimposed on the chronic area of left knee discomfort as drawn by the patient. Her program settings included: Amplitude of 4.9-5.1 milliamperes, a pulse width 400 microseconds, and a frequency of 70 Hertz. Contacts 5 and 6 were cathodes (56% of current on 5 and 44% on 6) and anodes were contacts 4,7,8 fractionalized as 8%, 55%, and 37% respectively. She was able to walk

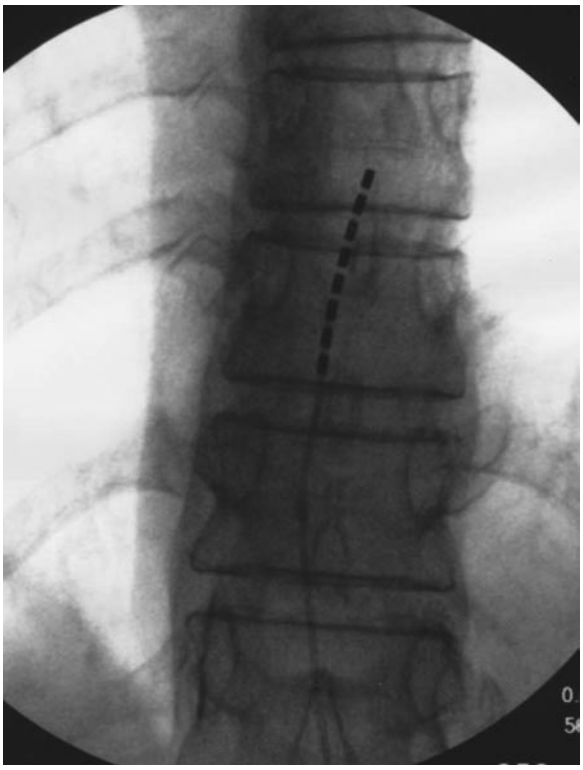

Fig. 2. *An 8-contact lead with the tip at the level of the base of the T9 vertebral body and just to the left of the spinous processes.*

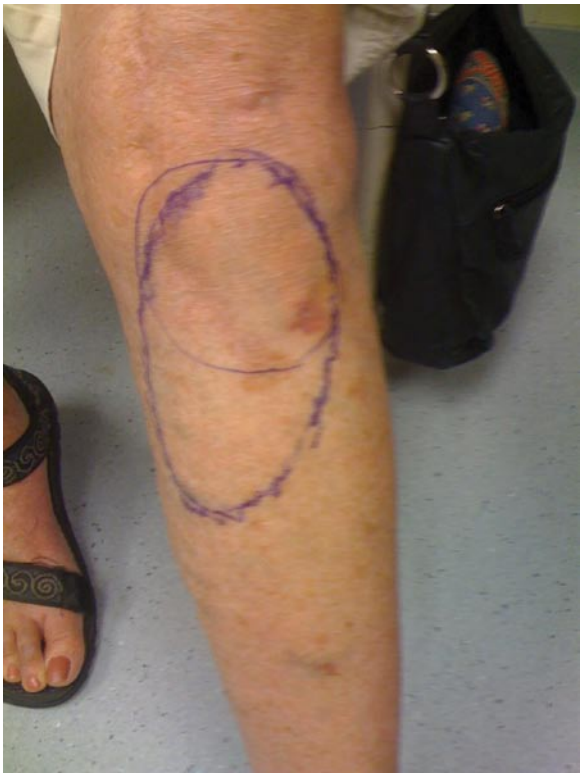

Fig. 3. *Paresthesia overlying the painful area after spinal cord stimulator implantation is indicated by the thick oval outline. The thin circle represents the painful area (Fig.1).*

with less discomfort and reported less pain with activities such as dancing following SCS implantation. The OKS performed 4 months and one year after permanent SCS implantations declined to 28 and 26 respectively. An OKS of 22 or less indicates satisfactory knee function without need for treatment (5). She continued to express satisfaction with her level of functioning and pain control one year after spinal cord stimulator implantation.

Discussion

In this case presentation, we report the successful use of spinal cord stimulation in the management of the neuropathic element of chronic knee pain following total knee replacement. The average OKS following knee replacement is 25 and patients who are satisfied with their outcomes average 22 (4). The OKS in unsatisfied patients averages 41 (4). Our patient's OKS did not fall into the range of satisfactory even with targeted paresthesia via a tightly spaced electrode and current fractionalization. This might reflect only partial relief of her neuropathic pain or that there is a significant component of chronic nociceptive pain. The lack of studies characterizing the nature of chronic pain post-TKR makes the management particularly challenging. Typically, these patients have exhausted medical, rehabilitative and interventional modalities for their pain. In addition, a failure to meet patient expectations following joint replacement surgery can further confound attempts at symptomatic improvement. Nonetheless, a comprehensive approach to patients' pain following TKR can aid in the recovery and improvement of their quality of life.

As in many patients with chronic knee pain following TKR, there was no definitive explanation for our patient's persistent discomfort. The prosthesis was functioning normally and there was no evidence of infection. A DN4 was used to help establish the presence of neuropathic pain. Our patient did not meet criteria for complex regional pain syndrome and did not develop a neuroma following her operation. The pain was in a wide circular pattern and did not fit the usual distribution of an infrapatellar nerve entrapment. The patient furthermore did not experience sensory loss in the distribution of the infrapatellar nerves or relief with anesthetic injection. Disruption of major articular nerves required for placement of the prosthesis might be the source of the chronic neuropathic pain. A significant predisposing risk factor for persistent pain in this case was the need for reoperation (6). The patient had her first surgery in 2003 that left her with chronic knee pain (approx age 63) and her second surgery just before her 65th birthday. After 3-6 months for healing, she has had chronic pain for 3 years thereafter. And at the time of presentation she was 68. Other potential risk factors leading to reduced satisfaction post TKR include female gender, age less than 65, diagnosis of osteoarthritis, and optimal physical health as evaluated by the American Society of Anesthesiologists (ASA) standards (4). The identification and minimization of risk factors for TKR revision may be an important step in reducing post-TKR pain and improving patient satisfaction following this operation.

Chronic pain associated with the TKR operation is likely to escalate as it is estimated that the operation will grow 601% by the year 2030 (3). According to large recent national surveys in the United Kingdom and Sweden, 81% of patients are satisfied with the outcome of their surgery (4,18). There remains a discrep-

ancy between patient and surgeon satisfaction after TKR (19). Orthopedic assessments have focused on objective outcomes such as knee stability and alignment, prosthetic survivorship, radiologic results and range of motion. Unfortunately, objective outcome measures such as range of motion have not correlated well to patient function and final outcome (12). In addition, as discussed earlier, recent analgesic strategies for postoperative pain control that enhance the ability to do immediate mobilization have failed to improve long-term outcome with respect to chronic pain and function (13). The overall implication is that there will be a greater need to develop effective pain management modalities for chronic post-TKR pain.

Spinal cord stimulation is a minimally invasive and reversible treatment option that is frequently employed as a last resort therapy. Because SCS can be trialed before implanted, it has an advantage when treating poorly understood chronic neuropathic pain conditions and it has a wide range of applications (20,21). Anterior thigh stimulation has been reported in the past to be very reliably achieved, and with current technology, focal paresthesia is possible as illustrated in this case (22). The physiological mechanisms of action for SCS have been slow to emerge and remain partially understood. In the alleviation of neuropathic pain, SCS activates the dorsal columns as its primary target both orthodromically and antidromically (20). The antidromic activity activates inhibitory GABAergic circuits in the dorsal horn that dampen central excitation (23). The ascending activity from SCS may activate a supraspinal neural loop that results in central inhibition from descending pathways (24). Whether these or other mechanisms are responsible for analgesia in humans is uncertain, but if the mechanism(s) of action of SCS therapy was better defined, then there would be potentially more insight into chronic pain post TKR. In addition, SCS therapy would be less underused as a whole, and it would likely improve in the arena of evidence-based medicine.

Conclusion

Patients with persistent knee pain following total knee replacement despite a normally functioning prosthesis can pose a management challenge. Conservative modalities such as medications and physical therapy should be utilized to maximize functionality and minimize risk to the patient. Interventional pain therapies such as nerve blocks can also be considered to palliate persistent pain symptoms. In those patients who fail to respond to conservative and interventional therapies, spinal cord stimulation may provide a viable option in the management of chronic neuropathic knee pain following total knee replacement.

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