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SHORT COMMUNICATION

Ultrasound-guided sciatic nerve pulsed radiofrequency for chronic knee pain treatment: a novel approach

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Abstract Chronic knee pain management with current nonpharmacological or pharmacological measures often has suboptimal results and significant side effects. Sciatic nerve pulsed radiofrequency (SNPRF) is an unexplored alternative for chronic knee pain management. We show a prospective short series of chronic knee pain patients managed with ultrasound-guided SNPRF. Visual analogue scale (VAS) was measured at baseline and 4 weeks after the procedure. The study included 25 elderly patients with severe knee pain. A total of 47 procedures were performed during a 3-month period. VAS scores showed a significant pain difference ($p < 0.001$) in successive comparison. No patient reported adverse events during the 1-month follow-up period. Ultrasound-guided SNPRF is a new approach for chronic knee pain management that leads to significant pain reduction in the short term. Randomized studies with adequate size, longer follow-up period, and appropriate evaluating tools are warranted to verify these preliminary data.

Keywords Chronic knee pain · Pulsed radiofrequency · Ultrasound-guided blockade

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Chronic knee pain is a common complaint in elderly patients. Most cases are caused by osteoarthritis (OA) [1], but there are other common causes such as rheumatoid arthritis, chronic posttraumatic pain, and chronic postsurgical pain [2]. Pharmacological therapy may offer limited benefit for chronic pain and is associated with serious side effects [3]. Although joint replacement is effective for patients with advanced disease [4], older individuals with significant comorbidities may not be appropriate surgical candidates.

A recently developed therapeutical option for some pain conditions is pulsed radiofrequency (PRF) [5]. To our knowledge, this is the first series describing percutaneous ultrasound-guided sciatic PRF for chronic knee pain management. The anatomy of the knee joint innervation (Fig. 1) is complex [6]. There are two differentiated areas, the anteromedial femoral-dependent branches and the posterolateral sciatic-dependent branches. Neuroablation of proximal major nerves (sciatic or femoral) with continuous radiofrequency (CRF) is not acceptable because of the resulting extensive motor weakness. Targeting terminal branches is technically difficult. The use of PRF upon proximal branches would be a feasible and secure issue with a straight-forward guidance method as ultrasound (Fig. 2), but it is necessary to demonstrate effective results and lack of side effects.

This prospective cohort study was conducted at the Pain Clinic of a University Hospital. All participants provided written consent, and the study was approved by the Institutional Ethics Committee. From January 1 to March 31, 2012, 25 patients with chronic knee pain were chosen. These patients had failed to respond to other conventional treatments including physiotherapy, oral analgesics, and intra-articular injection of hyaluronic acid or steroids. The exclusion criteria were acute knee pain, serious neurological or psychiatric disorders, and patients unable to lay prone.

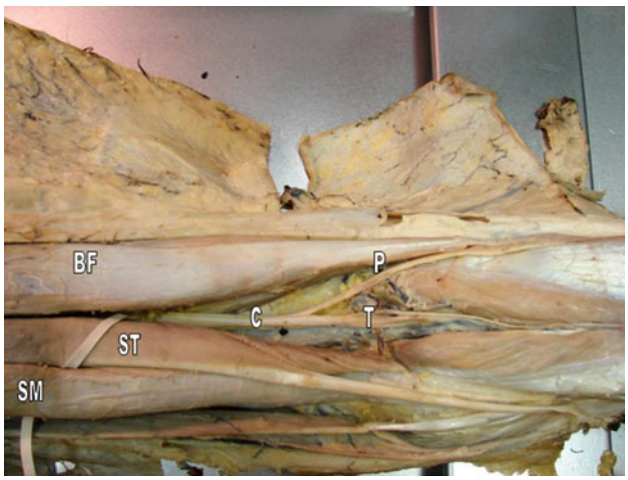

Fig. 1 Anatomic dissection of leg. Posterior view. *BP* biceps femoral muscle, *ST* semitendinous muscle, *SM* semimembranous muscle, *C* sciatic nerve, *P* peroneal nerve, *T* tibial nerve

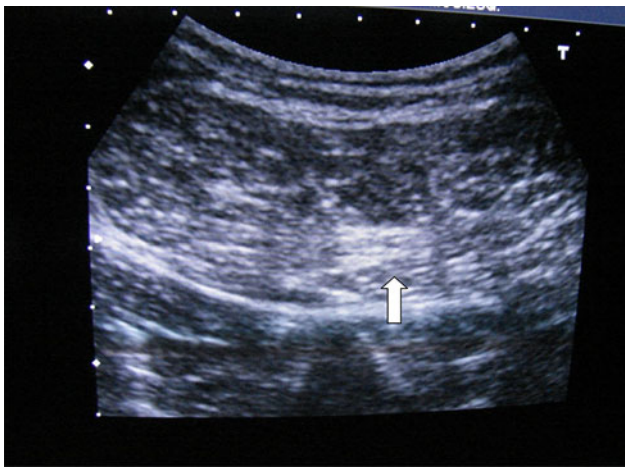

Fig. 2 Ultrasound view of sciatic nerve (*arrow*)

All examinations were performed by the same physician, experienced in ultrasound blockade guidance. The patients were placed in bed in prone position, with a pillow under their feet. A scout scanning was performed on the posterior surface of the thigh with a 3- to 6-MHz probe. The sciatic nerve was identified just before the division to tibial and peroneal branches. The field and the probe were prepared in sterile fashion and the skin and soft tissues anesthetized with 1 % lidocaine.

A 10-cm-long, 23 Fr. radiofrequency cannula with a 5-mm active tip (Cosman CR-10 P) was used for the technique. Under sonographic guidance, the cannula was advanced percutaneously along the long axis toward the sciatic nerve area. Motor stimulation at 2 Hz and 0.4 V was used to identify the appropriate motor response (dorsoflexion of the ipsilateral foot). At this point, a radiofrequency generator (Cosman G 4) was activated in the PRF program at 45 V during 480 s per local protocol.

The main outcome was pain improvement attributable to the procedure walking and at rest. It was measured by the patients pinpointing across a colored ruler scaled 0–100 mm, according to the visual analog scale (VAS) score, before the procedure and 28 days later, during the follow-up visit.

Quantitative variables were presented as mean and standard deviation, and qualitative variables as number and percentage. We considered a significance level of 95 % ($p = 0.05$). Student's t test for paired variables was used for quantitative variable analysis and the chi-square test for qualitative variables. In some cases the Pearson r correlation was calculated. The statistical package 18 PASW (SPSS, Chicago, IL, USA) was used.

A total of 47 procedures were performed in 25 patients. The technique was carried out on the right knee in 27 cases and on the left in 20 cases. Most of the knees (38) were diagnosed with OA, 7 had a previous knee joint replacement, and 2 suffered posttraumatic pain. The characteristics of the population and procedures are summarized in Table 1. The average VAS difference before and after the procedures was 27 mm (81 ± 7 vs. 54 ± 17; t test, $p < 0.001$) walking and 11 mm at rest (43 ± 18 vs. 32 ± 15; t test, $p = 0.06$) (Table 1). Only 3 of the patients whose pain improved after the procedure evaluated their improvement as <30 mm. There were 10 failed procedures (the same VAS score pre- and post procedure). There were no significant differences ($p = 0.06$) as to the pain cause of these failed cases (20 % joint replacement and 80 % OA) compared to the successful cases (15 % and 81 %,

Table 1 Population and procedure

Age, mean ± SD	70.6 ± 9.7	
Gender	*n* (%)	
Male	6 (12.8)	
Female	41 (87.2)	
Side	*n* (%)	
Right	27 (57.4)	
Left	20 (42.6)	
Diagnosis	*n* (%)	
Osteoarthritis	38 (80.9)	
Chronic postsurgical	7 (14.9)	$p = 0.06$
Chronic posttraumatic	2 (4.3)	
Current intensity (mA), mean ± SD	87.1 ± 40.8	Correlation (r) = 0.15
Resistance (Ω), mean ± SD	625 ± 146	
Voltage (V), mean ± SD	0.33 ± 0.17	
Visual analogue scale (mm), mean ± SD		
Pre-procedure walking	81 ± 7	$p = 0.001$
Post-procedure walking	54 ± 17	
Pre-procedure at rest	43 ± 18	$p = 0.06$
Post-procedure at rest	32 ± 15	

respectively). There was no correlation of the VAS improvement with the intensity of the current ($r = 0.15$) or the impedance ($r = 0.14$).

No motor or sensory side effects and no improvement of joint range of motion were noticed by basic clinical examination during the 4-week follow-up period. Only five patients achieved a 20 % improvement in walking distance, but this was difficult to assess because of coexisting medical conditions and the presence of contralateral disease. No rehabilitation was provided during those 4 weeks. The patients were instructed to not change the antiinflammatory drug dose during that period of time. No rescue opiate-containing compounds (including codeine) were used by the patients.

Our patient population significantly improved their average VAS score by 27 mm 4 weeks after the procedure. Ten of our procedures were ineffective. It should be expected a considerable consistency in the outcome within each diagnostic group, i.e., pain relief may be slightly better or worse, but you should not expect a total absence of *relief*. One possible explanation is that there is a percentage of failed technique itself. On the other hand, knee is a joint whose innervation is rather complex. Branches of the femoral and the obturator nerves innervate anteromedial aspects of the joint. The common peroneal and tibial nerves, branches of the sciatic nerve, innervate the posterior and lateral aspects. The terminal intracapsular branches are the six genicular nerves. Three come from the tibial nerve on the medial side and two from the peroneal nerve on the lateral side, accounting for the five branches that belong to the posterolateral innervation. The sixth genicular nerve originates from the obturator nerve, which belongs to the anteromedial innervation of the joint. The femoral, saphenous, and obturator afferences were not covered by our procedure, but the contribution of these nerves to the intracapsular innervation is theoretically marginal [6]. It is possible to miss an involved area when you attempt one single nerve blockade. To preserve the integrity of the neural structures, we targeted the sciatic nerve with a PRF technique instead of approaching the genicular branches with a CRF technique. At the same time, our choice allowed us to cover a large intracapsular sensory area, increasing therefore the efficacy rate. Despite this intention, we were unable to match the remarkable results of Choi et al. [7] using CRF upon genicular branches (45/100 mm improvement compared to our 27/100). Our topographic findings oppose those described by Akbas et al. [8], who used PRF in a large series targeting the saphenous nerve. They found a beneficial period of at least 6 months. Whether a double access, posterolateral plus anteromedial, can improve the effectiveness of PRF for knee joint pain should be evaluated by further controlled studies. *Chronic knee pain* is a wide generic designation. Different areas could be involved in different patients. It may be necessary to target specific genicular nerve areas for specific patients when the CRF technique is chosen. CRF for chronic knee pain has been studied in a randomized, double-blind trial [7] targeting genicular branches and showing a remarkable efficacy and safety profile according to the data. In some cases, an approach involving a single large nerve may be insufficient. It would be reasonable and suitable to combine a PRF technique for an extensive area with a more specific genicular branch CRF neurotomy. The transcutaneous PRF approach has been successfully attempted with limited benefit (19/100 improvement of VAS score at 4 weeks) [9]. It has also been tried as an intraarticular approach with a slightly better result (22/100 VAS improvement at 4 weeks) [10]. Our percutaneous approach with ultrasound guidance technique was more effective (27/100 at 4 weeks) than these other PRF approaches. The ultrasound-guided approach that we used has been shown to be more effective than the electrical neurostimulation guidance [11].

Additional safety evidence has been claimed by Kvarstein [12] before radiofrequency knee pain recommendations can be issued. In our series no patient reported postprocedural adverse events, neither motor deficit nor sensitivity, during the 1-month follow-up period. Clinical studies describe PRF treatment as a technique without any visible neurological deficits [13]. The few available histological studies are contradictory: some describe no signs of cellular damage and some demonstrate visible intracellular modifications [14]. PRF applied to the afferent axon of the sciatic nerve of rats has produced microscopic damage in the internal ultrastructural components of the axons, as abnormal cellular membranes, abnormal mitochondrial morphology, and disruption–disorganization of cytoplasmatic microfilaments and microtubules. The damage appears to be more intense for amyelinated C-fibers than for A-delta and A-beta myelinated fibers [15]. This finding suggests that PRF would be particularly useful in conditions with significant neuropathic involvement such as chronic postsurgical and posttraumatic knee pain.

Our cohort study shows preliminary evidence concerning the efficacy of sonographic-guided sciatic nerve pulsed radiofrequency (SNPRF) for chronic knee joint pain treatment. However, our intention was not to provide strong evidence. The functional benefit was not addressed with an appropriate tool, and the effective time period that followed our study was insufficient. No control group was available. Appropriately sized randomized studies are necessary to show the possible efficacy of PRF for chronic knee pain. Longer follow-up periods and detailed functional information are necessary to rule out adverse effects.

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