

Percutaneous Radiofrequency Denervation in the Treatment of Hip Pain Secondary to Osteoarthritis

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Abstract

Yearly 500,000 hip replacements are done in USA. Common reasons to avoid it include younger patients and serious comorbidities.

Retrospective study June 1998-July 2014. 131 osteoarthritic patients refused by Orthopedic Surgeons for arthroplasty underwent anesthetic block of hip obturator branches. 91 (69.46%) showing significant pain improvement underwent radiofrequency thermo-coagulation of these branches, ages 56 - 83yrs (mean 71.95 ± 6.21 SD yrs.), 39 males/52 females. 40 (30.53%) with no pain improvement underwent further conservative treatment. Outcome evaluation: VAS, WOMAC, NSAID's and OME consumption. Follow-up: 1, 6, 12 and 24 months, and at year intervals until relapse, arthroplasty or death. Bad outcomes: no pain improvement or recurrence in < 6 months.

Results: Follow-up 24 months-8 yrs. (mean 3.91 ± 1.67 SD yrs.). Marked improvement in 72 patients (79.12%). VAS preop 8.2±0.84SD; postop 2.53 ± 0.76 SD 1 month, 2.40 ± 0.78 SD 6months, 3.82 ± 1.27 SD 12 months and 5.07 ± 1.61 SD 24 months. WOMAC pain 16.10 ± 2.15 SD pre-op, post-op 3.72 ± 1.44 SD 1 month, 3.56 ± 1.2 SD 6 months, 5.1 ± 2.12 SD 12 months and 8.36 ± 4.54 SD 24 months. NSAID'S consumption, pre-op 2.78 ± 0.41 SD; postop 1.67 ± 0.74 1 month, 1.44 ± 0.95 6 months, 1.55 ± 0.86 SD 12 months and 1.78 ± 0.74 24 months. Opioid consumption pre-op 20.74 ± 30.23 SD, post-op 9.34 ± 17.28 1 month, 8.60 ± 23.23 SD 6 months, 6.63 ± 16.59 SD 12 months and 12.50 ± 32.83 SD 24 months. No changes after two years. No complications seen.

Conclusion: Percutaneous radiofrequency denervation may provide pain relief when hip arthroplasty is not advisable.

Keywords: Chronic Hip Joint Pain; Hip Osteoarthritis; Hip Joint Denervation; Treatment of Chronic Hip Pain; Radiofrequency Hip Joint Denervation

Perspective

Open hip joint denervation has been performed for over 50-years. The results were poor and fell into disrepute. Percutaneous selective hip joint denervation is well tolerated and provides good pain relief in most patients. Can be performed to old and infirm people, under local anesthesia and as an ambulatory procedure.

Abbreviations

VAS: Visual Analogue Scale to Report Pain Intensity; WOMAC: Western Ontario and McMaster Universities Arthritis Index; NSAID: Non-Steroidal Anti-Inflammatory Drug; OME: Oral Morphine Equivalent

Introduction

Total hip arthroplasty (THA) is often performed in patients suffering severe pain and disability due to osteoarthritis of the hip, inflammatory or rheumatoid arthritis and avascular necrosis. More than 500 thousand total hip replacements are done yearly in USA [21] and 400 total hip replacements per 105 inhabitants and year are performed in Sweden [26]. That means that for the whole European Union with 350 million people, we should expect 1.4 million hip replacements per year. Severe pain secondary to hip osteoarthritis represents the most common indication followed by inflammatory or rheumatoid arthritis and avascular necrosis [21,30]. Common reasons to avoid surgery include younger patients and co-morbidities that may increase the risk of per-operative complications [32].

Sensory supply of the hip joint is provided by articular branches coming from obturator, femoral and sciatic nerves [4,8] and by the lumbar sympathetic plexus [3,4]. The main sensory distribution to the hip comes from the articular branches of the obturator nerve and the nerve to the quadratus femoris [18]. Groin pain with hip flexion is the main patients' complaint, mostly conveyed through the obturator nerve. Selig [35] in 1912 described the open surgical resection of this nerve to treat hip osteoarthritic pain. A large proportion of these patients complained of pain in the posterior area of the hip, Tavernier [39] sectioned both the obturator and the quadratus femoris nerves. This technique became commonplace [27], but increasing numbers of unsatisfactory results prompted its abandonment [11,18]. Others found effective the infiltration of the obturator and quadratus femoris nerves effective but short-lasting [10,12]. To obtain a longer lasting pain relief percutaneous radiofrequency lesion of the obturator nerve trunk where it exits from the obturator canal was performed to obtain longer lasting pain relief [2,30]. Unfortunately, weakness of the adductor muscles and sensory loss at the inner aspect of the thigh were reported [2]. To minimize these side-effects, more selective approaches have been tried [20,32,42]. Following this trend, we selectively lesioned the sensory branches of the obturator nerve to the hip joint. As this nerve leaves the obturator canal it divides into anterior and posterior branches [3] (Figure 1). The anterior branch supplies articular innervation to the hip joint and other branches to the adductor longus, pectineus and gracilis muscles (Figure S1). The posterior branch supplies the obturator externus, adductor magnus and brevis muscles as well as an articular branch to the knee joint (Figure S2). We aimed a selective lesion of the hip joint articular branch coming from the obturator's nerve anterior branch.

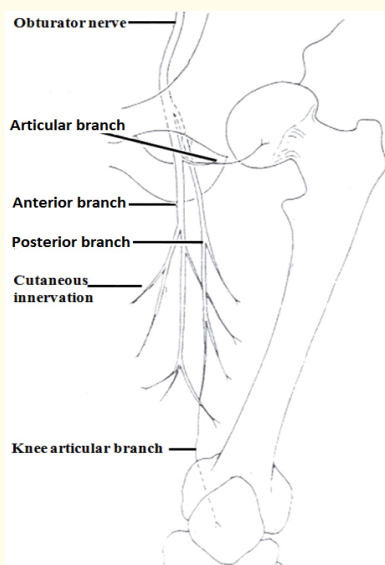


Figure 1: sketch of the obturator nerve and its branches.

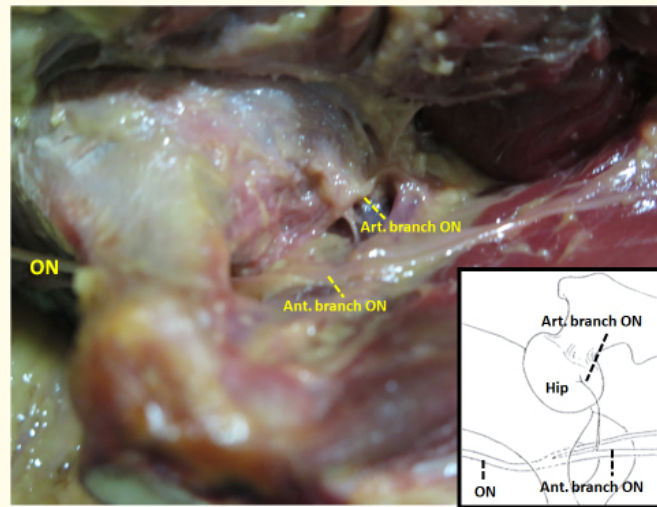


Figure S1: the pubic ramus has been removed, exposing the obturator canal. ON (obturator nerve), Ant. branch ON (anterior branch obturator nerve). Art. branch ON (articular branch obturator nerve), Post. branch ON (posterior branch obturator nerve), HF (femoral head), HJC (hip joint capsule).

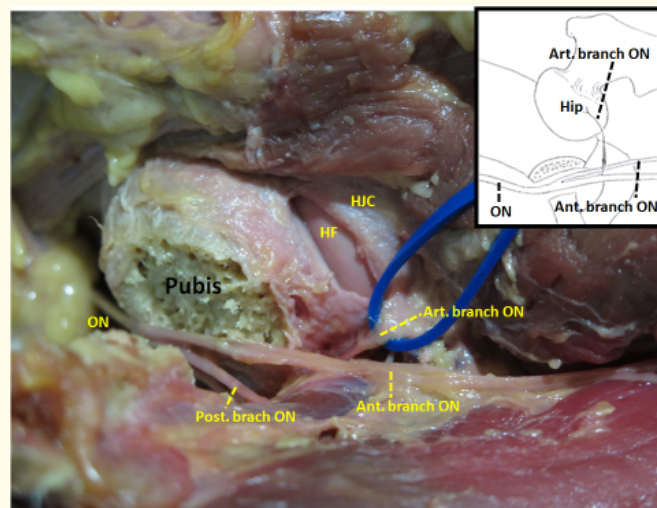


Figure S2: above, sketch of the obturator nerve and its branches. Below, anatomical preparation of the obturator nerve (ON) and its branches. Ant. branch ON (anterior branch obturator nerve). Art. branch ON (articular branch obturator nerve).

In this retrospective study, we present the results of a large patients' series treated with selective radiofrequency lesion of the obturator's nerve articular branch.

Patients and Methods

Patients

Retrospective study including 131 hip osteoarthritic patients refused for arthroplasty included from June 1998 to July 2014. A hip AP X-ray confirmed the diagnosis of hip osteoarthritis. Patients filled a questionnaire about underlying diseases, previous surgical proce-

dures, pain characteristics (on walking and/or at night), previous treatments and NSAID's (Non-Steroidal Anti-Inflammatory Drugs) and opioid intake. These patients initially received an anesthetic block of the hip joint branches of the obturator nerve to evaluate the response to pain improvement and depending on the results achieved a radiofrequency thermocoagulation of said obturator nerve branches was considered.

A week after the anesthetic block, those patients reporting over 50% pain improvement for the time in which the local anesthetic agent was active (2hours), were considered candidates for the procedure of percutaneous obturator's nerve hip joint branches radiofrequency denervation. All the patients included in this study satisfied these criteria before the radiofrequency denervation.

Inclusion Criteria (Figure 2): 1) Chronic hip pain (groin) due to osteoarthritis with radiographic Tönnis grades I and II [40], refractory to conservative treatment when the Orthopedic Surgeons found the arthroplasty not indicated. Reasons for refusal in younger patients were lack of concordance between pain intensity and radiological hip osteoarthritis, and severe co-morbidities with poor general status in older patients. All patients suffered only from chronic osteoarthritis, other conditions such as Paget's or metastatic disease of the hip joint and neurological disorders were excluded. 2) Pain improvement of at least 50% after the anesthetic block.

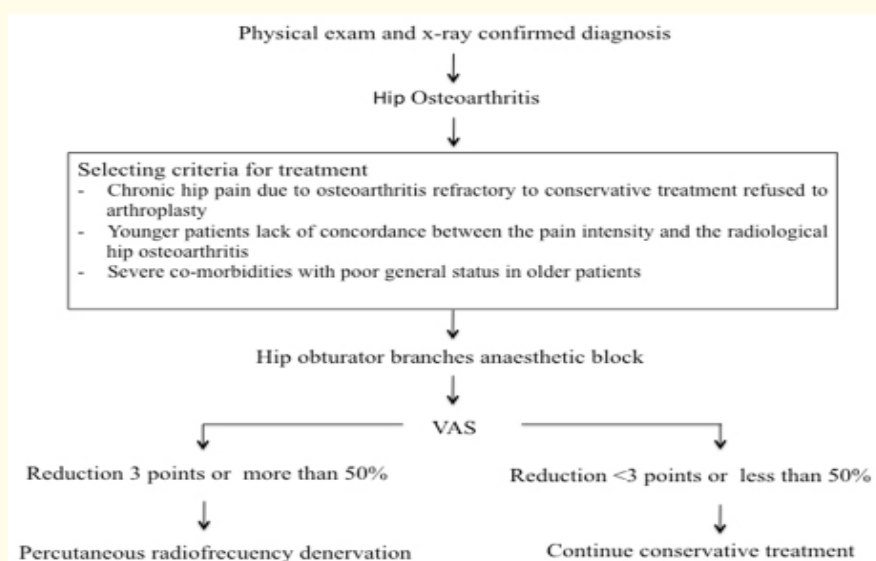


Figure 2: inclusion criteria.

Description of the procedure

The nerve block was performed under radiosopic guidance with patients in the supine position and sedated by and anesthesiologist with Propofol (0.5 mg/kg/h). Lignocaine 2% was used at the puncture site. The light sedation was used to facilitate patients remaining still until the needle was in place. We only injected local agent in the skin and not in the needle tract to avoid confusion with the results of the anesthetic block of the obturator's nerve hip branches with the unintended anesthetic block of the main trunk of the obturator nerve. The pubic tubercle and femoral artery pulse were palpated and a mark made halfway between the two, about 2 - 3 cm below the inguinal ligament. When location was not clear (e.g. obese patients) ultrasound guidance was used to locate the femoral nerve and vessels to avoid damaging them. Ultrasound guidance was not used regularly, only when the physician felt uncomfortable to do it only with X-ray guidance and palpating the femoral pulses. A Neurotherm, KC, Cosman® 20G 145 mm long needle with a 10 mm un-isolated tip was inserted in the point previously marked and its tip placed in the angle between the superior pubic and the ischia-iliac rami, at the same site where later the radiofrequency lesion would be performed in case of good response. This point has a teardrop shape on AP fluoroscopic imaging (Fig-

ure 3). Electrical stimulation with a Cosman® Radiofrequency Generator (Burlington, Massachusetts, USA) was performed at 0.4 - 0.6V at 50 Hz, 1 msec (sensory testing) and less than 0.9V at 2Hz, 1 msec (motor testing) to exclude proximity to the obturator nerve trunk. The needle was repositioned more laterally, in case the adductor muscles contracted. After aspiration, ruling out intravascular injection, 2 ml of 2% mepivacaine were injected and the needle withdrawn. No intra-articular anesthetic agent injection was performed. One week later, patients were asked to report in a VAS (Visual Analogue Scale) the pain relief noticed after the infiltrations as well as its duration. Patients had not been reviewed earlier, allowing them to see the effects of the block on their normal lives. Only those reporting at least a 50% VAS improvement were considered for radiofrequency thermocoagulation while the others were sent back for further conservative treatment. Only a single anesthetic block was considered as, in case of failure, patients were treated with oral medication (including opioids when needed), physiotherapy if applicable and the recommendation to avoid walking. Some patients requested to be re-considered for a hip replacement and in these cases a strict diet program was introduced to reduce the body weight to a BMI below 25%, aiming to reduce the peri-procedural risks.

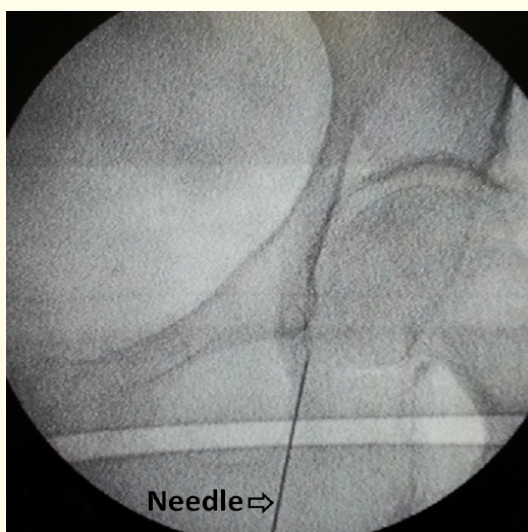


Figure 3: x-ray showing position of the needle for the anesthetic block.

For the radiofrequency lesioning the same technique was followed, including the light sedation provided by an anesthesiologist. Under fluoroscopic guidance the tip of the needle (Neurotherm, KC, Cosman® 20G 145 mm long needle with a 10 mm un-isolated tip) was placed at the junction of the pubic and ischia-iliac rami (Figure 4). As in the anesthetic block performed earlier, electrical stimulation with a Cosman® Radiofrequency Generator (Burlington, Massachusetts, USA) was performed at 0.4 - 0.6V at 50 Hz, 1 msec (sensory testing) and less than 0.9V at 2Hz, 1 msec (motor testing) to disregard proximity to the obturator nerve trunk. This step was essential to avoid nervous damages that could induce sensory anesthesia, neuropathic deafferentation pain or motor nerve damage that could induce weakness of the adductor muscles. Once in a safe position, two consecutive thermocoagulation lesions were made at 900C for 120" varying briefly the position of the needle. Patients were continuously monitored for any signs of discomfort. On finishing the procedure, the radiofrequency cannula is removed and a bandage applied. After the I.V. Propofol effect weaned off, patients were sent home under a friend or relative surveillance.

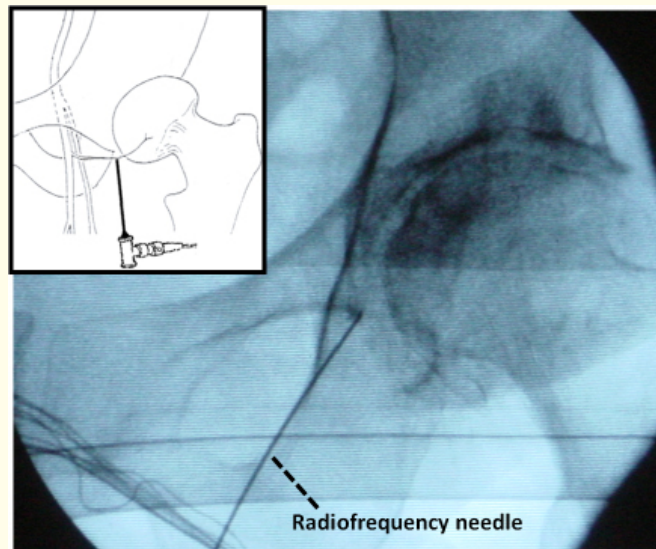


Figure 4: For the articular branch lesioning a Neurotherm, KC, Cosman® 20G 145 mm long needle with a 10 mm un-isolated tip and radiofrequency TIC electrode is placed at the junction of the pubic and ischia-iliac rami.

Result evaluation: Results were evaluated pre-op radiofrequency treatment and post-op radiofrequency treatment at each follow-up visit with the VAS-score and WOMAC (Western Ontario and McMaster Universities Arthritis Index) scales, as by the NSAID's and opioid (Oral Morphine Equivalents, OME) consumption. Patients were enquired for any sensory loss, dysesthesia or hip weakness that they might notice. Sensation was tested by rubbing the area with a piece of cotton ball and with a disposable needle. Motor strength was tested by asking patients to resist hip abduction. A plain AP pelvic X-ray was ordered at each follow-up visit to evaluate the evolution of the hip arthritic changes. Patients were reviewed post-op radiofrequency treatment at 1, 6, 12 and 24 months and afterwards at year intervals until relapse, hip prosthesis surgery or death. Bad outcomes were reported as those that noticed no pain improvement or with pain recurrence in less than 6 months.

NSAID's consumption was calculated in accordance with Harden., *et al.* 2005 [16] and Gallizzi., *et al.* 2008 [15]. Oral morphine equivalents were calculated in accordance with an online opioid dose calculator from the State of Washington [1].

Statistical analysis was performed by a professional statistician using both Excel (Microsoft Corporation, Redmond, WA, USA) and SPSS, Version 22 (Chicago, IL), conducting a basic descriptive analysis based on the calculation of the mean, median, standard deviation and range. The Wilcoxon test with 95% confidence interval was used to compare between groups and to see the evolution of each variable over time. Oral morphine equivalents were compared using the Kruskal-Wallis test.

Results

From June 1998 to July 2014, 131 patients underwent an anesthetic block with mepivacaine of the obturator branches for the hip joint. Patients' flow chart is depicted in Figure 5. Out of them, the 91 (69.46%) who showed a marked improvement of their pain (mean VAS reduction $\geq 50\%$) were submitted to percutaneous radiofrequency thermocoagulation of the obturator nerve branches. Their demographic characteristics are shown in Table 1. In this group, age ranged from 56 to 83 years, mean 71.91 ± 6.21 SD years (range 56 to 83 yrs.), with 39 males and 52 females. IMC 33.83 ± 4.75 SD (range 19.85 to 34.89%). The 40 patients (30.53%) who showed a pain improvement of less than 50% were sent back for further conservative treatment. The mean time with hip pain spent with pain before the anesthetic block was 3.63 ± 1.46 SD years (range 1 to 7 years). The mean time of pain relieve with the anesthetic hip block was 4.71 ± 3.56 SD days (range 1 to 17 days).

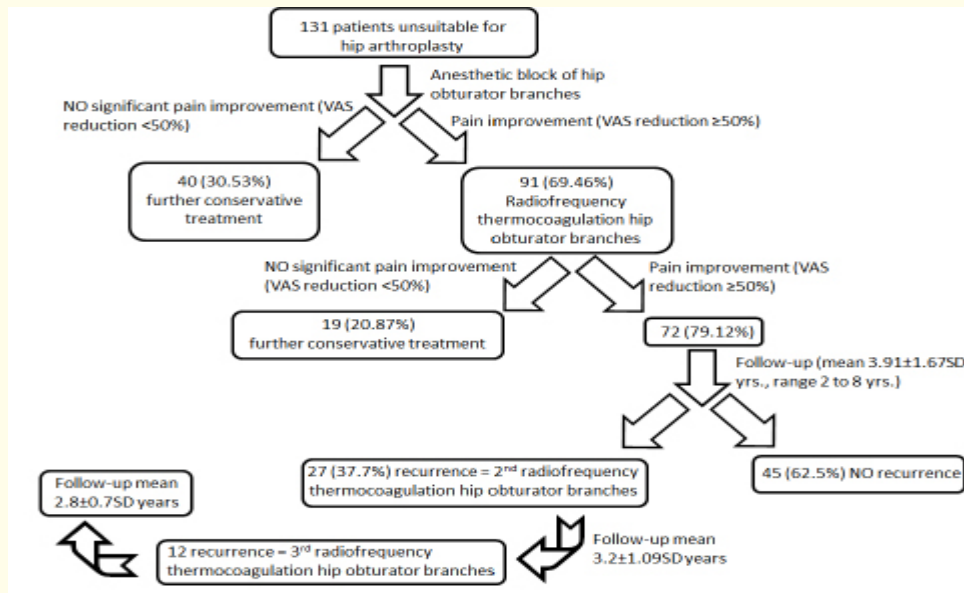


Figure 5: Patients' flow chart.

	Number of patients 91	Mean	Standard Deviation	Range
Age (years)		71.91	6.21	56 - 83
IMC (%)		33.83	4.75	19.85 - 34.89
Time with hip pain before anesthetic block (years)		3.63	1.46	1 - 7
Time pain relieve after anesthetic block (days)		4.71	3.56	1 - 17

Table 1: Demographic characteristics of patients.

Follow-up after radiofrequency hip obturator nerve branches 2 - 8 yrs. (mean 3.91 ± 1.67 SD yrs., range 2 to 8 yrs.). Pain improvement 50% or higher in 72 patients (79.12%). VAS pre-op 8.2 ± 0.84 SD; post-op radiofrequency treatment 2.53 ± 0.76 SD at 1 month, 2.40 ± 0.78 SD at 6 months, 3.82 ± 1.27 SD at 12 months and 5.07 ± 1.61 SD at 24 months) (Figure 6). WOMAC pain 16.10 ± 2.15 SD (range 12 to 20) pre-op radiofrequency treatment, 3.72 ± 1.44 SD (range 0 to 7) at 1 month post-op radiofrequency treatment, 3.56 ± 1.2 SD (range 2 to 8) at 6 months post-op radiofrequency treatment, 5.1 ± 2.12 SD (range 2 to 11) at 12 months and 8.36 ± 4.54 SD (range 3 to 19) at 24 months post-op radiofrequency treatment (Figure 7). NSAID'S consumption per day, pre-op 2.78 ± 0.41 SD; post-op radiofrequency treatment 1.67 ± 0.74 at 1 month, 1.44 ± 0.95 at 6 months, 1.55 ± 0.86 SD at 12 months and 1.78 ± 0.74 24 at months (Figure 8). Opioid consumption measured as Oral Morphine Equivalents (OME) pre-op radiofrequency treatment 20.74 ± 30.23 SD (range 0 to 202,5 OME) reduced post-op radiofrequency treatment to 9.34 ± 17.28 (range 0 to 120 OME) at 1 month post-op, 8.60 ± 23.23 SD (range 0 to 180 OME) 6 months post-op, 6.63 ± 16.59 SD (range 0 to 95.9 OME) at 12 months post-op and 12.50 ± 32.83 SD (range 0 to 202.5 OME) at 24 months post-op (Figure 9). No changes were seen after two years.

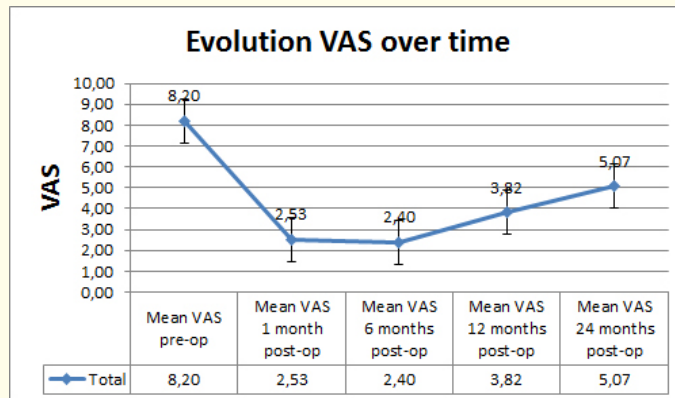


Figure 6: Mean VAS in the pre-op radiofrequency treatment and post-op radiofrequency treatment at 1, 6, 12 and 24 months.

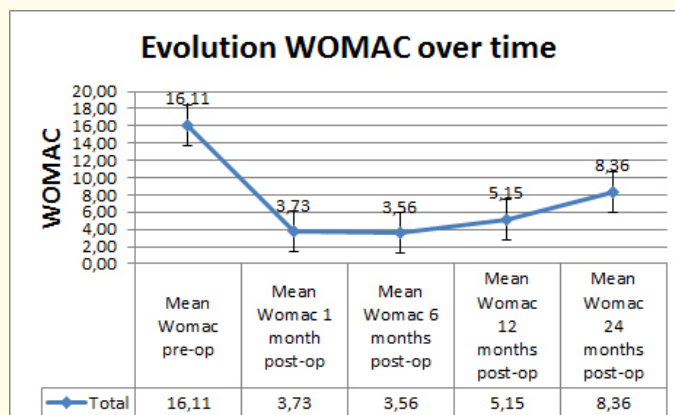


Figure 7: Mean WOMAC in pre-op radiofrequency treatment and post-op radiofrequency treatment at 1, 6, 12 and 24 months.

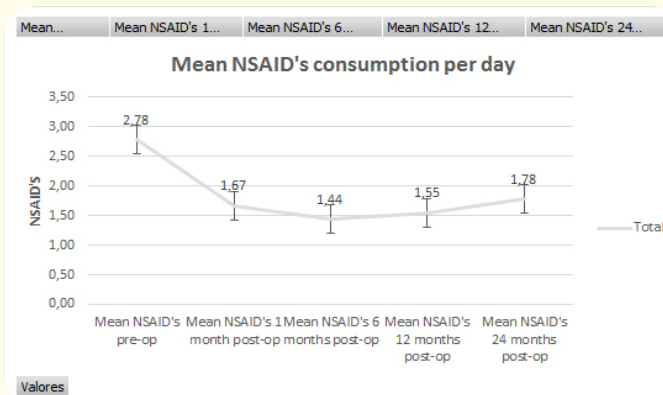


Figure 8: NSAID's consumption in pre-op radiofrequency treatment period and post-op radiofrequency treatment at 1, 6, 12 and 24 months.

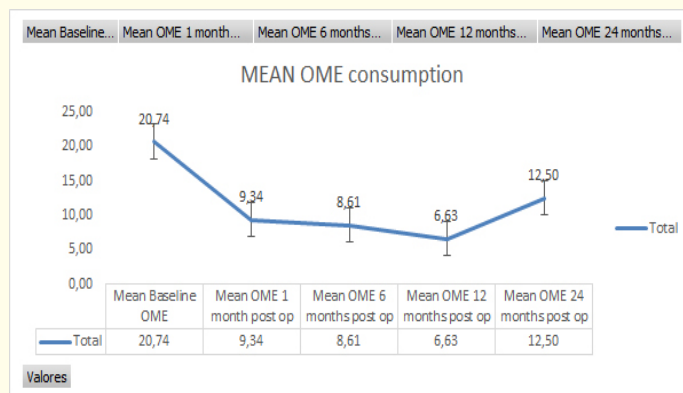


Figure 9: OME consumption in pre-op radiofrequency treatment period and post-op radiofrequency treatment at 1, 6, 12 and 24 months.

On the Wilcoxon test, there were statistically significant differences, 95% confidence interval, between pre-op radiofrequency treatment and post-op radiofrequency treatment VAS at 1 month ($Z = -8.409$; $p < 0.05$; $r = -0.881$), at 6 months ($Z = -8.419$, $p < 0.05$; $r = -0.882$) at 12 months ($Z = -8.351$, $p < 0.05$; $r = -0.875$); and at 24 months ($Z = -8.122$, $p < 0.05$; $r = -0.851$) (Table 2). The largest reductions in the VAS happened at 1 (-69.19%) and at 6 months (-70.77), while at 12 (-53.35%) and 24 months (-38.20%) the VAS also decreased but showed a trend towards recovery (Table 3, Figure 6). Statistically significant differences were found, 95% confidence interval, between the pre-op radiofrequency treatment and post-op radiofrequency treatment VAS at 1, 6, 12 and 24 months among both older and younger than 70 years old (Table S1, Figure S3), and between men and women (Table S2, Figure S4). The VAS improved from the baseline especially in the first post-op radiofrequency treatment months, this improvement being smaller with the passage of time. With respect to age, the improvement in the VAS was higher for patients ≥ 70 years at the post-op radiofrequency treatment 1 and 6 months, being this VAS improvement bigger at 12 and 24 months (Table S3). With respect to gender the improvement in the VAS was similar among men and women post-op radiofrequency treatment at 1 and 6 months, being somewhat higher in women at 12 and 24 months (Table S4).

Number of patient of the study	131
Patients with positive response anesthetic block	91
Patients radiofrequency with hip joint denervation	91
Age patients	72.7yr (range 56 - 83)
Gender (M/F)	39/52
Time follow-up	7.5yr (range 12 mo-11yr)
Patients dead on follow-up	37 (51.38%)
Patiens good results	72 (79.12%)
Duration pain relieve	5.3yr (range 4 - 9)
Repeat denervation	27 (37.5%)

Table 2: Wilcoxon test, dependent samples, for pain measured in the VAS analogue scale.

	VAS	Harris Hip Score	WOMAC Pain	WOMAC Stiffness	WOMAC Function	WOMAC Total Score	Walking Distance	NSAID's % Reduction
Base Line								
Pre-Denervation	7.6 ± 1.35SD	36.2 ± 11SD	44.3 ± 1.2SD	42.2 ± 1.4SD	37.6 ± 1.8SD	41.3	98 ± 27SD	
1 Month Post Denervation	3.1 ± 1.2SD	78 ± 14SD	87.3 ± 1.2SD	82.2 ± 1.1SD	79.4 ± 1.2SD	83.4	253 ± 47SD	82.9 ± 10.3SD
6 Month Post Denervation	3.8 ± 1.4SD	74 ± 11SD	86.3 ± 1.2SD	81.3 ± 1.1SD	77.4 ± 1.3SD	82.1	241 ± 33SD	76.3 ± 11.8SD
12 Month Post Denervation	4.1 ± 1.1SD	71 ± 9SD	85.2 ± 1.0SD	79.1 ± 1.3SD	76.6 ± 1.2SD	80.3	227 ± 17SD	68.2 ± 12.4SD
24 Month Post-Denervation	4.5 ± 1.3SD	68.5 ± 12SD	78.3 ± 1.1SD	73.1 ± 1.1SD	70.3 ± 1.0SD	77.4	211 ± 14SD	62.7 ± 9.3SD

Table 3: VAS evolution: from pre-op radiofrequency treatment to post-op radiofrequency treatment at 1, 6, 12 and 24 months.

Age ≥ 70						
	Cases	Mean positive range	Mean negative range	Z	p-value	Effect size (r)
Pre-op VAS – VAS 1 month post-op	32	16.5	0	-4.99	<0.05	-0.882
Pre-op VAS – VAS 6 months post-op	32	16.5	0	-4.992	<0.05	-0.882
Pre-op VAS – VAS 12 months post-op	32	16.5	0	-4.969	<0.05	-0.878
Pre-op VAS – VAS 24 post-op	32	16.5	0	-4.965	<0.05	-0.877
Age < 70						
Pre-op VAS – VAS 1 month post-op	59	30	0	-6.814	<0.05	-0.887
Pre-op VAS – VAS 6 months post-op	59	30	0	-6.830	<0.05	-0.889
Pre-op VAS – VAS 12 months post-op	59	30	0	-6.761	<0.05	-0.880
Pre-op VAS – VAS 24 months post-op	59	30	0	-6.466	<0.05	-0.842

Table S1: Wilcoxon test, dependent samples, VAS per age (years).

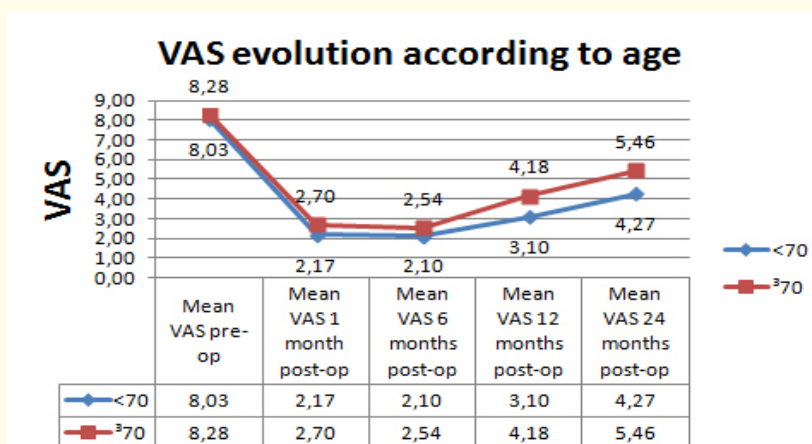


Figure S3: Mean VAS by age (years) pre-op radiofrequency treatment and post-op radiofrequency treatment at 1, 6, 12 and 24 months, depending on age under or over 70 years old.

MALES						
	Cases	Mean positive range	Mean negative range	Z	p-value	Effect size (r)
Pre-op VAS – VAS 1 month post-op	39	20	0	-5.552	<0.05	-0.889
Pre-op VAS – VAS 6 months post-op	39	20	0	-5.529	<0.05	-0.885
Pre-op VAS – VAS 12 months post-op	39	20	0	-5.475	<0.05	-0.877
Pre-op VAS – VAS 24 months post-op	39	19.88	5.5	-5.324	<0.05	-0.852
FEMALES						
Pre-op VAS – VAS 1 month post-op	52	26.5	0	-6.355	<0.05	-0.881
Pre-op VAS – VAS 6 months post-op	52	26.5	0	-6.376	<0.05	-0.884
Pre-op VAS – VAS 12 months post-op	52	26.5	0	-6.342	<0.05	-0.879
Pre-op VAS – VAS 24 months post-op	52	26.5	0	-6.151	<0.05	-0.853

Table S2: Wilcoxon test, dependent samples, VAS per gender.

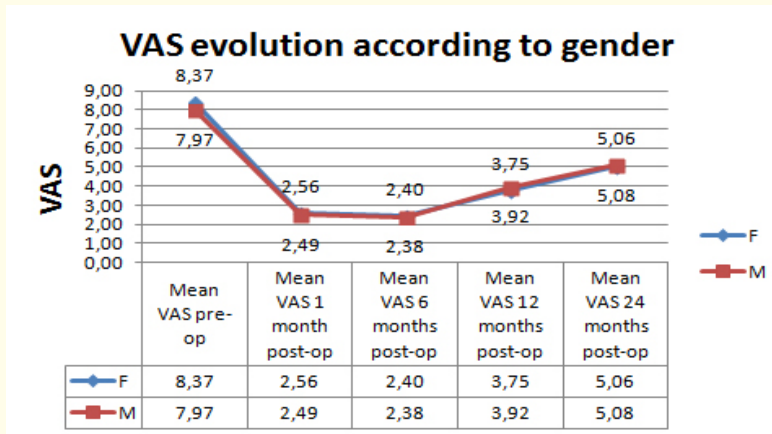


Figure S4: Mean VAS by gender pre-op radiofrequency treatment and post-op radiofrequency treatment at 1, 6, 12 and 24 months.

Age ≥ 70					
	Pre-op VAS	VAS 1 month post-op	VAS 6 months post-op	VAS 12 months post-op	VAS 24 months post-op
Cases	32	32	32	32	32
Mean	8	2.187	2.094	3.062	4.187
Median	8	2	2	3	4
Standard deviation	1.016	0.693	0.817	1.389	1.712
Mean variation (%) respect to pre-op VAS	0	-72.66	-73.83	-61.72	-47.66
Age <70					
Cases	59	59	59	59	59
Mean	8.3051	2.7119	2.5593	4.2373	5.5424
Median	8	3	2	4	5
Standard deviation	0.725	0.744	0.726	1.006	1.356
Mean variation (%) respect to pre-op VAS	0	-67.35	-69.18	-48.98	-33.26

Table S3: VAS evolution per age (years).

MALES					
	Pre-op VAS	VAS 1 month post-op	VAS 6 months post-op	VAS 12 months post-op	VAS 24 months post-op
Cases	39	39	39	39	39
Mean	7.974	2.487	2.385	3.923	5.077
Median	8	2	2	4	5
Standard deviation	0.706	0.790	0.877	1.403	1.734
Mean variation (%) respect to pre-op VAS	0	-68.81	-70.09	-50.80	-36.33
FEMALES					
	Pre-op VAS	VAS 1 month post-op	VAS 6 months post-op	VAS 12 months post-op	VAS 24 months post-op
Cases	52	52	52	52	52
Mean	8.365	2.557	2.404	3.750	5.057
Median	8	2	2	4	5
Standard deviation	0.908	0.752	0.721	1.186	1.539
Mean variation (%) respect to pre-op VAS	0	-69.43	-71.27	-55.17	-39.54

Table S4: VAS evolution per gender.

In the Wilcoxon test, there were statistically significant differences, 95% confidence interval, between the number of analgesics per day pre-op radiofrequency treatment and post-op radiofrequency treatment at 6 months ($Z = -7.811$; $p < 0.05$; $r = -0.818$) (Table S5). The NSAID’s consumption reduced from $M = 2.780$ ($SD = 0.416$) pre-op radiofrequency treatment to $M = 1.439$ ($SD = 0.957$) at 6 months’ post-op radiofrequency treatment (Table S6).

	Cases	Positive mean range	Negative mean range	Z	p-value	Effect size (r)
Analgesic medication/day pre-op compared to analgesic medication/day on 6 months post-op	91	40.24	21.5	-7.811	<0.05	-0.818

Table S5: Wilcoxon test, analgesic medication/day comparing pre-op radiofrequency treatment to 6-months post-op radiofrequency treatment.

	Pre-op analgesic medication	Analgesic medication at 6 months post-op
Cases	91	91
Mean (M)	2.780	1.439
Median	3	2
Standard deviation (ST)	0.416	0.957

Table S6: Detail analgesic medication/day.

In the Wilcoxon test, there were statistically significant differences, 95% confidence interval, between pre-op radiofrequency treatment WOMAC and post-op radiofrequency treatment WOMAC at 1 month ($Z = -8.314$; $p < 0.05$; $r = -0.872$), at 6 months ($Z = -8.310$, $P < 0.05$; $r = -0.871$) at 12 months ($Z = -8.306$; $p < 0.05$; $r = -0.871$); and at 24 months ($Z = -8.021$, $p < 0.05$; $r = -0.841$) (Table 4, Figure 7). The statistical differences detected were induced by the reduction in the WOMAC in the post-op radiofrequency treatment period compared to the pre-op radiofrequency treatment period (Table S7). Specifically, the largest reduction occurred at 1 (-76.88%) and at 6 months (-77.90%). Meanwhile, at 12 (-68.01%) and 24 months (-48.08%) the WOMAC also improved but at a slower rate, showing a trend towards recovery. Statistically significant differences were found, 95% confidence interval, between the pre-op radiofrequency treatment WOMAC and post-op radiofrequency treatment WOMAC at 1, 6, 12 and 24 months among both older and younger than 70 years of age (Table S8, Figure S5); and between men and women (Table S9, Figure S6). The WOMAC improved from the pre-op radiofrequency treatment period, especially in the first 6 months' post-op radiofrequency treatment, this improvement being smaller with the passage of time, with some recovery for each of the groups. Considering the age, the improvement in the WOMAC was similar between the two groups at 1 and at 6 months' post-op radiofrequency treatment, while at 12 and 24 months it was higher for patients ≥ 70 years (Table S10). With respect to gender the improvement in the WOMAC was somewhat higher at 1 and 6 months' post-op radiofrequency treatment and considerably bigger at 12 and 24 months, in the case of men compared to women (Table S11).

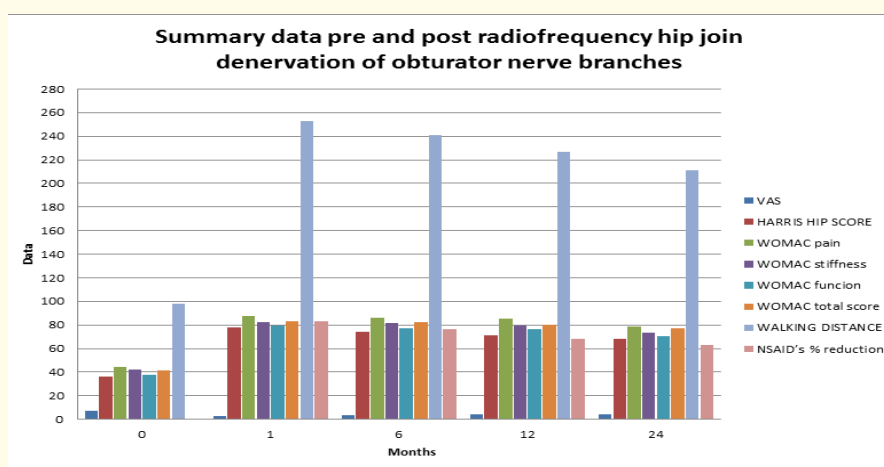


Table 4: Wilcoxon test, dependent samples, WOMAC.

	Pre-op WOMAC	WOMAC 1 month post-op	WOMAC 6 months post-op	WOMAC 12 months post-op	WOMAC 24 months post-op
Cases	91	91	91	91	91
Mean	16,109	3,725	3,560	5,154	8,363
Median	16	4	3	5	7
Standard deviation	2,157	1,446	1,240	2,123	4,547
Mean variation (%) respect to pre-op WOMAC	0	-76,88	-77,90	-68,01	-48,08

Table S7: WOMAC evolution over time.

Edad ≥ 70						
	Cases	Positive mean range	Negative mean range	Z	p-value	Effect size (r)
Pre-op WOMAC – WOMAC 1 month post-op	32	16,5	0	-4,955	<0,05	-0,876
Pre-op WOMAC – WOMAC 6 months post-op	32	16,5	0	-4,946	<0,05	-0,874
Pre-op WOMAC – WOMAC 12 months post-op	32	16,5	0	-4,947	<0,05	-0,874
Pre-op WOMAC – WOMAC 24 months post-op	32	16,5	0	-4,950	<0,05	-0,875
Edad < 70						
Pre-op WOMAC – WOMAC 1 months post-op	59	30	0	-6,704	<0,05	-0,873
Pre-op WOMAC – WOMAC 6 months post-op	59	30	0	-6,711	<0,05	-0,874
Pre-op WOMAC – WOMAC 12 months post-op	59	30	0	-6,702	<0,05	-0,872
Pre-op WOMAC – WOMAC 24 months post-op	59	27	0	-6,345	<0,05	-0,826

Table S8: Wilcoxon test, WOMAC per age (years).

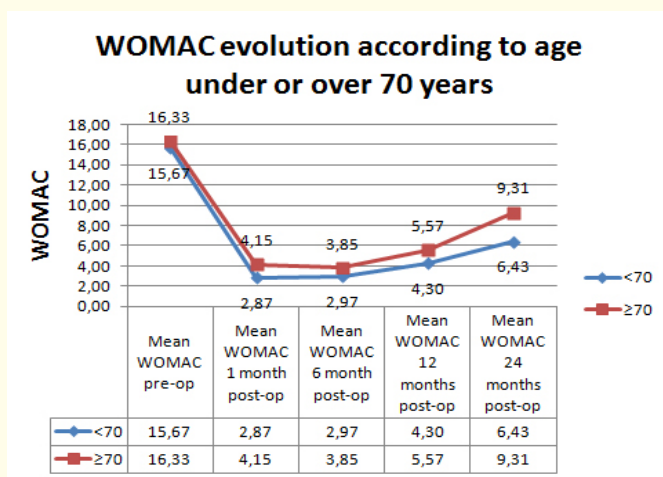


Figure S5: WOMAC mean in preoperative period and postoperative at 1, 6, 12 and 24 months, per age (years).

MALES						
Variables	Cases	Positive mean range	Negative mean range	Z	p-value	Effect size (r)
Pre-op WOMAC – WOMAC 1 month post-op	39	20	0	-5,466	<0,05	-0,875
Pre-op WOMAC – WOMAC 6 months post-op	39	20	0	-5,463	<0,05	-0,875
Pre-op WOMAC – WOMAC 12 months post-op	39	20	0	-5,463	<0,05	-0,875
Pre-op WOMAC – WOMAC 24 months post-op	39	20	0	-5,475	<0,05	-0,877
FEMALES						
Pre-op WOMAC – WOMAC 1 month post-op	52	26,5	0	-6,297	<0,05	-0,873
Pre-op WOMAC – WOMAC 6 months post-op	52	26,5	0	-6,301	<0,05	-0,874
Pre-op WOMAC – WOMAC 12 months post-op	52	26,5	0	-6,289	<0,05	-0,872
Pre-op WOMAC – WOMAC 24 months post-op	52	23,5	0	-5,910	<0,05	-0,819

Table S9: Wilcoxon test, WOMAC per gender.

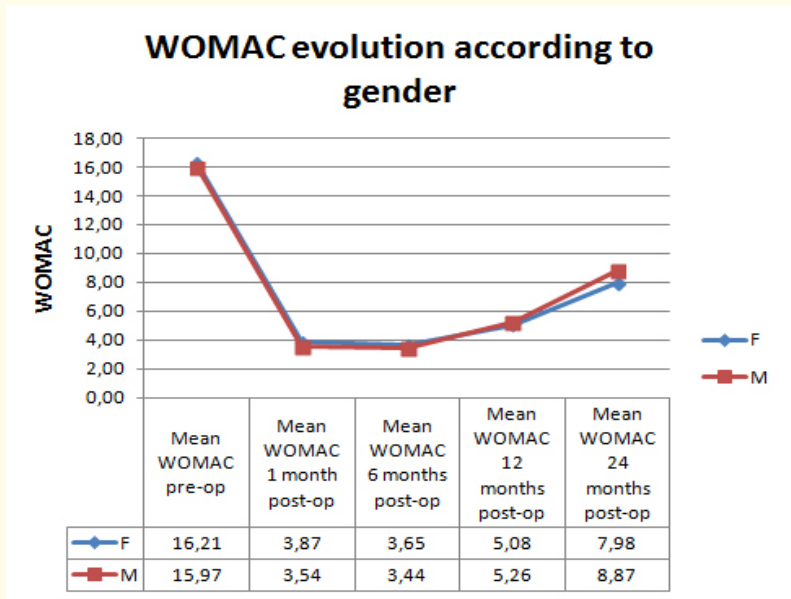


Figure S6: Mean WOMAC per gender in preoperative period and postoperative at 1, 6, 12 and 24 months, per gender.

Edad ≥ 70					
	Pre-op WOMAC	WOMAC 1 month post-op	WOMAC 6 months post-op	WOMAC 12 months post-op	WOMAC 24 months post-op
Cases	32	32	32	32	32
Mean	15,594	3,437	3,531	4,281	5,562
Median	15	3	3	4	5,5
Standard deviation	2,499	1,389	1,367	1,571	1,831
Mean variation (%) respect to pre-op WOMAC	0	-77,96	-77,36	-72,55	-64,33
Edad < 70					
Cases	59	59	59	59	59
Mean	16,389	3,881	3,576	5,627	9,881
Median	17	4	4	5	8
Standard deviation	1,912	1,463	1,177	2,242	4,860
Mean variation (%) respect to pre-op WOMAC	0	-76,32	-78,18	-65,66	-39,71

Table S10: WOMAC per age (years).

MALES					
Variable	Pre-op WOMAC pre	WOMAC 1 month post-op	WOMAC 6 months post-op	WOMAC 12 months post-op	WOMAC 24 months post-op
Cases	39	39	39	39	39
Mean	15,179	3,154	3,231	3,923	5,436
Median	15	3	3	4	5
Standard deviation	2,199	1,328	1,202	1,345	1,698
Mean variation (%) respect to pre-op WOMAC	0	-79,22	-78,71	-74,15	-64,18
FEMALES					
Cases	52	52	52	52	52
Mean	16,807	4,154	3,807	6,077	10,557
Median	17	4	4	6	10,5
Standard deviation	1,858	1,392	1,221	2,1411	4,783
Mean variation (%) respect to pre-op WOMAC	0	-75,28	-77,35	-63,84	-37,19

Table S11: WOMAC per gender.

Twenty-seven patients required a second repeat procedure, and 12 needed a third time. The duration of pain relief for the second-time denervation was 3 - 4 years (mean 3.2 ± 1.09 SD years) and for the third time 2.5 - 3 years (mean 2.8 ± 0.7 SD years).

X-ray examinations carried out during the whole post-op radiofrequency treatment period did not reveal any undesirable changes, specifically acceleration of hip destruction.

No major complications attributable to the procedure were seen (motor weakness, sensory loss, dysesthesia or vessel damage). Seven patients developed a small hematoma in the groin, all of which resolved spontaneously. No patient was aggravated nor showed more lameness or had an increase in pain.

We saw no cases of new hip joint pain that could be attributed to anesthesia dolorosa or neuropathic pain. When the pain recurred, it was always related to the activity, improving with rest and getting worse on walking.

Discussion

Although local anesthetic blocks have been used to treat hip joint pain [7,11,17,18], nowadays they are used only for diagnostic purposes as their results are usually short lasting [10,12], with a reported mean time of pain relief ranging from 1 to 4 days [17,32]. The duration of the anesthetic block is longer than the anesthetic agent administered. The underlying reason for this might be the break in the pain vicious circle [13,17].

Adding electrical stimulation [12] or ultrasound guidance [5,25,38,41,43] to the fluoroscopy increases the accuracy of obturator nerve and great vessel localization, but did not improve the pain relief [32].

Open surgical section of the obturator nerve to treat the painful osteoarthritis of the hip was introduced by Selig [35]. Pain relief ranged from 83% at six months [22] to 18% at three years [33]. Since many of these patients remained with posterior hip pain, Tavernier [39] added the open section of the branch to the quadratus femoris. Although results were further improved by adding the section of the branches of the femoral nerve for the hip [44], increasing numbers of unsatisfactory results led to a gradual decline of open procedures. They were replaced by percutaneous lesioning of the obturator, femoral and quadratus femoris nerves introduced by [29]. Radiofre-

quency was used as the shape and size of the lesion can be controlled and repeated once and again [6]. Akatov and Dreval [2] lesioned only the obturator nerve trunk reporting an 80% of excellent results at a 3-year follow-up. Unfortunately, some of their patients showed a sensory loss in the medial aspect of the thigh. The procedure was further refined by others, with reduction in complication and side effect rate [5,14,20,24,32,36,42]. They lesioned both the obturator and femoral nerve branches, in contrast with us. It is known that groin pain is transmitted by obturator nerve branches and trochanteric pain by femoral nerve branches [32]. We have focused on patients with groin pain as the trochanteric pain can also be due to trochanteric bursitis and be amenable to greater trochanter steroid infiltration. The follow-up of these series varies between 3 months [5,24,42], 6 months [14,32], 11 months [20], to a maximum of 3 years [2]. We have longer and more extensive follow-up with similar clinical results and comparable complication and side effect rates.

The needle can be inserted from a lateral or medial approach. The lateral approach has been used to avoid unwanted femoral vessel puncture [23,32]. We insert the needle more medial and caudal than in other series, minimizing the chance of unintentional femoral vessel puncture. As the obturator nerve branches have a big area of distribution [23], we aim the needle tip as parallel as possible to the ischia-iliac ramus to increase the probability of lesioning them.

The size of the exposed electrode tip varies from 4 mm [14], 5 mm [5],32 and 10 mm [42]. In our series, we have used a 10 mm exposed tip as the location of the hip branches of the obturator nerve vary between patients and between sides of the same patient [23]. Thus, a bigger lesion has a bigger chance of being successful.

The temperature used to create the lesion is 80 - 90°C, except Wu and Groner [42] that rise the temperature only to 45°C (pulsed radiofrequency). Based on the studies of Cosman, *et al.* [6] the temperature must be raised over 80°C to induce a lesion of sufficient size to include a nerve branch that has not an exact anatomical location. The time used to create the lesion also matters, as its size increases 11 - 20% from 1 to 2 minutes and 20 to 23% from 2 to 3 minutes [6]. Most series have used between 90" [24,32] to 120" [2,14,42], as it is our case.

Radiofrequency thermal coagulation over 55°C induces an indiscriminate damage of median and small caliber myelinated fibers, carrying the potential risk of inducing sensory loss, motor weakness and Wallerian degeneration with neuropathic pain [31,37]. To overcome this, Wu and Groner [42] reported the use of pulsed radiofrequency in two cases with good pain response but only lasting for 3 - 4 months. The concern to induce neuropathic pain, dysesthesia or motor weakness is what made us to do a thorough electrical stimulation and to re-position the needle until a safe position was found. In our series, we did not find any of these complications. Probably we lesion the hip branches of the obturator nerve more lateral and closer to the hip joint than others. We have not seen any case of post-op radiofrequency treatment neuropathic pain. In all patients, post-op radiofrequency treatment pain improved on resting and got worse on activity.

A major concern is that hip joint denervation might accelerate the progression of hip osteoarthritis. Oblatz in 1949 [28] reported no radiological changes at 20 months following open partial sensory denervation of the hip. Fernandes, *et al.* [12] showed no radiological deterioration in a 5 to 14 months' follow-up after anesthetic block. Only Kang and Bulstrode [19] saw radiological deterioration after repeated hip anesthetic and cortisone blocks, perhaps attributable to the cortisone being injected inside the hip joint. We have not seen any radiographic changes suggestive of acceleration of the natural degenerative progress.

In chronic pain the peripheral and central nociceptive system interact synergistically and undergo changes that result in perpetuation of the pain [34]. That is why surgical procedures intended for pain control are sometimes not as effective as expected, since they only attack the peripheral component, obviating the complex net of events underlying higher levels such as the medulla, the thalamus, the somatosensory area, the anterior cingulate, the periaqueductal grey matter, the limbic system, ...). Nevertheless, the experience with spinal (lumbar and cervical) zygapophyseal joint rhizotomy as well as other joints like the shoulder, shows us that the lesioning of a peripheral articular sensory branch can be helpful in controlling the pain for a long time [9]. As only the nerve fibers are damaged but not the endoneurial connective tissue tubes, recovery over a variable period is to be expected. On the other hand, repeating the lesion might further prolong the pain alleviation period.

The relative simplicity of this technique is worthwhile for these unfortunate patients, often confined to wheel chair and with no prospect of surgical relief. They are often pleased even with a partial pain improvement. In accordance to our experience and the existing literature, no major complications appear to be associated with this technique, if allergy against local anesthetic contrast agent is ruled out [20,24,32,42]. Abscess or hematoma may have to be considered, as in any intervention. Our procedure had no major complications and could be applied to patients who had a very poor general status.

The lack of pain relief in some cases despite a correctly performed procedure may be explained by the fact that innervation of the hip varies widely from patient to patient [3,4,23]. This is the reason why we always perform two correlative lesions with a needle tip of 10 mm in an oblique trajectory, to increase the area of lesion increasing the chance of damaging the articular branch of the obturator nerve.

Limitations of the study

The main limitation of our study is that it does not include a control group. Moreover, hip joint pain is multi-factorial, and we are treating only one of the main sensory supplies of the joint. It is at times difficult to objectively evaluate the pain improvement as there is heavy dependence on the patients' subjective comments.

Conclusion

Ageing population may suffer from significant co-morbidities that may impede hip arthroplasty. Percutaneous radiofrequency denervation of the obturator sensory branches to the hip offers an alternative for those patients with severe hip pain who are not surgical candidates.



Video

1. Percutaneous radiofrequency hip joint denervation by Doctor Vicente Vanaclocha from Valencia, Spain
2. The hip joint is innervated by three nerves: femoral, obturator and quadratus femoris. The first two are in the anterior aspect of the hip, and the last one lies posteriorly
3. The femoral nerve goes out under the inguinal ligament close to the femoral vessels, giving one or more than one hip joint sensory branches
4. In this anatomical specimen, the femoral nerve and its articular branch can be found in the groin area, lateral to the femoral vessels
5. The obturator nerve can be found as it exits the obturator canal below the ilio-pubic ramus
6. In this anatomical specimen, we can see the obturator nerve exiting the obturator canal and reaching the thigh medial to the femoral vessels

7. The quadratus femoris nerve lies posteriorly, in the buttock area, very close to the sciatic nerve. Hence its percutaneous lesion is dangerous
8. In this anatomical specimen, we see the quadratus femoris nerve with its articular branches, very close by the sciatic nerve, that has been displaced from its regular position to show the quadratus femoris nerve more clearly
9. The obturator nerve conveys the sensory input from the hip external rotation and flexion. These movements are involved genital area hygiene, putting on trousers or climbing stairs
10. Chronic hip joint pain due to osteoarthritis is commonly treated with hip joint replacement. When this is not possible, mostly due to a poor general condition of the patients with serious co-morbidities, the percutaneous hip joint denervation becomes an option.
11. As the obturator nerve leaves the obturator canal it divides into anterior and posterior branches.
12. The anterior branch supplies articular innervation to the hip joint and other branches to the adductor longus, pectineus and gracilis muscles.
13. The posterior branch supplies the obturator externus, adductor magnus and brevis muscles as well as an articular branch to the knee joint.
14. We aim to selectively lesion the hip joint articular branch from the obturator's nerve anterior branch
15. In this anatomical specimen, we can see the anterior branch of the obturator nerve with its articular branch
16. The anatomy is more visible once the ilio-pubic ramus is removed and the capsule of the hip joint opened
17. The patient is placed supine with the affected leg in slight hip flexion and external rotation
18. The inguinal ligament and the femoral vessels are marked
19. A 20G 145 mm long needle with a 10mm un-isolated tip is used. On the inset, the approximate size of the lesion is depicted
20. With the left-hand thumb palpating the femoral vessels, the needle is inserted and its tip placed in the angle between the superior pubic and the ischia-iliac rami
21. Once the needle is in place 5ml of 2% mepivacaine are injected to reduce the intra and post-operative pain
22. Electrical stimulation is performed to exclude proximity to the obturator nerve trunk
23. Once in a safe position, two consecutive thermocoagulation lesions are made at 90°C for 120" varying slightly the position of the needle
24. After the I.V. Propofol effect weans off, the patient is sent home under a friend or relative surveillance

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Conflicts of Interest

The authors have no conflicts of interest.

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