Randomized Control Trial

Comparison of the Efficacy of Conventional Radiofrequency to Intraarticular Steroid Injections for Advanced Hip Osteoarthritis: A Randomized Trial

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Background: Osteoarthritis (OA) is characterized by the destruction of the articular cartilage and narrowing of the joint space and bone formations around the joint due to mechanical, genetic, and inflammatory causes. The hip joints are some of the most commonly affected in OA. Hip OA is also known as coxarthrosis.

Objectives: This study aimed to compare the effects of conventional radiofrequency (RF) to those of intraarticular steroid treatment methods on pain, limitations, and quality of life in patients who had advanced OA of the hip and could not undergo surgery for any reason.

Study Design: The study was designed as a randomized, prospective single-center study. Setting: A total of 40 patients with advanced primary hip OA who met the inclusion criteria were included in the study.

Methods: Patients were randomized into 2 groups, each of which included 20 individuals. One group received conventional (thermal) radiofrequency ablation (RFA) to the femoral and obturator sensory branches of the hip, while the other group received intraarticular steroid injections in their hips. Scores on the Visual Analog Scale (VAS) and the physical-function component of the Medical Outcomes Study Short Form Health Survey (SF-36) were completed before, one month after, and 3 months after the procedure. The VAS was recorded both at rest and during activity. Each patient's gender, body mass index (BMI), affected hip side, duration of pain, and previous treatments for the hip were recorded, as were the procedure-related complications each patient experienced.

Results: Forty patients were followed up on for 3 months. The analysis revealed that at both one month and 3 months after treatment, the 2 groups of patients showed a significant improvement in their scores on the resting VAS, activity VAS, and physical-function component of the SF-36 from the pre-procedure values ($P < 0.05$). As for resting VAS scores in the hip intraarticular steroid injection (HIASI) group and activity VAS scores in the thermal radiofrequency ablation (TRFA) group, there was a statistically significant difference between the groups at one month and 3 months after the procedure, respectively ($P < 0.05$). This study found a statistically significant correlation between hip stage and age, but no significant correlation was found for gender and weight. No difference between the groups appeared in the complications related to the procedure at the 3-month follow-up.

Limitations: The follow-up period was relatively short. The sample size was small, and to avoid neuritis, a half dose of triamcinolone acetonide was given to the patients in the TRFA group.

Conclusions: Conventional RF is more effective at treating the symptoms of advanced coxarthrosis than are intraarticular steroids, based on observations of the activity in the 3-month follow-up of patients with the condition.

Key words: Hip osteoarthritis, conventional radiofrequency, intraarticular steroid injection

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Osteoarthritis (OA) is a disease characterized by the destruction of articular cartilage, narrowing of joint space, and small bone formations around the joint, resulting from mechanical, genetic, and inflammatory causes and biochemical processes in the body. The hip joints are among the most commonly affected in OA, with a prevalence of approximately 11%. In hip OA, also known as coxarthrosis, activity limitation and the accompanying pain reduce the patient's quality of life significantly. While symptomatic medical treatments and physical therapy modalities may provide relief for some patients, the efficacy of these methods is limited, especially in advanced hip OA (classified as stages 3 and 4, according to the Kellgren-Lawrence Staging) (1,2).

Both intraarticular steroid injections (IASI) and radiofrequency ablation (RFA) of the articular sensory branches of the hip represent treatment modalities for advanced hip OA. Hip arthroplasty usually becomes the last resort for these patients. In cases in which hip arthroplasty is not indicated, conventional (thermal) RFA (TRFA), cooled RFA (CRFA), and pulsed RF (PRF) methods can serve as alternative approaches (3).

In RFA, electrical energy is produced with a generator. This energy causes destructive effects on the nerve tissue. Generally, the target of the procedure involves the sensory branches of the nerve. Besides its application in advanced hip OA, RFA can also be employed in avascular necrosis and refractory pain following hip arthroplasty. Hip TRFA is performed under fluoroscopic guidance, although ultrasound-guided (USG) cases have also been reported. Although hip RFA is predominantly carried out on adults, instances of hip RFA in the pediatric age group have been documented (4-7).

The articular sensory innervation of the hip joint is supplied anteriorly by the obturator, accessory obturator (variational), and femoral nerves and posteriorly by the sciatic area, quadratus femoris, superior gluteal nerve, and inferior gluteal nerve (variational). In TRFA, the articular sensory branches of the obturator and superolateral femoral nerve anterior inferomedial to the hip are targeted. Various approaches, including the anterior, ischial (inferior), and lateral varieties, have been described in the supine position under fluoroscopy (8-11).

Hip intraarticular steroid injections (HIASIs) represent a standard treatment modality in advanced hip OA. Although HIASIs are effective in the short term, surgery is required in approximately 50% of patients in the long term. Cases of avascular necrosis have been reported after a single dose of steroid injection (12). The impact of an HIASI applied before total hip arthroplasty on surgical complications remains unclear. An HIASI can be performed under USG or fluoroscopy guidance, with approximately 40% of blind injections determined to be extra-articular (13-16).

Medical and physical treatment modalities can be applied to hip OA. Afterward, intraarticular injections and radiofrequency (RF) can be used as advanced treatments. This study aims to compare the effects of HIASIs to those of TRFA, commonly utilized in the treatment of patients with advanced coxarthrosis, on pain, disability, and quality of life.

Methods

This prospective randomized single-center study was conducted following approval from the Ethics Committee of Istanbul University Istanbul Faculty of Medicine. The Declaration of Helsinki was strictly adhered to throughout the study. This study was registered in the Clinicaltrials.gov registry, with the code number NCT05564065. Forty-seven patients who presented to the Pain Medicine (Algology) outpatient clinic between June 2020 and October 2022, were diagnosed with primary hip osteoarthritis (OA), and met the inclusion criteria were enrolled in this study.

Three of the 47 patients refused to participate in the study. A computer-assisted randomization program was used to categorize the rest of the patients into groups, each of which was designed to comprise 22 individuals. Finally, 40 out of 44 patients met the inclusion and exclusion criteria (Fig. 1). The study's target population consisted of patients given a diagnosis of primary coxarthrosis based on the American College of Rheumatology (ACR) criteria. Additional inclusion criteria included an age greater than 45 years, stage 3-4 disease according to the Kellgren-Lawrence classification of OA, an activity score of 5 or higher on the VAS despite prior medical treatment and physical therapy, and no motor or sensory loss discovered in the neurological examination. Exclusion criteria consisted of a history of previous hip surgery, interventional hip procedures within the last 6 months, hip OA attributed to secondary causes, sepsis, bleeding disorders, known drug allergies, active infection, bleeding diathesis, presence of a cardiac pacemaker, active psychosis, and contraindications for RF procedures.

While HIASIs were administered to the first group, TRFA was performed on the second group. Volunteers, upon informed consent, followed the study protocol. Assessments Scores on the Visual Analog Scale (VAS) and the

physical-function component of the Medical Outcomes Study Short Form Health Survey (SF-36) were conducted before the procedure, and follow-up evaluations were performed at one month and 3 months. The VAS score was recorded both at rest and during activity. Patient demographics, including gender, body mass index (BMI), hip side, pain duration, and previous hip treatments, were recorded as well. Baseline VAS and SF-36 physical function scores were also recorded before the procedure.

Each patient in the first group was taken to a room with a C-arm fluoroscopy machine. An anterior-posterior (AP) image of the patient's affected area was captured. Under continuous AP imaging, a 22-gauge, 90 mm–long spinal needle was directed to the femoral neck under sterile conditions and appropriate monitoring (saturation, 5-lead electrocardiogram, and blood pressure) in the supine position. After an appropriate contrast spread was observed, 40 mg of triamcinolone acetonide was injected (Fig. 2).

In the second group, ultrasound was utilized to locate the neurovascular bundle while the patient was in the supine position. Anterior-posterior imaging was performed by the C-arm flurosocopy machine, and the anatomical landmarks, including the acetabular notch, walls of the pelvis minor, and acetabular wall, were identified. A 22-gauge, 90 mm–long RF needle with a 10 mm–long active tip was directed to the inferior and medial hip joint for the articular branch of the obturator nerve, using an anterior approach under fluoroscopic guidance (Fig. 3). The direction of this needle occurred under sterile conditions and appropriate monitoring (saturation, 5-lead electrocardiogram, and blood pressure), with the patient lying supinely. Motor stimulation (2 Hz, 0.9 V) was used to exclude muscle

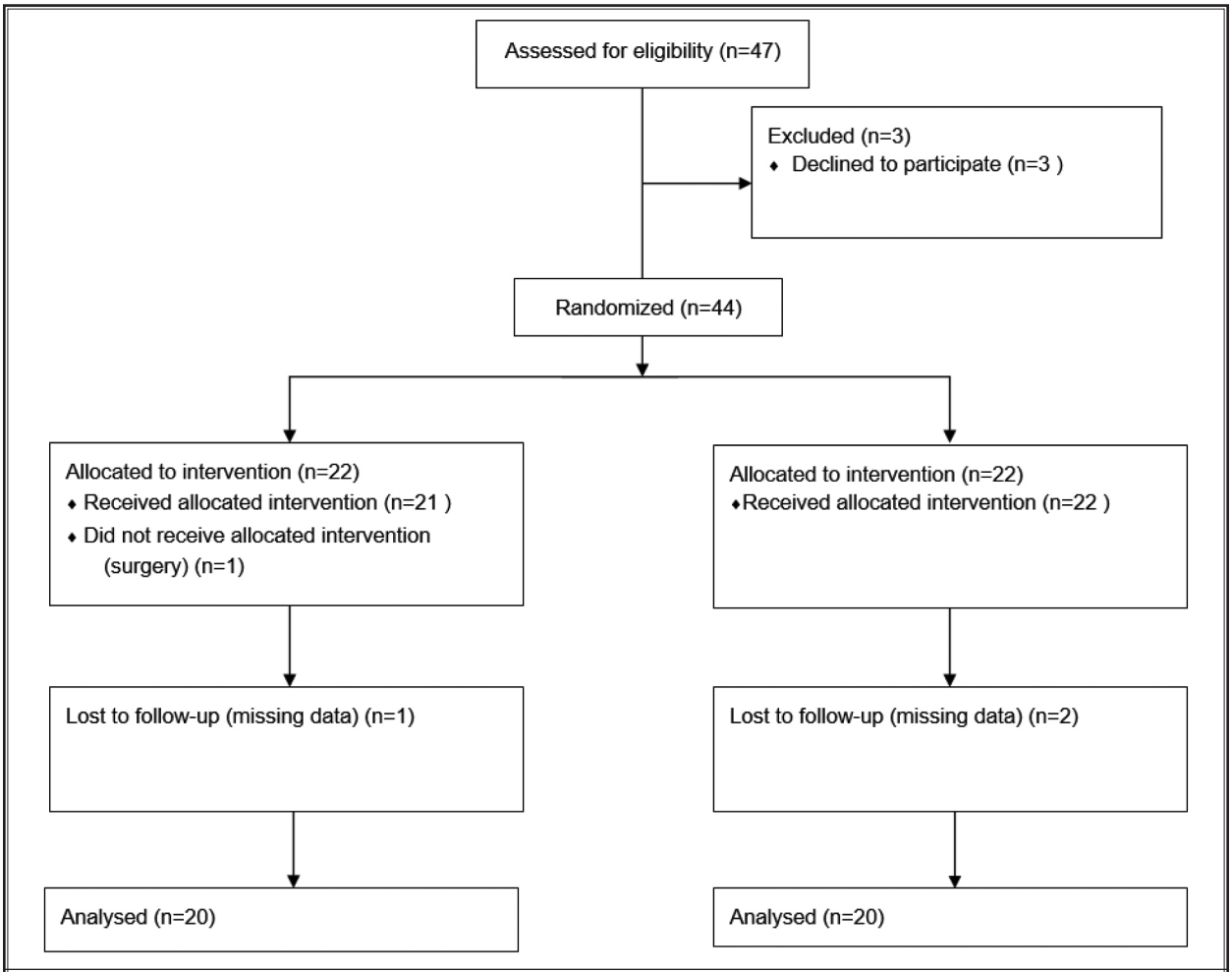

Fig. 1. *Flow chart*.

contractions, and sensory stimulation (50 Hz, 0.6 V) elicited a paresthesia response at the appropriate location. An RF needle was directed according to the motor and sensory responses, considering the variational nature of articular sensory nerves. After an injection of one mL of 2% lidocaine, continuous RFA was applied at 80°C for 90 seconds using an RF generator (CoATherm AK-A304, Apro Korea Inc.).

Similarly, AP imaging was performed with the C-arm fluoroscopy machine. The needle tip was directed superiorly and laterally to the hip joint, using anatomical landmarks such as the anterior-inferior iliac process, and TRFA was applied to the sensory articular branches of the femoral nerve (Fig. 4). Following the TRFA, 300 mg/mL of iohexol (1 mL) and 20 mg of triamcinolone acetonide were given for each treated area to mitigate the risk of neuritis. During the procedure, the active-tip temperature of the needle did not exceed 80°C, and the impedance ranged between 200 and 360 ohms. For 120 minutes after the procedure, patients were observed, during which time they were checked for severe pain, bleeding, numbness, leg weakness, neuritis, and hematoma. The patients were discharged without additional problems. After the procedure, patients were scheduled for outpatient follow-ups, and their activity, resting VAS, and SF-36 physical function scores were assessed at one and 3 months.

The parameters were reevaluated during the first and third months of the follow-up.

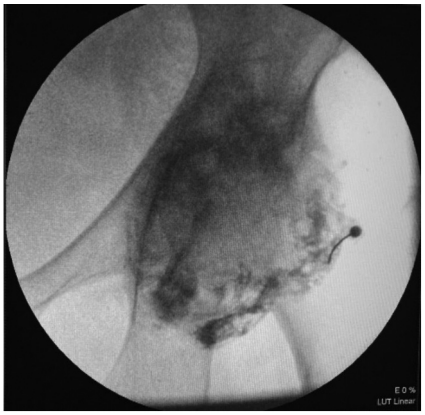

Fig. 2. *Contrast spread and needle position after hip intraarticular steroid injection by fluoroscopy.*

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 26 (IBM Corporation). Descriptive statistics were presented as numbers (n), percentages (%), means ± standard deviations, medians, minimums, and maximums. The normality of the distribution of data for the numerical variables was assessed using the Shapiro-Wilk normality test. The TRFA and HIASI groups were compared based on numerical variables, using the independent samples t-test in cases of normal distribution and the Mann-Whitney U-test when the distribution was not normal. Chi-square tests were used to compare groups based on categorical variables, and the Friedman test was applied to analyze the resting VAS, activity VAS, and SF-36 physical function scores after the procedure during the follow-up period. Significance values were adjusted by the Bonferroni correction for multiple tests. Spearman's correlation analysis was performed among disease stage, patient age, and BMI. Statistical significance was set at $P < 0.05$.

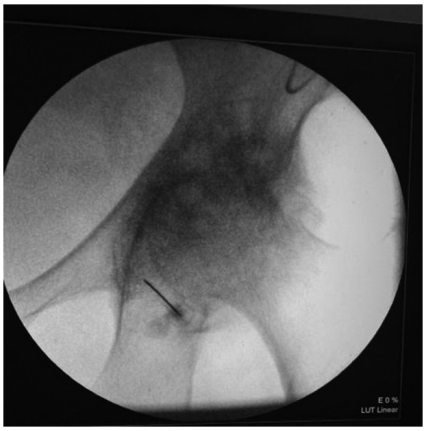

Fig. 3. *Position of the needle for CRFA into the sensory articular branch of the obturator nerve by fluoroscopy.*

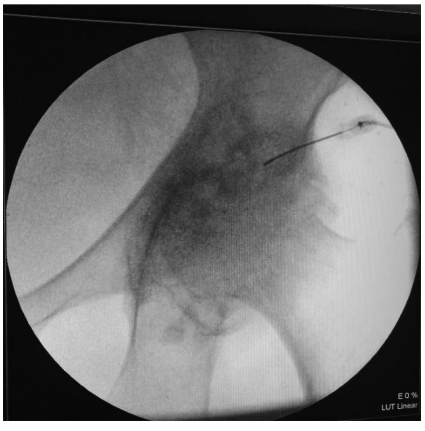

Fig. 4. *Position of the needle for CRFA into the sensory articular branch of the femoral nerve by fluoroscopy.*

During the literature review, no study comparing OA patients who received TRFA to OA patients who received HIASIs was found. Therefore, a literature review was conducted on the minimum number of patients who needed to be included in a randomized controlled pilot study. In a study by Whitehead et al, the recommended values for 5 different investigators were examined (17). In accordance with the primary objective of our study, data were collected for VAS values on a total of 40 cases, 20 in each group. The collected data were accepted as pilot study data. These pilot data provide the minimum sample size recommended by Whitehead et al (17). As for the mean and standard deviation values of the activity VAS in each group, the study was stopped at that stage because the researchers determined that 20 cases per group would be sufficient, according to the results of the one-way independent samples t-test power analysis with 95% confidence interval (1-α), 80% test power (1-β), and d = 0.82035 effect size.

Results

There was no statistically significant difference between the groups in age, BMI, pain duration, and pain side (Table 1).

The analysis revealed that in their resting VAS, activity VAS, and SF-36 physical function scores, all patients experienced a significant improvement from the pre-procedure values at both one month and 3 months after treatment ($P < 0.05$) (Table 2).

A comparison between the 2 groups revealed a statistically significant difference in resting VAS at one month after the procedure and activity VAS at 3 months after the procedure ($P < 0.05$).

No statistically significant differences were observed between the groups in other variables ($P > 0.05$) (Table 3 and 4).

Furthermore, a statistically significant correlation was identified between hip stage and age ($P < 0.05$). However, no significant correlations were found between hip stage and gender or BMI ($P > 0.05$) (Table 5).

In this study, at the one- and 3-month follow-ups, no differences were observed between the groups regarding lower extremity motor and sensory loss, bleeding, hematoma, infection, or neuritis.

Discussion

This study compared the outcomes of 2 widely utilized interventional treatments for advanced hip OA. The assessment of VAS scores at rest and during activity, along with the evaluation of the physical function score as a key sub-parameter of the SF-36, provided insights into patient complaints and the efficacy of the procedures. The analysis revealed that all patients' rest-

Table 1. *Demographic features*

	Performed procedure		Test Statistics	
	Conventional radiofrequency	Intraarticular steroid injection	Test value	*P* value
Gender, n (%)				
Female	18 (52.9)	16 (47.1)	0.196	0.658†
Male	2 (33.3)	4 (66.7)		
Side of pelvic pain, n (%)				
Right	10 (62.5)	6 (37.5)	0.938	0.333†
Left	10 (41.7)	14 (58.3)		
Stage, n (%)				
Stage 3	12 (42.9)	16 (57.1)	1.071	0.301†
Stage 4	8 (66.7)	4 (33.3)		
Age, (years)	68.15 ± 14.33	69.45 ± 13.25	0.298	0.767‡
BMI, (kg/m^2)	27.85 ± 3.62	27.5 ± 4.33	0.277	0.783‡
Duration of pain, (years)	3.0 (1-15)	3.0 (1-20)	183	0.641&

n: Number of patients, Numerical variables are presented as mean ± SD or median (minimum-maximum) values. †: Chi-square test, ‡: Independent samples t test, &: Mann-Whitney U test

Table 2. *Comparative analysis of the pre-procedure, post-procedure 1st and 3rd month resting and activity VAS scores and SF-36 physical function scores*

		Mean (S.D.)	Median (min-max)	Test İst*	*P*
Resting VAS	Pre-procedure	2.73 (1.65)	2.5 (0-8)[a]	53.856	0.000
	1st-month	1.08 (0.92)	1 (0-3)[b]		
	3rd-month	1.95 (0.99)	2 (0-4)[ac]		
Activity VAS	Pre-procedure	8.2 (0.91)	8 (6-10)[a]	75.640	0.000
	1st-month	3.5 (1.85)	4 (0-7)[b]		
	3rd-month	5.38 (1.37)	5.5 (2-8)[c]		
SF-36 PFS	Pre-procedure	38.13 (13.53)	40 (15-75)[a]	67.841	0.000
	1st-month	50.88 (13.25)	50 (25-85)[b]		
	3rd-month	48.25 (13.04)	50 (25-80)[bc]		

*Friedman test statistic, a-c: Values sharing the same letter within each column do not different significantly. PFS: physical function scores. A significant improvement in resting VAS, activity VAS, SF-36 physical function scores were noted in both groups at 1st and 3rd month when compared to the baseline values ($P = 0.000$).

Table 3. *Pre-procedure, post-procedure 1st and 3rd-month resting and activity VAS scores on the procedure*

	Steroid injection (n = 20)		Conventional radiofrequency (n = 20)		Z	*P*
	Mean ± SD	Median (Min.-Max.)	Mean ± SD	Median (Min.-Max.)		
Resting VAS pre-procedure	2.4 ± 1.31	2 (0-5)	3.05 ± 1.9	3 (0-8)	-1.082	0.279
Resting VAS 1st-month	0.7 ± 0.73	1 (0-2)	1.45 ± 0.94	2 (0-3)	-2.545	0.011
Resting VAS 3rd-month	1.95 ± 1.05	2 (0-4)	1.95 ± 0.94	2 (0-3)	-0.086	0.932
Activity VAS pre-procedure	8.1 ± 0.72	8 (7-10)	8.3 ± 1.08	8 (6-10)	-0.781	0.435
Activity VAS 1st-month	3.05 ± 1.73	3.5 (0-6)	3.95 ± 1.9	5 (0-7)	-1.706	0.088
Activity VAS 3rd-month	5.9 ± 1.07	6 (4-8)	4.85 ± 1.46	5 (2-7)	-2.331	0.020

Mann Whitney U Test, Independent sample t test

Table 4. *Pre-procedure, post-procedure 1st and 3rd-month SF-36 physical function scores based on the procedure*

	Steroid injection (n = 20)		Conventional radiofrequency (n = 20)		Z	*P*
	Mean ± SD	Median (Min.-Max.)	Mean ± SD	Median (Min.-Max.)		
SF-36 Physical function score pre-procedure	39.75 ± 12.4	40 (20-75)	36.5 ± 14.7	35 (15-65)	0.756	0.455
SF-36 Physical function score 1st-month	52.25 ± 12.92	55 (30-85)	49.5 ± 13.76	47.5 (25-75)	0.652	0.519
SF-36 Physical function score 3rd- month	49.5 ± 12.97	50 (30-80)	47 ± 13.32	45 (25-75)	0.601	0.551

Mann Whitney U Test, Independent sample t test

Table 5. *Correlation between disease stage, patient age and body-mass index*

	Disease stage	
	R	P
Age	0,786	0,000
Gender	0,031	0,852
BMI	-0,162	0,318

Spearman's rho Correlation analysis

ing VAS, activity VAS, and SF-36 physical function scores improved significantly from the pre-procedure values at both one month and 3 months after treatment.

The likelihood of developing OA increases with age. Approximately 30% of patients over 45 years of age have radiographic gonarthrosis, and half of these patients have knee-related symptoms. The prevalence of radiographic and symptomatic coxarthrosis in the same age group is approximately 10%, and coxarthrosis progresses as the patient ages (18). Some studies have suggested a correlation among coxarthrosis stage and BMI, age, and gender (19,20). The parameters were reevaluated during the first and third months of follow-up.

In our study, while advanced-stage coxarthrosis was more prevalent in older patients, no correlation was identified among BMI, gender, and disease stage.

Rare complications, such as hematomas, loss of sensation, infections, and neuritis, may occur in patients undergoing TRFA procedures. During TRFA, an increase in pain can occur when the patient is given sensory stimulation to confirm the needle's correct placement before the procedure (21-23). Evaluation of conditions during and after the procedure in both groups revealed that 15 patients in the TRFA group experienced pain during the procedure, despite the administration of one mL of 2% lidocaine beforehand. In contrast, only one patient in the steroid group reported pain. One patient in the TRFA group reported increased pain on the third day after the procedure, with a VAS value rising from 7 to 9. Investigations and physical-examination findings were unremarkable. With appropriate analgesia and close follow-up, the patient's complaints regressed after 21 days, and the VAS score was below 7 on the thirtieth day after the procedure. No short-term readmissions were observed in the steroid group.

Another patient in the TRFA group bled during the procedure, though no bleeding was reported at the one-hour follow-up. Based on the findings of the present study, the utilization of ultrasound to determine

the location of the vascular-nerve bundle before TRFA, regardless of the approach method, may mitigate potential bleeding and nerve damage. At the one- and 3-month follow-ups, no differences were observed between the groups in lower extremity motor and sensory loss, bleeding, hematoma, infection, or neuritis.

In this study, steroids were administered to each patient as a precaution against routine post-TRFA neuritis. However, it is noteworthy that some studies have reported that steroids may not necessarily reduce the risk of this complication (24).

Over the past decade, physicians have emphasized alternative approaches such as TRFA and pulsed RF (PRF) for hip-related conditions. Limited patient-group studies have reported the effectiveness of both TRFA and PRF in addressing hip issues (25-27).

Although the exact mechanism of action for PRF is not fully understood, it is hypothesized that the synaptic activity is decreased due to short energy waves, leading to changes in c-Fos gene expression, A-delta and C fibers, and cellular mitochondria. PRF was associated with less nerve damage than was TRFA (27). The current study revealed no procedure-related nerve damage in either patient group. To reduce TRFA-related nerve damage, the patient's sensory and motor reactions should be assessed before the procedure.

In a study by Kawaguchi, 14 patients underwent RFA of the sensory branches of the obturator and femoral nerves. Significant pain reduction (at least 50%) was reported in 12 patients, and the procedure demonstrated effectiveness for up to 11 months in terms of pain relief (28).

The impact of hip joint effusion on the success of these procedures remains unclear (29).

A study by Karaoglu et al (29) observed an association of TRFA with improvements in pain, functionality, and quality of life for patients with chronic hip pain at the 6-month follow-up. Tinnirello et al (22) reported that PRF was effective in reducing patients' chronic hip pain for 6 months, but this effect was found to decrease at the 12-month follow-up. No significant complications related to the procedure were observed in either study (22,30). In our study, it was determined that TRFA provided a significant improvement in VAS and SF-36 scores up to the third month. The mean activity VAS in TRFA patients decreased from 8.3 to 3.95 in the first month and 4.85 in the third month. The mean activity VAS in the HIASI group decreased from 8.1 to 3.05 at one month and 5.95 at 3 months. No serious complications were observed during the follow-up.

As the number of cases of primary coxarthrosis, observed predominantly in elderly patients, continues to rise, it is crucial to develop novel treatment strategies, especially considering the constraints associated with surgery in some OA patients. Factors such as persistent post-surgical pain, compromised quality of daily life, the necessity for multiple pain medications, side effects, and escalating costs underscore the need for innovative approaches. Although HIASIs appear effective in the short term, their efficacy diminishes over time. TRFA, however, emerges as a viable alternative for patients with advanced coxarthrosis who are unable to undergo surgery for various reasons. Despite the increased pain during the procedure, TRFA demonstrates superior effectiveness in long-term follow-up to HIASIs, making this form of RFA a valuable alternative for patients with advanced primary coxarthrosis (30,31). Caution should be exercised, however, due to the rare occurrence of neuritis in TRFA patients.

In summary, while TRFA and HIASIs prove to be effective and reliable methods of managing advanced coxarthrosis, HIASI exerts a positive impact on resting VAS during the short-term one-month follow-up. Conversely, TRFA demonstrates superior efficacy in relation to activity VAS during the 3-month follow-up. Scores on the physical-function component of the SF-36 increased comparably across both treatment groups.

Conclusion

In conclusion, both TRFA and HIASIs are effective and safe treatments for coxarthrosis, but TRFA is more effective than HIASIs, as measured by the activity level shown in patients' 3-month follow-ups. Future comprehensive studies are essential to further understand the prolonged effects of TRFA and HIASIs.

Author Contributions

HIA designed the study and was responsible for data acquisition and analysis. FAE drafted the initial manuscript and made substantial contributions to data interpretation. HC collected, analyzed, and interpreted the study data. GKT revised the manuscript critically and made substantial contributions to the study design. All authors read and approved the final version of the manuscript.

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