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ORIGINAL ARTICLE

Comparison of radiological and clinical results of knee intra-articular injections with two ultrasonography-guided approach techniques: A randomized controlled study

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ABSTRACT

Objectives: The objective of this study was to evaluate the clinical and radiological results of intra-articular injections performed with two different ultrasound-guided approaches in knee osteoarthritis.

Patients and methods: The randomized controlled study was conducted on 80 knees of 40 patients (9 males, 31 females; mean age: 63.6±8.2 years; range, 46 to 78 years) with Grade 2-3 gonarthrosis that underwent ultrasound-guided intra-articular injections with suprapatellar (SP) or infrapatellar (IP) approaches between March 2020 and January 2021. After the injection, opaque material spread was fluoroscopically observed. Before the procedure and at the one and three months after the procedure, patients' Visual Analog Scale (VAS) scores for pain and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores for functional recovery were recorded.

Results: In both techniques, one- and three-month VAS and WOMAC scores were found to be significantly lower ($p<0.001$ and $p<0.001$, respectively). Of the patients with positive opaque spread, 63.3% were in the IP technique group, and 36.7% were in the SP technique group ($p=0.003$). In 69.2% of those with radiologically positive opaque spread, the VAS score was significantly higher with >50% regression ($p=0.04$). In the IP technique, >50% regression rate of the VAS was 86.7% in patients with positive opaque spread, while VAS regression was significantly higher than those without opaque spread ($p=0.02$).

Conclusion: Although the IP approach shows an early-positive opaque transition due to its proximity to the joint, both approach techniques are clinically effective under ultrasound guidance.

Keywords: Chronic pain, infrapatellar approach, intra-articular injection, knee injection, knee osteoarthritis, suprapatellar approach, suprapatellar bursa, ultrasound-guided injection.

Knee osteoarthritis (gonarthrosis) is a common type of arthritis, particularly among the elderly, that causes chronic disability. The severity of symptoms correlates with cartilage degeneration, osteophyte formation, and synovitis.[1] Nonsteroidal anti-inflammatory drugs and intra-articular steroid and hyaluronic acid injections are beneficial in early-stage gonarthrosis.[2] Intra-articular steroid injection is recommended in patients with signs of local inflammation or effusion due to inflammation.[3] This injection, performed with minimally invasive methods under imaging guidance, may cause steroid lipoatrophy infiltrating the extra-articular adipose tissue and skin tissue when done blindly, and the local effectiveness

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of the steroid may decrease.[4] Consequently, the importance of imaging-guided injections, such as fluoroscopy and ultrasound (US), in reaching the target tissue is increasing. In addition, although blind injections are effective and practical in the presence of effusion, the efficacy of imaging-guided injection in dry knees has been confirmed.[5] Intra-articular injections with US are performed with three approaches: suprapatellar (SP), midpatellar, and infrapatellar (IP). All three approaches have advantages and disadvantages in different situations. The SP approach is preferred in obese patients and if there is effusion in the SP bursa. Since the medial femoral condyle is shorter in terms of anteroposterior length, the midpatellar medial approach provides easy needle insertion.[6] Comparisons of intra-articular radiographic distribution of intra-articular injections performed with different US-guided approaches have been made; however, the radiological results of different techniques, as well as pain and functional results, have not been examined. In this study, we examined the pain and functional recovery of patients who underwent US-guided SP and midpatellar lateral intra-articular injections with fluoroscopic confirmation.

PATIENTS AND METHODS

This randomized controlled study was conducted on 80 knees of 40 patients (9 males, 31 females; mean age: 63.6±8.2 years; range, 46 to 78 years) diagnosed with knee osteoarthritis according to the criteria of the American College of Rheumatology and Grade 2-3 gonarthrosis according to the Kellgren-Lawrence classification at the Adnan Menderes University Medical Faculty, Department of Algology between March 2020 and January 2021. The patients were separated with computer-assisted randomization into two groups of 20 to be applied US-guided SP or IP approaches. Patients with inflammatory arthritis, crystal arthropathy, knee trauma/surgery, psychiatric disorders, uncontrolled diabetes and hypertension, renal failure, coagulopathy, local infection, iodine allergy, and cases in which injection was contraindicated were excluded from the study.

The operating room was sterilized for the patients before the intra-articular injection, and the procedure was performed with the knee flexed at 30 to 90° in the supine position. An US device (LOGIQ™, GE Healthcare, USA) with a 10-15 MHz linear probe was used. Infrapatellar and SP intra-articular injection approaches were performed under sonographic guidance. A mixture of 1 mL nonionic contrast agent (iohexol), 0.5 mL betamethasone, and 3 mL 0.5% bupivacaine was injected into each knee. After the injection, the opaque material spread was fluoroscopically observed. Before the procedure and at one and three months, patients' Visual Analog Scale (VAS) scores for pain and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) osteoarthritis indices for functional recovery were recorded.

In the SP approach, the knee was placed in a semiflexed position (Figure 1a). Quadriceps muscle and the suprapatellar bursa were found to be longitudinally hypoechoic (Figure 1b). In this longitudinal plane, the transducer was moved slowly from medial to lateral and then rotated along the axis of the patella to prevent the needle from entering the suprapatellar tendon body. The probe was placed on the prepatellar ligament in the axial plane, and the suprapatellar pouch was targeted with a 22-gauge needle (Figures 1a, b). Care was taken to avoid injury to the quadriceps tendon, retropatellar cartilage, prefemoral fat pad, and SP fat pad.

In the IP (lateral) approach, the knee was placed in 90° flexion (Figure 1c). The entry point was approximately 1.5 cm from the lateral edge of the IP tendon. The US probe was placed on the anteromedial portal with its light close to the 25-gauge needle shaft. The needle tip was advanced from the anterolateral portal through the anterior fat pad under the IP tendon until it entered the synovial membrane covering the medial condyle (Figure 1d).

After the placement of the needle was completed, aspiration was performed with negative pressure. The intra-articular injection was made into the knee joint area with 3 mL 0.5% bupivacaine and 0.5 mL betamethasone mixture, and 1 mL of nonionic contrast agent

(iohexol) was given. All injections were performed by a single algologist.

After the sonography-guided intra-articular injection, fluoroscopic lateral and anterior-posterior views were taken to confirm correct the intra-articular injection. The injection was considered positive radiologically when the nonionic contrast material was observed only in the suprapatellar bursa (Figure 1e) or meniscus (Figure 1f). The injection was considered radiologically negative if the contrast medium was visible in the fat pad or the subsynovial tissue layers.

Statistical analysis

Data were analyzed with the IBM SPSS version 21.0 software (IBM Crop., Armonk, NY, USA). Conformity of continuous variables

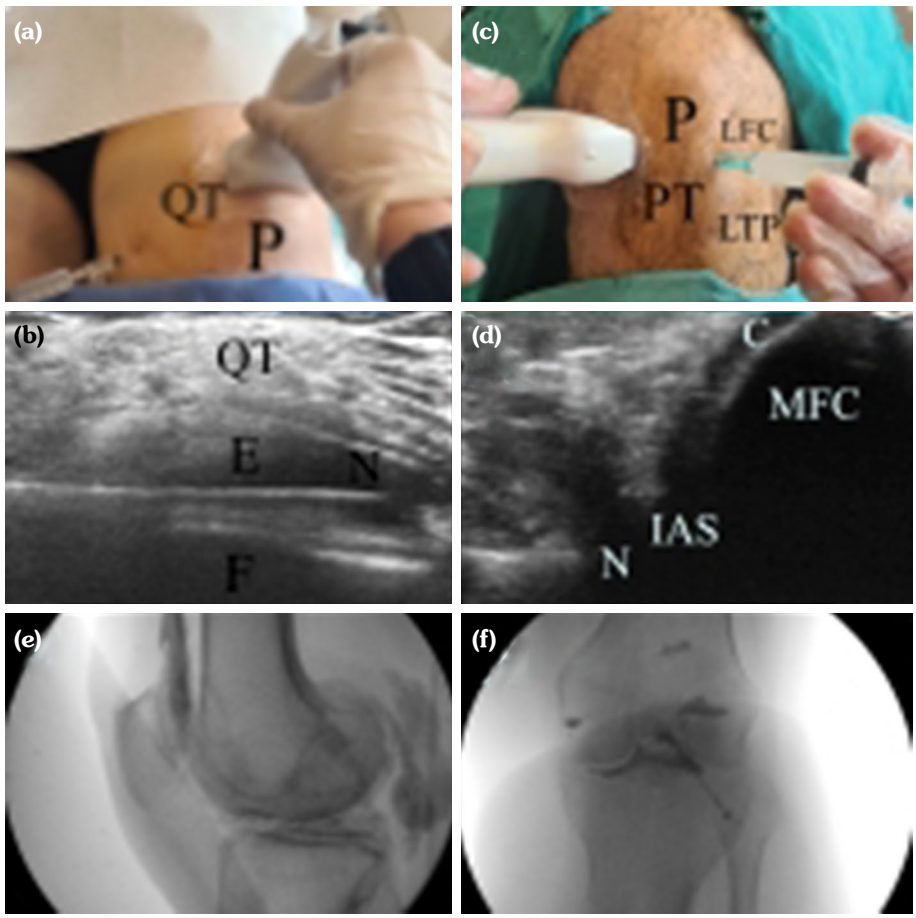

Figure 1. Images of patient positions, injection sites, US images of needle placements, and fluoroscopic confirmation of injection sites with opaque material for both approaches techniques. **(a)** In the SP approach, the placement of the US probe and the image of the needle insertion site while the knee is semiflexed. **(c)** In the IP lateral approach, with the knee flexed to 90°, the placement of the US probe and the image of the needle insertion site. **(b)** Sonographic axial image of the needle in the effusion in the SP bursa under the quadriceps tendon in the SP insertion technique. **(d)** Sonographic image of the needle in the synovium near de medial femoral condyle in the IP insertion technique. **(e)** Fluoroscopic lateral view of the opaque material spread in the subpopliteal recess, given from the suprapatellar pouch in the SP approach technique in the joint area. **(f)** Fluoroscopic AP image of the opaque material spread introduced into the joint area around the meniscal tissue in the midpatellar approach technique.

US: Ultrasound; QT: Quadriceps tendon; P: Patella; E: Effusion; LFC: Lateral femoral condyle; PT: Patellar tendon; LTP: Lateral tibial plateau; F: Femur; N: Needle tip; C: Cartilage; MFC: Medial femoral condyle; IAS: Intra-articular space; AP: Anteroposterior.

to normal distribution was investigated using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/ Shapiro-Wilk tests). For the descriptive statistics of the study, the data with normal distribution are expressed as mean and standard deviation, and the data that do not fit the normal distribution are presented as median, minimum, and maximum. The chi-square test was used to examine whether there was a difference between categorical variables in the study. Student's t-test and one-way analysis of variance were used for the comparison of continuous variables with parametric properties in independent groups. The Mann-Whitney U test and the Kruskal-Wallis analysis of variance were utilized in the comparison of continuous variables with nonparametric properties in independent groups. The paired samples t-test and the Friedman test were employed in the comparison of continuous variables with parametric properties in dependent groups. The Wilcoxon test and the Spearman test were used in the comparison of continuous variables in dependent groups that did not have parametric properties. A *p* value of <0.05 was considered statistically significant.

RESULTS

The mean body mass index was 29.9±4.6. Osteoarthritis was Stage 2 for 21 (26.3%) knees and Stage 3 for 59 (73.8%) knees. Synovial fluid drainage was performed with arthrocentesis in 22 (27.5%) knees. Forty-nine (61.3%) of 80 knees had radiologically positive opaque transition on fluoroscopic imaging. The comparison of demographic and clinical characteristics of the groups are given in Table 1.

In both techniques, the one-and three-month VAS scores were significantly lower after the procedure than before the procedure. In both techniques, one- and three-month WOMAC scores were significantly lower after the procedure than before the procedure (p<0.001 and p<0.001, respectively; Table 2). The rate of patients with >50% regression in the VAS score was 42.3% in the SP technique and 57.7% in the IP technique (p=0.06; Table 3).

Of the patients with positive opaque spread, 63.3% were in the IP technique group, and 36.7% were in the SP technique group. Positive opaque spread was significantly higher in the IP technique group (p=0.003).

While there was >50% regression in the VAS score in 69.2% of those with radiologically positive opaque spread during the procedure, 30.8% of those with negative opaque spread had a >50% regression in the VAS score. The rate of pain regression was significantly higher in those with positive opaque spread (p=0.04).

In the IP technique, >50% regression rate of VAS was 86.7% in patients with positive

Table 1. Comparison of demographic and clinical characteristics of the groups

	Total	SP technique group			IP technique group			
	n	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)	40			63.5±9.1			63.7±7.5	0.9
BMI	40			29.7±4.4			30±4.8	0.8
Sex								1.0
Male	9	5	25		4	20		
Female	31	15	75		16	80		
Kellgren Lawrence classification								0.8
Grade 2	21	11	27.5		10	25		
Grade 3	59	29	72.5		30	75		
Arthrocentesis (+)	22	15			7			0.04
Opaque spread (+)	49	18			31			0.003

SP: Suprapatellar; IP: Infrapatellar; SD: Standard deviation; BMI: Body mass index.

Table 2. Comparison of VAS and WOMAC scores of groups at 0, 1, and 3 months

	SP technique group				IP technique group				
	n	Mean±SD	Median	Min-Max	n	Mean±SD	Median	Min-Max	*p*
VAS 0	80	7.8±1.3	8	5-10	40	8±1.3	8	6-10	
VAS 1	80	4.3±1.9	4	2-9	40	3.7±1.8	3	1-8	<0.001
VAS 3	80	5.0±2.1	4	2-10	40	4.1±1.5	4	2-8	
WOMAC0	80	52.3±14.6	51.5	21.9-77	40	60.1±13.1	67.1	39.6-76	
WOMAC1	80	34.9±14.0	36.4	13.5-58.2	40	32.4±15.5	31.2	11.4-62.4	<0.001
WOMAC3	80	39.9±13.9	36.4	16.6-64.5	40	41.3±12.6	42.1	16.7-65.5	

VAS: Visual Analog Scale; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; SP: Suprapatellar; IP: Infrapatellar; SD: Standard deviation; Non-parametric test: Friedman test.

Table 3. Comparison of >50% VAS regression rates between groups

	VAS >%50 regression				
	Absent		Present		
	n	%	n	%	*p*
Approach techniques					
Suprapatellar	18	64.3	22	42.3	0.06
Infrapatellar	10	35.7	30	57.7	

VAS: Visual Analog Scale.

Table 4. Comparison of opaque spreads with >50% regression in VAS scores according to the approach technique

				VAS >%50 regression				
				Absent		Present		
				n	%	n	%	*p*
Approach techniques	SP	Opaque spread	+	10	55.6	12	54.5	0.949
			–	8	44.4	10	45.5	
	IP	Opaque spread	+	5	50	26	86.7	0.029
			–	5	50	4	13.3	

VAS: Visual Analog Scale; SP: Suprapatellar; IP: Infrapatellar.

opaque spread, and the VAS regression was significantly higher than those without opaque spread (p=0.02). In the SP technique, there was no significant relationship between opaque spread and VAS score regression (p=0.95; Table 4).

While >50% VAS regression was 28.8% in those who underwent arthrocentesis and 71.2% in those who did not, no significant relationship was found between arthrocentesis and pain relief (p=0.7).

DISCUSSION

The application of intra-articular injections guided by imaging is important for safe and effective injection. Blind applications may cause tissue damage as well as decreased effectiveness, particularly in obese patients and patients with dry knees. Studies comparing the palpation method and US guidance have revealed the high accuracy of US-guided injection. Im et al.[6]

found a high degree of accuracy with US (95.6%) compared to the blind method (77.3%) in the intra-articular injection of the knee. In the radiological confirmation of blind injection and US-guided injection, Bum Park et al.[7] found an accuracy of 96% with US and 83.7% with the blind method. As supported by studies, injections with imaging guidance and radiological confirmation increase success.

In addition to imaging guidance, another factor that can change the effectiveness of the injection is the approach. Existing studies examining the effectiveness of imaging-guided injections according to the approach are limited to either clinical or radiological analyses, and we obtained comprehensive results with both radiological confirmation, pain, and functional evaluation in this study. In our study, we found that both approach techniques were effective with a decrease in VAS and WOMAC scores at one- and three-month follow-ups. In the comparison of the two techniques, we did not find a significant difference between the groups in pain relief. In radiological confirmation, positive opaque spread was significantly higher in the IP approach. Again, regression in pain was significantly higher in those with positive opaque spread. In this study, unlike previous studies, we correlated radiological confirmation results with pain regression scores; in the IP approach, we also found positive opaque spread to be directly associated with pain relief. While the IP approach provides an injection closer to the joint area, the synovial folds that can be located in the SP recess in the SP approach are opaque and may delay and complicate the passage of the injection into the knee joint area.[8] It should be kept in mind that the injection made from the SP region may create a barrier in reaching the knee joint area due to these synovial membrane extensions, and the plica syndrome should be investigated with clinical and imaging in unsuccessful SP injections.

The studies available in the literature have combined radiologically different efficacy results according to the approach technique. In the study of Park et al.,[9] US-guided intra-articular injections were radiologically confirmed, revealing an accuracy rate of 75% with the medial approach and 100% with the superolateral approach. The results suggested that the suprapatellar bursa is more clearly visualized through sonographic guidance, and coaxial injection in medial and midpatellar approaches may increase the risk of extra-articular injection due to difficulty in detecting the needle tip. In another study, intra-articular propagation of injections performed with three US-guided approach techniques was confirmed with X-ray and color Doppler, and the mid-medial, mid-lateral, and superolateral approaches had 95%, 98.5%, and 100% intra-articular penetration rates, respectively.[10] Jackson et al.[11] fluoroscopically confirmed the passage of anterolateral, anteromedial, and midpatellar lateral approach injection into the knee joint in dry knees; they found 93% more midpatellar transition. Choi et al.[12] examined the clinical outcomes of US-guided IP (anterior) approach with two approach techniques; they reported a success rate of 87.8% with the medial approach and 91.5% with the lateral approach.

In a randomized study of Chavez-Chiang et al.,[13] the results of US-guided anterolateral and midpatellar lateral access techniques were compared in terms of pain score; both techniques were equally effective.

In a cadaver study, anterolateral 85% transition was shown with the four approach techniques, and it was not found to be significantly different from the anteromedial and midpatellar lateral approach.[14] Furthermore, the midpatellar medial entrance with 56% transition was found to be the least significant. The evaluation made with the present results is that the SP technique is more effective in cases where effusion can be seen under US guidance, the IP approach is more effective in dry knees, and a patient-oriented approach in the preprocedural sonographic evaluation of patients who will receive intra-articular injections and in the selection of the most appropriate approach technique is recommended. Lee et al.[15] concluded that the anterolateral technique with the IP approach was less painful compared to the anterolateral technique with the SP approach, although no difference was found in both techniques in terms of pain relief. Each technique has advantages and disadvantages, and patient-oriented technique selection should be made in line with the clinician's experience.

In our study, unlike previous similar studies, positive opaque spread rates have been found

to be lower for both techniques (SP: 45%, IP: 77.5%). In the study of Chagas-Neto et al.,[16] radiological confirmation of the injections with the US-guided SP approach was performed with magnetic resonance imaging and computed tomography within 10 to 15 min, and intra-articular penetration was found to be at a rate of 94.2%. In one study, radiological image confirmation was performed with X-ray 10 to 15 min after the injection, and the transition from the SP bursa to the joint was confirmed at a rate of 96%.[7] In our study, we obtained fluoroscopic images in the early period after the injection. This may have caused false-negative opaque propagation, specifically in the SP technique, and dry knees due to the imaging of the opaque material before it enters the joint area. The fact that neither technique is superior to the other in function and pain scores and that both are effective shows that radiological evaluation alone will not be sufficient, revealing the importance of correlating radiological confirmation with clinical evaluation.

It is important to evaluate the safety as well as efficiency of the approach techniques. In the SP approach, it is difficult to insert the needle at the target point if there is little or no effusion, resulting in a risk of muscle-tendon damage. In the IP approach, there is a risk of cartilage and periosteal damage due to close proximity. These complications may cause negative results, such as changing the character of the pain after the procedure and increasing the severity of pain. We did not evaluate the approach techniques in terms of tissue injury complications in our study. However, safety as well as efficiency are important in the choice of approach technique. Future studies will shed light on this issue.

In our study, both techniques had equal clinical efficacy. In the results we radiologically obtained, a delayed radiological confirmation after injections would have given more accurate results. The most appropriate approach technique in line with the clinical experience of the practitioner should be selected considering the patient's clinical characteristics (body mass index and effusion), anatomical barriers (presence of osteophytes, plica syndrome, Hoffa pad, and medial narrowing), and complications for possible tissue injury (tendon, muscle, periosteum, and cartilage damage).

The main limitations of our study are the low number of patients and knee injections, the radiological confirmation images being taken in a short time after the procedure, which might have caused a false-negative radiological transition record, and the lack of safety comparison. Future studies with large samples are needed to elucidate these limitations.

In conclusion, both the SP and IP approaches are effective in US-guided intra-articular injections in early to mid-stage knee osteoarthritis. Injections applied with the correct approach in the appropriate patient increase efficiency and safety.

Ethics Committee Approval: Approval was obtained from the Interventional Clinical Research Ethics Committee (2020/03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, design: E.E., S.S.; Control/supervision, critical review: E.E., S.S., O.N.A.; Data collection and/or processing, writing the article: E.E., D.E.; Analysis and/or interpretation: E.E., D.E., S.S.; Literature review: E.E., D.E., S.S., O.N.A.

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