Turk J Phys Med Rehab 2026;72(1):93-98
DOI: 10.5606/tftrd.2026.16756
Available online at www.turkishjournalpmr.com

Original Article

Evaluation of loss of resistance technique using an air-filled injector to enhance accuracy of landmark-guided knee joint injections

Hamit Göksu

Department of Pain Medicine, University of Health Sciences, Ankara Dr. Abdurrahman Yurtaslan Oncology Health Application and Research Center, Ankara, Türkiye

ABSTRACT

Objectives: This study aims to compare the accurate intra-articular contrast distribution ratios between the loss of resistance with an air-filled injector (AFI) technique and the traditional landmark-guided knee injection in patients with knee osteoarthritis (OA).

Patients and methods: Between July 2023 and December 2023, a total of 65 patients (8 males, 57 females; mean age: 65.6±8.3 years; range, 51 to 84 years) with Kellgren-Lawrence Stage 2-4 knee OA were randomly assigned to two groups as Group 1 (n=33) who were injected with a mixture of a contrast agent and triamcinolone hydrochloride and as Group 2 (n=32) who were injected with a 5-mL syringe containing 2 mL of air. After the air in the syringe was removed by loss of resistance, a mixture of contrast agent and triamcinolone hydrochloride was injected. Data including demographic and clinical characteristics of the patients were recorded. The contrast distribution was visualized by fluoroscopy in both groups. The patient's pain after the knee injection was evaluated using the Visual Analog Scale (VAS).

Results: The groups were similar in terms of age, sex, body mass index, Kellgren-Lawrence stage, VAS score, duration of knee pain, and pain during knee injection ($p>0.05$). The accurate intra-articular contrast distribution ratios were 66.7% and 90.6% in Groups 1 and 2, respectively ($p=0.019$). No variable was found to be associated with an accurate intra-articular injection ratio.

Conclusion: The AFI loss of resistance technique may significantly enhance the accuracy of landmark-guided knee injections and serve as a practical alternative in outpatient settings where imaging is unavailable.

Keywords: Anatomic landmarks, corticosteroids, injections, intra-articular, knee, osteoarthritis.

Knee osteoarthritis (OA) is a prevalent health issue worldwide, with its prevalence increasing with age.[1] Various treatment modalities are available for the treatment of knee OA in clinical practice.[2] Exercises, weight management, education, oral or topical nonsteroidal anti-inflammatory drugs, and intra-articular steroid injections are the most recommended methods, with high-level evidence.[3] Joint injections are frequently performed in outpatient clinics by physicians of various specialties under imaging guidance or using anatomic landmarks. The drugs should be administered directly into the intra-articular space rather than into the extra-articular space, the anterior fat pad, or extra-synovial tissue to achieve the maximum therapeutic effect and minimize complications. To achieve accurate injection, the knee injection may be performed under ultrasound (US) or fluoroscopic guidance.[4] However, imaging modalities do not exist in every outpatient setting. Therefore, landmark-guided injections still remain the most commonly used method for knee joint injections. Superolateral and anterolateral landmark methods are the most widely used landmark-guided techniques for knee joint injections. The accuracy rates for knee injections using the superolateral and anterolateral anatomical landmarks have been reported to vary from 71 to 91%.[5] Methods such as attaching a syringe of injectate to the needle and applying slight pressure to the plunger during needle insertion to achieve a loss of resistance, as well as

Corresponding author: Hamit Göksu, MD. Ankara Sağlık Bilimleri Üniversitesi, Ağrı Tıp Anabilim Dalı, Dr. Abdurrahman Yurtaslan Onkoloji Sağlık Uygulama ve Araştırma Merkezi, 06200 Yenimahalle, Ankara, Türkiye.

E-mail: hamitgoksu@yahoo.com

Received: April 22, 2025 **Accepted:** November 25, 2025 **Published online:** January 14, 2026

Cite this article as: Göksu H. Evaluation of loss of resistance technique using an air-filled injector to enhance accuracy of landmark-guided knee joint injections. Turk J Phys Med Rehab 2026;72(1):93-98. doi: 10.5606/tftrd.2026.16756.

post-injection imaging with a 10-mL air-arthrogram and fluoroscopy were used to improve the accuracy of joint injections.[6-8]

In the present study, we aimed to compare the accurate intra-articular contrast distribution ratios between the loss of resistance with an air-filled injector (AFI) technique and the traditional landmark-guided knee injection.

PATIENTS AND METHODS

This observational study was conducted at Ankara Dr. Abdurrahman Yurtaslan Oncology Health Application and Research Center, Department of Pain Medicine between July 2023 and December 2023. Patients over 50 years of age with Kellgren-Lawrence Stage 2-4 knee OA, no additional pathology on radiography, and physical examination findings to explain the knee pain, and persistent pain despite medical treatment were included in the study. Exclusion criteria were as follows: fractures, malignancies, bone marrow diseases, substance addiction, previous knee surgery, active effusion in the knee joint, a bleeding disorder hindering joint injection, systemic or any local infection, Stage 1 knee OA, and a history of knee injection in the previous six months. Finally, a total of 65 patients (8 males, 57 females; mean age: 65.6±8.3 years; range, 51 to 84 years) who met the inclusion criteria were recruited. Using computer-assisted randomization,[9] the patients were randomly assigned to two groups as Group 1 (n=33) who were injected with a mixture of a contrast agent and triamcinolone hydrochloride and as Group 2 (n=32) who were injected with a 5-mL syringe containing 2 mL of air. After the air in the syringe was removed by loss of resistance, a mixture of contrast agent and triamcinolone hydrochloride was injected. Data including demographic and clinical characteristics of the patients were recorded. A written informed consent was obtained from each patient. The study protocol was approved by the Health Sciences University, Dr. Abdurrahman Yurtaslan Ankara Oncology Health Practice and Research Center Clinical Research Ethics Committee (Date: 09.06.2023, No: 2023-08/284). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Knee joint injections were administered to all patients in the supine position with the knee flexed to 90 degrees using the anterolateral approach, 1 cm proximal to the joint line, lateral to the patellar tendon. The needle was directed toward the intercondylar notch after cleaning the injection area with betadine.[10] In Group 1, the patients were injected with 1 mL of a mixture of contrast agent (iohexol) and triamcinolone hydrochloride (5 mg/mL) in a 5-mL 21-G syringe, following the sensation of the intra-articular space. The patients in Group 2 were injected with a 5 mL 21-G syringe containing 3 mL of air. After the air in the syringe was removed with the loss of resistance, 1 mL of a mixture of contrast agent (iohexol; Omnipaque® 300 mg/mL vial, GE Healthcare Ireland, Cork, Ireland) and triamcinolone hydrochloride 5 mg/mL (1 mL; Koçak Pharma®, Istanbul, Türkiye) was injected. Following the procedure, contrast material distribution was visualized by fluoroscopy in both groups and the frequency of intra-articular contrast enhancement was documented. The procedure was repeated under fluoroscopy guidance in patients without intra-articular contrast enhancement. The procedural pain of the patients was evaluated by a nurse using the Visual Analog Scale (VAS) of 0-10.

Statistical analysis

Study power analysis and sample size calculation were performed using the G*Power version 3.1.4 software (Heinrich Heine Universität Düsseldorf, Düsseldorf, Germany). According to the comparison of accuracy rates between the two methods (89% vs. 58%) as described by Chernchujit et al.,[4] it was calculated that 60 patients, 30 in each group, were required with a 0.580 effect size, 5% of margin of error of and 80% study power.

Statistical analysis was performed using the IBM SPSS version 27.0 software (IBM Corp., Armonk, NY, USA). The normality of numerical data distribution was examined using the Shapiro-Wilk normality test. Normally distributed continuous variables were presented in mean ± standard deviation (SD), while non-normally distributed ones were presented in median and interquartile range (IQR; 25^{th}-75^{th} percentiles). Qualitative data were presented in numbers and frequencies. Categorical variables were analyzed using the Fisher exact test to compare the groups. Numeric variables with parametric distribution were compared using the independent samples t-test, equality of variances was tested with the Welch t-test, and non-parametric variables were analyzed using the Mann-Whitney U test. Binary logistic regression was performed to determine

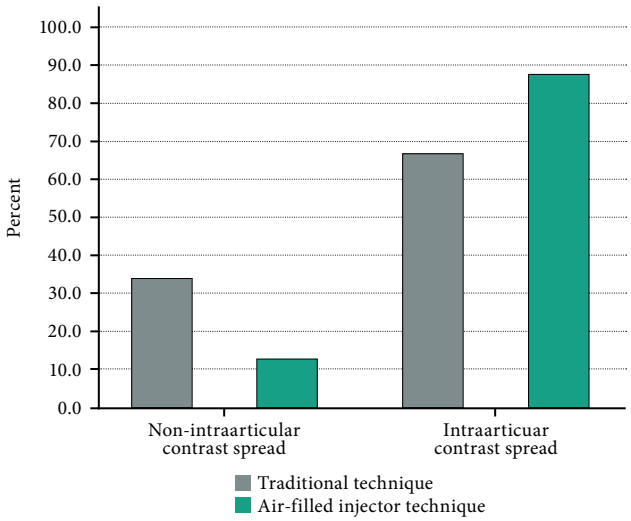

Figure 1. Ratio of inaccurate and accurate contrast spread of the groups.

which variables were associated with the ratio of accurate intra-articular injections. The confidence interval was set at 95%, and the accepted margin of error was 5%. A *p* value of <0.05 was considered statistically significant.

RESULTS

The non-intraarticular and intraarticular contrast distribution ratios are shown in Figure 1. The intra-articular contrast distribution rates were 66.7% and 90.6% in the traditional technique and AFI groups, respectively (p=0.019). The groups were similar in terms of age, sex, and body mass index (BMI) (p>0.05). The sociodemographic characteristics of the groups are given in Table 1. The clinical features of the patients, categorized by group, are presented in Table 2. The ratios of Kellgren-Lawrence stage, VAS score, injection side, pain duration, and pain after knee injection were similar between the groups (p>0.05). An example of accurate injection using the loss of resistance technique and inaccurate injection with traditional methods is illustrated in Figure 2.

No complications were observed in any of the patients. Binary logistic regression analysis, which included age, BMI, sex, OA stage, painful side, and treatment groups, revealed no significant variables that increased the odds ratio (OR) for accurate intra-articular contrast distribution in either group (p>0.05), except for in favor of AIF technique above traditional technique (OR=4.25, 95% CI: 1.003-18.282; p=0.039).

TABLE 1
Sociodemographic features of the patient groups

	Group 1 (n=33)			Group 2 (n=32)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			65.9±8.6			65.1±8.2	0.664
Sex							0.258
Female	27	81.8		30	93.8		
Male	6	18.2		2	6.2		
Body mass index (kg/m^2)			29.3±4.9			26.8±6.5	0.085
Occupation							*
Housewife	25	75.8		28	87.5		
Retired	7	21.2		1	3.1		
Worker	1	3.0		1	3.1		
Officer	-	-		2	6.3		
Marital status							*
Married	24	72.7		25	78.1		
Widow	9	27.3		7	21.9		
Education							*
Illiterate	5	15.2		6	18.8		
Primary school	20	60.6		20	62.5		
Intermediate school	6	18.29		3	9.4		
High school	2	6.1		1	3.1		
University	-	-		2	6.3		
Smoking	4	12.1		2	6.3		*

SD: Standard deviation; * Not evaluated because of a low number of cases, which does not meet chi-square test criteria.

TABLE 2
Clinical features of the injection groups

	Group 1 (n=33)				Group 2 (n=32)				
	n	%	Median	IQR	n	%	Median	IQR	*p*
Systemic diseases									*
Hypertension	13	39.4			10	31.3			
Diabetes mellitus	5	15.2			2	6.3			
Coronary arterial disease	2	6.1			-	-			
Asthma	2	6.1			-	-			
Hypothyroidism	-	-			2	6.3			
Others	2	6.1			-	-			
Kellgren-Lawrence stage									0.930
2	6	18.2			7	21.9			
3	17	51.5			16	50.0			
4	10	30.3			9	28.1			
VAS score			7.0	1.0			7.0	2.0	0.362
Side of pain/injection									0.890
Right	18	54.5			18	56.3			
Left	15	45.5			14	43.8			
Duration of pain (months) (median; IQR)			12.0	15.0			15.5	14.0	0.389
Pain in injection (median; IQR)			3.0	1.0			3.0	1.0	0.863
Proper contrast spread (n/%)	22	66.7			29	90.6			**0.019**

IQR: Interquartile range; VAS: Visual analog scale; * Not evaluated because of a low number of cases, which does not meet chi-square test criteria.

DISCUSSION

Knee OA is one of the most common conditions seen by physicians managing pain in the growing elderly population. There are various treatment modalities for knee OA, including exercise, weight loss, analgesic agents, physical therapy, acupuncture, viscosupplementation, thermal modalities, intra-articular steroid injections, platelet-derived growth factors, mesenchymal stem cell therapy, and, ultimately, surgery.[11-13] Intra-articular knee joint injections have been used for a long time for knee OA and are most commonly performed in knee injections, although many different substances have emerged in recent years. Intra-articular steroid is recommended for pain relief in the American College of Rheumatology (ACR) and Osteoarthritis Research Society International (OARSI) guidelines.[14,15] Although imaging modalities such

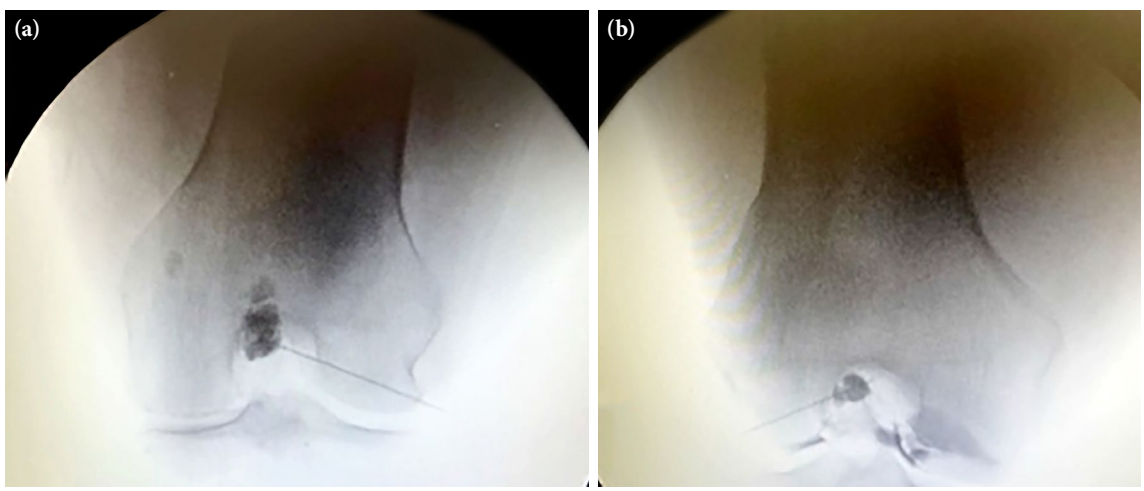

Figure 2. Inaccurate **(a)** and accurate **(b)** contrast spread.

as US and fluoroscopy are widely used, knee joint injections are still most commonly performed using the landmark method in clinical practice. However, US-guided injections have been shown to be more accurate than the landmark technique.[16,17]

Ultrasound guidance may not be necessary for easily accessed joints such as the knee. Also, US may not be available in every outpatient setting. Fluoroscopy is commonly used to guide joint injections, as it is widely available, cost-effective, rapid, and easy to use.[18] Fluoroscopy also enables us to visualize the contrast injection, the needle's position and location within the joint, the integrity of the bone, and any additional pathologies.[19] There is no concern about loss of needle image as with US. However, fluoroscopy has certain disadvantages, such as radiation exposure, and cannot be performed in outpatient rooms.

To date, various approaches have been defined and used for landmark-guided knee injections.[5] Superolateral and anterolateral approaches are commonly used. The anterolateral approach has been shown to be more accurate and less painful in some studies.[4,10] However, a systematic review revealed that the superolateral approach (91%) was more accurate than the midpatellar (85%), anterolateral (67%), and anteromedial (72%) approaches.[20] Also, a modified anterolateral approach was described in patients with knee OA by Chernchujit et al.[4] They found that this new technique led to a higher accuracy rate than the superolateral technique. The authors used a 10-mL air injector and observed air backflow in both groups. The accuracy rate of the anterolateral approach in this study was 66.7%, which is similar to the accuracy ratio reported in the review mentioned above. The low accuracy rates highlight the importance of accurate intra-articular needle placement guided by imaging. Oo et al.[21] reported that US-guided intra-articular injections achieved superior outcomes compared to landmark-guided injections. Varlotta et al.[22] showed that hyaluronic acid injection into the suprapatellar recess under US guidance spreads into the tibiofemoral joint in fluoroscopic confirmation. Therefore, imaging modalities may not be available in outpatient clinics, and using imaging techniques requires more time for physicians. In the outpatient setting, the time needed for imaging-guided injections may not always be feasible, particularly in Türkiye, where there are many patients per outpatient clinic. In our study, we found an extremely high accuracy rate of 90.6% using an AFI, suggesting that this technique may enhance the perception of joint sensation. Nevertheless, the AFI technique could not be as valuable as imaging. Additionally, the VAS pain score in the AFI technique was comparable to that achieved with the traditional anterolateral injection.

The main limitations to this study include its relatively small sample size, the lack of patient-reported outcome measures and long-term follow-up, and the inclusion of patients who received only steroid injections.

In conclusion, our study results suggest that the AFI loss of resistance technique may significantly enhance the accuracy of landmark-guided knee injections and serve as a practical alternative in outpatient settings where imaging is unavailable.

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

Conflict of Interest: The author declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The author received no financial support for the research and/or authorship of this article.

REFERENCES

1. Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, et al. The global burden of hip and knee osteoarthritis: Estimates from the global burden of disease 2010 study. Ann Rheum Dis 2014;73:1323-30. doi: 10.1136/annrheumdis-2013-204763.
2. Brophy RH, Fillingham YA. AAOS Clinical practice guideline summary: Management of osteoarthritis of the knee (Nonarthroplasty), Third Edition. J Am Acad Orthop Surg 2022;30:e721-9. doi: 10.5435/JAAOS-D-21-01233.
3. Gibbs AJ, Gray B, Wallis JA, Taylor NF, Kemp JL, Hunter DJ, et al. Recommendations for the management of hip and knee osteoarthritis: A systematic review of clinical practice guidelines. Osteoarthritis Cartilage 2023;31:1280-92. doi: 10.1016/j.joca.2023.05.015.
4. Chernchujit B, Tharakulphan S, Apivatgaroon A, Prasetia R. Accuracy comparisons of intra-articular knee injection between the new modified anterolateral Approach and superolateral approach in patients with symptomatic knee osteoarthritis without effusion. Asia Pac J Sports Med Arthrosc Rehabil Technol 2019;17:1-4. doi: 10.1016/j.asmart.2019.02.001.
5. Douglas RJ. Aspiration and injection of the knee joint: Approach portal. Knee Surg Relat Res 2014;26:1-6. doi: 10.5792/ksrr.2014.26.1.1.
6. Rastogi AK, Davis KW, Ross A, Rosas HG. Fundamentals of joint injection. AJR Am J Roentgenol 2016;207:484-94. doi: 10.2214/AJR.16.16243.

7. Wani Z, Bali N, Shahid M, Jiggins M, O'Hara J. Air arthrography to confirm intra-articular positioning for hip injections. Ann R Coll Surg Engl 2014;96:389. doi: 10.1308/rcsann.2014.96.5.389.
8. Bliddal H. Placement of intra-articular injections verified by mini air-arthrography. Ann Rheum Dis 1999;58:641-3. doi: 10.1136/ard.58.10.641.
9. Research randomizer. Available at: https://www.randomizer.org, Accessed: 30.03.2025
10. Lee SY, Gn KK, Chung BJ, Lee SW, Kim TK. Anterolateral portal is less painful than superolateral portal in knee intra-articular injection. Knee Surg Relat Res 2015;27:228-32. doi: 10.5792/ksrr.2015.27.4.228.
11. Katz JN, Arant KR, Loeser RF. Diagnosis and treatment of hip and knee osteoarthritis: A review. JAMA 2021;325:568-78. doi: 10.1001/jama.2020.22171.
12. Kan HS, Chan PK, Chiu KY, Yan CH, Yeung SS, Ng YL, et al. Non-surgical treatment of knee osteoarthritis. Hong Kong Med J 2019;25:127-33. doi: 10.12809/hkmj187600.
13. Sharma L. Osteoarthritis of the knee. N Engl J Med 2021;384:51-9. doi: 10.1056/NEJMcp1903768.
14. Kolasinski SL, Neogi T, Hochberg MC, Oatis C, Guyatt G, Block J, et al. 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Management of Osteoarthritis of the Hand, Hip, and Knee. Arthritis Care Res (Hoboken) 2020;72:149-62. doi: 10.1002/acr.24131.
15. Bannuru RR, Osani MC, Vaysbrot EE, Arden NK, Bennell K, Bierma-Zeinstra SMA, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. Osteoarthritis Cartilage 2019;27:1578-89. doi: 10.1016/j.joca.2019.06.011.
16. Wu T, Dong Y, Song Hx, Fu Y, Li JH. Ultrasound-guided versus landmark in knee arthrocentesis: A systematic review. Semin Arthritis Rheum 2016;45:627-32. doi: 10.1016/j.semarthrit.2015.10.011.
17. Shen PC, Lin TY, Wu WT, Özçakar L, Chang KV. Comparison of ultrasound- vs. landmark-guided injections for musculoskeletal pain: An umbrella review. J Rehabil Med 2024;56:jrm40679. doi: 10.2340/jrm.v56.40769.
18. Rastogi AK, Davis KW, Ross A, Rosas HG. Fundamentals of joint injection. AJR Am J Roentgenol 2016;207:484-94. doi: 10.2214/AJR.16.16243.
19. Malhotra G, Hansford BG, Felcher C, Wuerfel KA, Yablon CM. Fluoroscopic-guided procedures of the lower extremity. Skeletal Radiol 2023;52:855-74. doi: 10.1007/s00256-022-04139-w.
20. Hermans J, Bierma-Zeinstra SM, Bos PK, Verhaar JA, Reijman M. The most accurate approach for intra-articular needle placement in the knee joint: A systematic review. Semin Arthritis Rheum 2011;41:106-15. doi: 10.1016/j.semarthrit.2011.02.007.
21. Oo WM, Linklater J, Siddiq MAB, Fu K, Hunter DJ. Comparison of ultrasound guidance with landmark guidance for symptomatic benefits in knee, hip and hand osteoarthritis: Systematic review and meta-analysis of randomised controlled trials. Australas J Ultrasound Med 2024;27:97-105. doi: 10.1002/ajum.12386.
22. Varlotta C, Harbus M, Spinner D. Accuracy of ultrasound-guided knee injections confirmed by fluoroscopy. Interv Pain Med 2023;2:100174. doi: 10.1016/j.inpm.2022.100174.