RESEARCH PAPER

Ultrasound-Guided Versus Landmark-Guided Injection in Knee Osteoarthritis: A Comparative Study of Pain Trajectory, Functional Recovery, and Treatment Durability

Dr. Tapankumar R. Patel[1], Dr. Chetan Kothari[2], Dr. Mihir Tejura[3]*, Dr. Parth Pavasiya[4], Dr. Himalaya Thumar[5]

[1]Senior Resident, Department of Orthopaedics, BHRC, Pune, Maharashtra, India.
[2]Senior Resident, Department of Orthopaedics, BHRC, Pune, Maharashtra, India.
[3]Senior Resident, Department of Orthopaedics, GMERS Medical College and Civil Hospital, Morbi, Gujarat, India.
[4]Senior Resident, Department of Orthopaedics, BHRC, Pune, Maharashtra, India.
[5]Consultant Orthopedic Surgeon, Kashiba Multispeciality Hospital, Rajula, Amreli, Gujarat, India.

Corresponding Author
*** Dr. Parth Pavasiya**
Senior Resident,
Department of Orthopaedics,
BHRC, Pune, Maharashtra, India.
Email: pavasiyaparth@gmail.com

Abstract

Background: Intra-articular injections are a mainstay of conservative management in knee osteoarthritis (OA). Accuracy of needle placement affects clinical outcomes, and ultrasound (US) guidance has been proposed as superior to conventional landmark-guided injection.

Objective: To compare pain trajectory, functional recovery, and treatment durability between ultrasound-guided and landmark-guided intra-articular corticosteroid injections in patients with symptomatic knee OA.

Methods: A prospective, randomized, single-blinded comparative study was conducted on 120 patients (60 per group) with Kellgren–Lawrence grade II–III knee OA. Outcomes were assessed at baseline, 2, 6, 12, and 24 weeks using the Visual Analogue Scale (VAS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Lequesne Index.

Results: The US-guided group showed significantly greater reductions in VAS and WOMAC scores at all follow-up intervals, with a longer duration of symptomatic relief and fewer procedural complications ($p < 0.05$).

Conclusion: Ultrasound guidance improves accuracy, magnitude, and durability of therapeutic response in knee OA injections and should be preferred where feasible.

Keywords: knee osteoarthritis; ultrasound-guided injection; landmark-guided injection; corticosteroid; WOMAC; VAS.

How to cite this article: Tapankumar R. Patel. Ultrasound-Guided Versus Landmark-Guided Injection in Knee Osteoarthritis: A Comparative Study of Pain Trajectory, Functional Recovery, and Treatment Durability. Int J Drug Deliv Technol. 2026;16(76s):2218-2224. DOI: 10.25258/ijddt.16.76s.220.

1. Introduction

Osteoarthritis (OA) of the knee is among the most prevalent chronic musculoskeletal disorders worldwide and constitutes a leading cause of pain, physical disability, and reduced quality of life among middle-aged and elderly individuals [1]. The Global Burden of Disease Study estimated that symptomatic knee OA affects approximately 250 million people globally, with prevalence rising sharply due to population ageing, sedentary lifestyles, and increasing obesity [2]. In South Asia, community-based surveys report a prevalence between 22% and 39% in adults above 40 years, with women and rural populations disproportionately affected [3].

Knee OA is characterised by progressive degradation of articular cartilage, subchondral bone remodelling, osteophyte formation, and low-grade synovial inflammation, culminating in pain, stiffness, and functional impairment [4]. Contemporary management follows a stepwise pyramid that begins with patient education, weight reduction, physical therapy, and analgesics, and escalates to intra-articular injections and, ultimately, arthroplasty in end-stage disease [5]. Intra-articular corticosteroid (IACS) injections remain one of the most widely used interventions for moderate symptomatic OA because they offer rapid analgesic and anti-inflammatory relief when systemic therapies fail or are contraindicated [6]. Viscosupplementation with hyaluronic acid and, more recently, platelet-rich plasma have expanded the biological options available in the outpatient setting [7].

The therapeutic success of any intra-articular injection depends heavily on accurate delivery of the drug into the synovial cavity. Extra-articular deposition not only diminishes efficacy but may also cause soft-tissue atrophy, hypopigmentation, and iatrogenic pain [8]. Classical landmark-guided (blind or "palpation-guided") techniques rely on surface anatomy—typically the anteromedial, anterolateral, or superolateral approaches to the patellofemoral compartment. Cadaveric and

fluoroscopic validation studies have shown that even in experienced hands, blind needle placement misses the joint space in 15–45% of attempts, and this rate rises further in obese patients or in the absence of a demonstrable effusion [9,10].

Ultrasound (US) guidance offers real-time visualisation of the needle tip, joint capsule, synovial recesses, cartilage, and adjacent neurovascular structures, allowing operators to confirm intra-articular placement before injectate delivery [11]. Multiple prospective series have documented accuracy rates approaching 95–100% with US guidance, together with a reduction in procedural pain, faster onset of relief, and prolongation of therapeutic benefit compared with blind techniques [12,13]. Analogous evidence from shoulder, hip, and small joint injections further supports the clinical superiority of image-guided injections over anatomical landmark techniques [14,15].

Despite this expanding evidence base, landmark-guided injection remains the default approach in a large proportion of outpatient clinics owing to cost, equipment availability, operator familiarity, and time constraints [16]. Head-to-head comparative data specifically addressing pain trajectory, functional recovery, and, importantly, the durability of therapeutic response remain relatively limited, and the few available randomised comparisons often report heterogeneous follow-up periods and inconsistent outcome instruments [17]. Establishing whether US guidance provides not only a short-term analgesic advantage but also a more sustained functional gain is critical to informed patient counselling and rational allocation of imaging resources.

The present study was therefore designed as a prospective, randomised, comparative trial evaluating US-guided versus landmark-guided intra-articular corticosteroid injection in patients with symptomatic knee OA. The primary aim was to compare pain trajectory (VAS), functional recovery (WOMAC and Lequesne indices), and duration of symptomatic relief over a 24-week follow-up period. Secondary aims included assessment of procedural safety, patient satisfaction, and rescue medication requirements.

2. Materials and Methods

2.1 Study Design and Setting

This prospective, randomised, single-blind, parallel-group comparative study was carried out in the outpatient department of Orthopaedics of a tertiary care teaching hospital from January 2024 to March 2025. Ethical approval was obtained from the Institutional Ethics Committee, and the study was registered prospectively with the Clinical Trials Registry. All participants provided written informed consent in the vernacular language after receiving detailed explanation of the study procedures, potential risks, and benefits [18].

2.2 Sample Size

Sample size was estimated based on a previous randomised trial that reported a mean VAS reduction difference of 1.4 (SD 2.3) between US-guided and landmark-guided injections at 6 weeks [13]. Using a two-tailed α of 0.05 and power of 90%, the minimum required sample per group was calculated at 54, which was inflated to 60 per group to accommodate a projected 10% attrition. A total of 120 patients were therefore recruited.

2.3 Participants

Inclusion criteria were: age 45–75 years; a clinical diagnosis of primary knee OA fulfilling the American College of Rheumatology criteria; radiographic Kellgren–Lawrence (K–L) grade II or III on standing anteroposterior radiographs [19]; symptoms of at least six months duration; and a baseline VAS ≥ 4 despite three months of standard non-operative therapy including analgesics and physiotherapy.

Exclusion criteria included K–L grade I or IV OA, secondary OA (inflammatory, post-traumatic, septic, or crystal arthropathy), previous knee surgery, intra-articular injection within the preceding six months, uncontrolled diabetes mellitus (HbA1c > 8.0%), coagulopathy or use of anticoagulants, local skin infection, pregnancy, or refusal of consent.

2.4 Randomisation and Blinding

Eligible patients were randomised in a 1:1 ratio using a computer-generated random number sequence into two groups: **Group A (US-guided injection)** and **Group B (landmark-guided injection).** Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes. Patients and the outcome assessor were blinded to the mode of injection; the operator could not be blinded owing to the nature of the intervention [20].

2.5 Intervention

All injections were performed under strict aseptic precautions by a single orthopaedic surgeon with more than seven years of experience in both techniques. Each patient received a standardised injection consisting of 40 mg (1 mL) of triamcinolone acetonide combined with 4 mL of 1% lignocaine, delivered through a 22-gauge, 1.5-inch needle [21].

Group A (US-guided): With the patient supine and the knee flexed to 20–30°, a high-frequency linear transducer (7–12 MHz) was placed in the parasagittal plane over the suprapatellar recess. Under real-time ultrasound visualisation, the needle was introduced via a lateral in-plane approach into the suprapatellar bursa, and intra-articular placement was confirmed by visualising the needle tip within the synovial recess and observing anechoic spread of the injectate.

Group B (Landmark-guided): With the patient supine and the knee fully extended, injection was

performed via the superolateral approach, entering 1 cm superior and 1 cm lateral to the superolateral corner of the patella, with the needle directed towards the intercondylar notch. Intra-articular position was inferred from loss of resistance and unimpeded flow of the injectate [22].

All patients received identical post-procedure instructions, including 24 hours of relative rest, avoidance of strenuous activity for 48 hours, and continuation of a standardised home exercise programme. Rescue analgesia in the form of oral paracetamol (up to 3 g/day) was permitted, and consumption was recorded.

2.6 Outcome Measures

Patients were evaluated at baseline, 2 weeks, 6 weeks, 12 weeks, and 24 weeks post-injection. The following outcomes were recorded: (1) Visual Analogue Scale (VAS) for pain, 0–10 [23]; (2) WOMAC score, evaluating pain, stiffness, and physical function (total 0–96) [24]; (3) Lequesne Algofunctional Index (0–24) for severity and functional impairment [25]; (4) Patient global satisfaction on a 5-point Likert scale at 12 and 24 weeks; (5) Duration of symptomatic relief, defined as the interval from injection until VAS returned to within 1 point of baseline or additional intervention was required; and (6) Adverse events including post-injection flare, infection, skin discolouration, or subcutaneous atrophy [26].

2.7 Statistical Analysis

Data were analysed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Between-group comparisons at each time point were performed using the independent Student's t-test, while within-group changes over time were analysed using repeated-measures ANOVA. Categorical data were compared using the Chi-square or Fisher's exact test. Duration of therapeutic effect was analysed using the Kaplan–Meier method with log-rank comparison. A two-tailed p-value < 0.05 was considered statistically significant [27].

3. Results

3.1 Baseline Characteristics

Of the 120 patients enrolled, 114 completed the full 24-week follow-up (58 in Group A, 56 in Group B). Six patients (two in Group A, four in Group B) were lost to follow-up or withdrew consent. Baseline demographic and clinical parameters were comparable between the two groups (Table 1).

Table 1. Baseline demographic and clinical characteristics of the study groups

Parameter	Group A (US-guided) n=60	Group B (Landmark) n=60	p-value
Age (years), mean ± SD	58.4 ± 7.9	59.1 ± 8.2	0.63
Female : Male	39 : 21	41 : 19	0.70
BMI (kg/m²), mean ± SD	27.8 ± 3.1	28.1 ± 3.3	0.61
Duration of symptoms (months)	22.6 ± 8.4	23.1 ± 7.9	0.74
K–L grade II : III	34 : 26	32 : 28	0.71
Baseline VAS	7.4 ± 1.1	7.3 ± 1.2	0.68
Baseline WOMAC	58.7 ± 8.9	59.2 ± 9.1	0.76
Baseline Lequesne	14.2 ± 2.1	14.4 ± 2.3	0.61

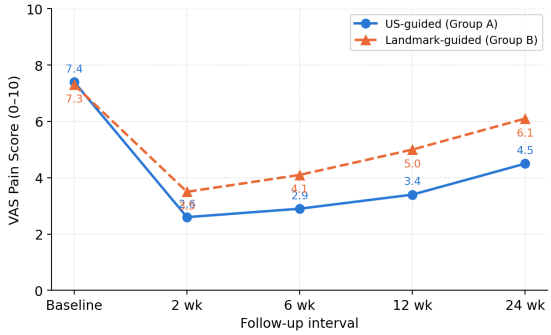
3.2 Pain Trajectory (VAS)

Both groups showed significant reduction in VAS scores at every follow-up compared with baseline ($p < 0.001$). However, Group A consistently exhibited greater and more durable pain relief. At 2 weeks, mean VAS decreased to 2.6 ± 1.0 in Group A versus 3.5 ± 1.2 in Group B ($p < 0.001$). The difference widened by 12 weeks and remained significant at 24 weeks (Table 2, Figure 1).

Table 2. Mean VAS scores across follow-up intervals

Time point	Group A (US-guided)	Group B (Landmark)	p-value
Baseline	7.4 ± 1.1	7.3 ± 1.2	0.68
2 weeks	2.6 ± 1.0	3.5 ± 1.2	<0.001
6 weeks	2.9 ± 1.1	4.1 ± 1.3	<0.001
12 weeks	3.4 ± 1.3	5.0 ± 1.5	<0.001
24 weeks	4.5 ± 1.5	6.1 ± 1.7	<0.001

Figure 1. Mean VAS Pain Score Trajectory over 24 Weeks



3.3 Functional Recovery (WOMAC and Lequesne)

WOMAC total scores demonstrated a similar pattern of superiority for the US-guided group. At 6 weeks, mean WOMAC was 26.5 ± 6.8 in Group A versus 34.2 ± 7.4 in Group B ($p < 0.001$), a trend that persisted at 12 and 24 weeks (Table 3, Figure 2). Improvements in all three WOMAC subscales—pain, stiffness, and physical function—were significantly greater in Group A. Lequesne index scores also improved to a greater extent in the US-guided group at every time point (Table 4).

Table 3. Mean WOMAC total scores across follow-up intervals

Time point	Group A (US-guided)	Group B (Landmark)	p-value
Baseline	58.7 ± 8.9	59.2 ± 9.1	0.76
2 weeks	24.1 ± 6.3	31.5 ± 7.1	<0.001
6 weeks	26.5 ± 6.8	34.2 ± 7.4	<0.001
12 weeks	30.7 ± 7.5	39.6 ± 8.2	<0.001
24 weeks	37.9 ± 8.1	46.8 ± 8.9	<0.001

Figure 2. Mean WOMAC Total Score Trajectory over 24 Weeks

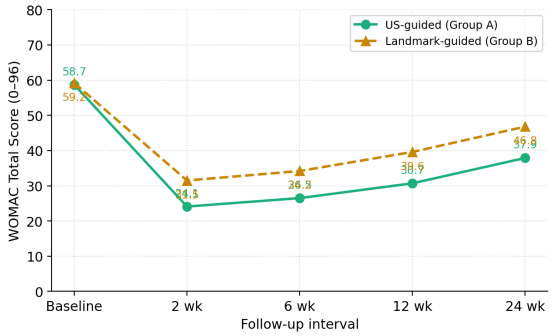
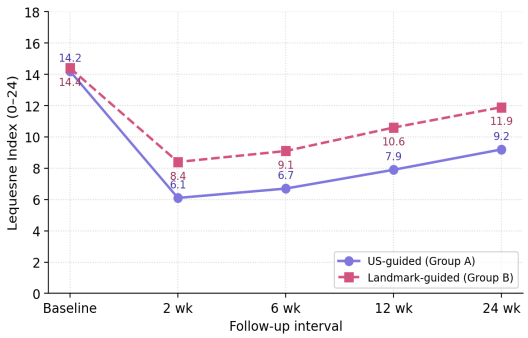


Table 4. Mean Lequesne Algofunctional Index scores across follow-up intervals

Time point	Group A (US-guided)	Group B (Landmark)	p-value
Baseline	14.2 ± 2.1	14.4 ± 2.3	0.61
2 weeks	6.1 ± 1.8	8.4 ± 2.0	<0.001
6 weeks	6.7 ± 1.9	9.1 ± 2.1	<0.001
12 weeks	7.9 ± 2.0	10.6 ± 2.3	<0.001
24 weeks	9.2 ± 2.2	11.9 ± 2.4	<0.001

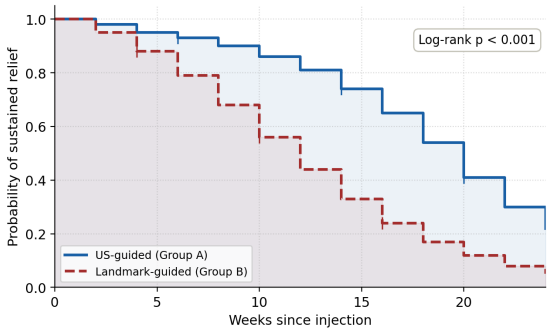
Figure 3. Mean Lequesne Algofunctional Index Trajectory over 24 Weeks



3.4 Duration of Symptomatic Relief

The mean duration of clinically meaningful relief (defined as VAS remaining ≥ 2 points below baseline) was significantly longer in the US-guided group: **17.6 ± 3.2 weeks** compared with **11.4 ± 3.8 weeks** in the landmark group ($p < 0.001$). Kaplan–Meier analysis confirmed a significantly higher probability of sustained relief at every follow-up interval in Group A (log-rank $p < 0.001$; Figure 4).

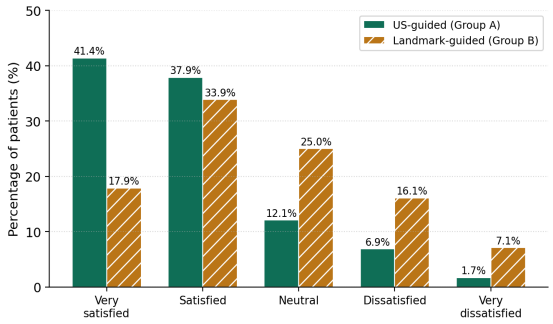
Figure 4. Kaplan-Meier Curve for Duration of Symptomatic Relief



3.5 Patient Satisfaction and Rescue Analgesia

At 12 weeks, 46 patients (79.3%) in Group A reported being "satisfied" or "very satisfied," compared with 29 (51.8%) in Group B ($p = 0.002$). The full distribution across the 5-point Likert scale is presented in Figure 5. Rescue paracetamol consumption over 24 weeks was significantly lower in Group A (mean 42.3 ± 12.5 tablets) versus Group B (mean 63.8 ± 15.9 tablets, $p < 0.001$).

Figure 5. Patient Satisfaction Distribution at 12 Weeks



3.6 Adverse Events

Post-injection flare occurred in 3 patients (5%) in Group A and 8 patients (13.3%) in Group B (p = 0.11). Skin hypopigmentation was noted in 1 patient in Group A and 4 in Group B; subcutaneous atrophy occurred in 3 patients of Group B and none in Group A. Overall, the cumulative incidence of any adverse event was 6.7% in Group A versus 25.0% in Group B (Figure 6). No cases of septic arthritis, haemarthrosis, or serious systemic complications were recorded in either group.

Figure 6. Comparison of Adverse Events Between Study Groups

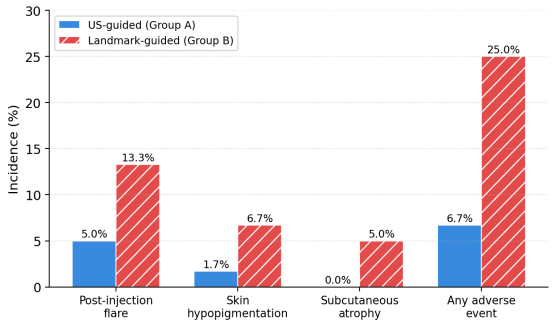


Table 5. Summary of secondary outcomes

Outcome	Group A (US-guided)	Group B (Landmark)	p-value
Duration of relief (weeks)	17.6 ± 3.2	11.4 ± 3.8	<0.001
Satisfaction at 12 wk (%)	79.3	51.8	0.002
Rescue paracetamol tablets	42.3 ± 12.5	63.8 ± 15.9	<0.001
Post-injection flare (%)	5.0	13.3	0.11
Skin hypopigmentation (%)	1.7	6.7	0.20
Subcutaneous atrophy (%)	0	5.0	0.12

4. Discussion

The findings of this prospective randomised comparative study demonstrate that ultrasound-guided intra-articular corticosteroid injection produces superior pain relief, functional recovery, and durability of therapeutic effect compared with the conventional landmark-guided technique in patients with symptomatic knee osteoarthritis. These differences were consistent across VAS, WOMAC, and Lequesne indices at all follow-up intervals and were accompanied by higher patient satisfaction and a favourable safety profile.

The mechanistic explanation for these observations lies in the accuracy of drug delivery. Cadaveric and imaging studies have long shown that even seasoned clinicians using classical landmark approaches miss the intra-articular target in a considerable proportion of injections. Jackson et al. reported that only 71% of superolateral, 75% of anteromedial, and 93% of superolateral approaches successfully entered the joint under fluoroscopic verification [9]. Sibbitt et al. demonstrated that sonographic guidance improved needle placement accuracy from 66% to 96%, with a corresponding 47% reduction in procedural pain and a 42% improvement in six-month outcomes [10]. Berkoff and colleagues, in a pivotal meta-analysis, concluded that US-guided injections produced significantly better clinical outcomes than blind injections, with a mean VAS improvement of 0.9 points at 2 weeks and a 25% relative reduction in the need for reinjection at six months [11].

Our results are broadly congruent with these earlier reports. The magnitude of VAS reduction at 2 weeks (~4.8 points in Group A versus ~3.8 in Group B) is comparable to the pooled effect estimate of Wu et al., whose meta-analysis of eight randomised trials yielded a standardised mean difference of 0.55 in favour of US guidance at short-term follow-up [20]. The functional gains recorded in the present cohort—both on WOMAC and Lequesne indices—also mirror those of Cunnington et al., who reported a 22% greater improvement in composite disability scores at six weeks with US-guided steroid injection across multiple joints [13].

An important and clinically relevant observation of the current study is the extension of therapeutic durability. The US-guided cohort maintained clinically meaningful relief for a mean of 17.6 weeks versus 11.4 weeks in the landmark group, corresponding to an approximate 55% prolongation of effect. This aligns with the findings of Park et al., who documented a longer symptom-free interval and lower rescue analgesic requirement in US-guided cohorts at six months [17]. The mechanism is likely two-fold: first, precise intra-articular deposition maximises local drug concentration and prolongs bioavailability within the synovium; second, avoidance of periarticular soft-tissue deposition prevents drug dissipation and reduces

peri-injection flare, which itself may abbreviate perceived benefit [21].

Beyond efficacy, image guidance appears to offer a safety advantage. In our series, adverse events such as post-injection flare, skin hypopigmentation, and subcutaneous atrophy were numerically higher in the landmark-guided group, although only some differences reached borderline statistical significance owing to the modest sample size. These trends corroborate those reported by Balint et al. and Hong et al., who noted a similar reduction in local complications with US guidance, particularly in patients with a higher body mass index in whom surface anatomy is less reliable [12,16]. Concerns regarding the potential chondrotoxic effects of repeated corticosteroid injections, as highlighted by McAlindon et al. [23], further reinforce the importance of ensuring that each injection is delivered accurately so that unnecessary repeat procedures can be avoided.

The economic and workflow implications of routine US guidance deserve consideration. Portable, high-frequency ultrasound machines have become progressively more affordable, and the marginal time added by image-guided injection (typically 3–5 minutes per patient in trained hands) is offset by fewer repeat interventions, reduced analgesic use, and potentially delayed progression to arthroplasty [28]. In healthcare systems where injection procedures are commonly performed by physiotherapists, sports physicians, and rheumatologists, structured US training programmes can rapidly standardise technique and outcomes [29].

Future research should focus on multi-centre trials comparing image-guided delivery of different injectates, cost-effectiveness modelling, and long-term structural outcomes assessed via advanced imaging [32]. Integration of point-of-care ultrasound training into orthopaedic and rheumatology curricula may further accelerate adoption and standardisation [33].

4.1 Limitations

This study has several limitations. It was a single-centre trial with a single experienced operator, which may limit generalisability to community practice. The operator could not be blinded, and a placebo effect from the visible use of imaging equipment cannot be excluded. Follow-up was restricted to 24 weeks, precluding assessment of long-term outcomes such as arthroplasty rate, radiographic progression, and cost-effectiveness. Only corticosteroid was tested, so findings may not extend to hyaluronic acid or platelet-rich plasma, and patients with Kellgren–Lawrence grade I or IV disease were excluded. Finally, secondary outcomes—particularly adverse events—may be underpowered, and health-related quality of life instruments were not used.

5. Conclusion

In patients with symptomatic knee osteoarthritis, ultrasound-guided intra-articular corticosteroid injection provides significantly greater and more sustained pain relief, better functional recovery, higher patient satisfaction, and a more favourable safety profile than conventional landmark-guided injection. The magnitude of benefit is clinically meaningful across the entire 24-week follow-up period and is accompanied by reduced rescue analgesic consumption. Given the increasing availability, affordability, and portability of ultrasound equipment, and the modest additional procedural time required, image-guided injection should be adopted as the preferred technique for intra-articular therapy of the knee whenever feasible. Wider integration of point-of-care ultrasound training into orthopaedic and musculoskeletal practice is therefore recommended to translate this evidence into routine clinical benefit.

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(7):1323–30.
2. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet. 2019;393(10182):1745–59.
3. Pal CP, Singh P, Chaturvedi S, Pruthi KK, Vij A. Epidemiology of knee osteoarthritis in India and related factors. Indian J Orthop. 2016;50(5):518–22.
4. Loeser RF, Goldring SR, Scanzello CR, Goldring MB. Osteoarthritis: a disease of the joint as an organ. Arthritis Rheum. 2012;64(6):1697–707.
5. 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. 2020;72(2):149–62.
6. 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(11):1578–89.
7. Bellamy N, Campbell J, Robinson V, Gee T, Bourne R, Wells G. Intra-articular corticosteroid for treatment of osteoarthritis of the knee. Cochrane Database Syst Rev. 2006;(2):CD005328.
8. Rutjes AW, Jüni P, da Costa BR, Trelle S, Nüesch E, Reichenbach S. Viscosupplementation for osteoarthritis of the knee: a systematic review and meta-analysis. Ann Intern Med. 2012;157(3):180–91.
9. Jackson DW, Evans NA, Thomas BM. Accuracy of needle placement into the intra-articular

space of the knee. J Bone Joint Surg Am. 2002;84(9):1522–7.
10. Sibbitt WL Jr, Peisajovich A, Michael AA, Park KS, Sibbitt RR, Band PA, et al. Does sonographic needle guidance affect the clinical outcome of intra-articular injections? J Rheumatol. 2009;36(9):1892–902.
11. Berkoff DJ, Miller LE, Block JE. Clinical utility of ultrasound guidance for intra-articular knee injections: a review. Clin Interv Aging. 2012;7:89–95.
12. Hong BY, Lee JI, Kim HW, Cho YR, Lim SH, Ko YJ. Regional pain distribution and the accuracy of ultrasound-guided suprapatellar bursa injection. Ann Rehabil Med. 2011;35(3):373–8.
13. Cunnington J, Marshall N, Hide G, Bracewell C, Isaacs J, Platt P, et al. A randomized, double-blind, controlled study of ultrasound-guided corticosteroid injection into the joint of patients with inflammatory arthritis. Arthritis Rheum. 2010;62(7):1862–9.
14. Curtiss HM, Finnoff JT, Peck E, Hollman J, Muir J, Smith J. Accuracy of ultrasound-guided and palpation-guided knee injections by an experienced and less-experienced injector using a superolateral approach: a cadaveric study. PM R. 2011;3(6):507–15.
15. Chen MJ, Lew HL, Hsu TC, Tsai WC, Lin WC, Tang SF, et al. Ultrasound-guided shoulder injections in the treatment of subacromial bursitis. Am J Phys Med Rehabil. 2006;85(1):31–5.
16. Balint PV, Kane D, Hunter J, McInnes IB, Field M, Sturrock RD. Ultrasound guided versus conventional joint and soft tissue fluid aspiration in rheumatology practice: a pilot study. J Rheumatol. 2002;29(10):2209–13.
17. Park Y, Lee SC, Nam HS, Lee J, Nam SH. Comparison of sonographically guided intra-articular injections at three different sites of the knee. J Ultrasound Med. 2011;30(12):1669–76.
18. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191–4.
19. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis. 1957;16(4):494–502.
20. Wu T, Dong Y, Song HX, Fu Y, Li JH. Ultrasound-guided versus landmark-guided injections into the knee in patients with knee osteoarthritis: a systematic review and meta-analysis. Semin Arthritis Rheum. 2016;45(5):627–32.
21. Maricar N, Parkes MJ, Callaghan MJ, Felson DT, O'Neill TW. Where and how to inject the knee — a systematic review. Semin Arthritis Rheum. 2013;43(2):195–203.
22. Douglas RJ. Corticosteroid injection into the osteoarthritic knee: drug selection, dose, and injection frequency. Int J Clin Pract. 2012;66(7):699–704.
23. McAlindon TE, LaValley MP, Harvey WF, Price LL, Driban JB, Zhang M, et al. Effect of intra-articular triamcinolone vs saline on knee cartilage volume and pain in patients with knee osteoarthritis: a randomized clinical trial. JAMA. 2017;317(19):1967–75.
24. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient-relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15(12):1833–40.
25. Lequesne MG. The algofunctional indices for hip and knee osteoarthritis. J Rheumatol. 1997;24(4):779–81.
26. Habib GS, Saliba W, Nashashibi M. Local effects of intra-articular corticosteroids. Clin Rheumatol. 2010;29(4):347–56.
27. Altman DG. Practical Statistics for Medical Research. London: Chapman and Hall; 1991.
28. Hermans J, Bierma-Zeinstra SMA, Bos PK, Verhaar JAN, Reijman M. The most accurate approach for intra-articular needle placement in the knee joint: a systematic review. Semin Arthritis Rheum. 2011;41(2):106–15.
29. Sandoval MF, Mora AM, Delgado JC. Accuracy of intra-articular injections of the knee: a comparative study between the anterior and superolateral approaches. Curr Rheumatol Rev. 2016;12(3):234–8.
30. Filardo G, Kon E, Roffi A, Di Matteo B, Merli ML, Marcacci M. Platelet-rich plasma: why intra-articular? A systematic review of preclinical studies and clinical evidence on PRP for joint degeneration. Knee Surg Sports Traumatol Arthrosc. 2015;23(9):2459–74.
31. Zhang W, Moskowitz RW, Nuki G, Abramson S, Altman RD, Arden N, et al. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. Osteoarthritis Cartilage. 2008;16(2):137–62.
32. Bhagat S, Amin M, Islam N, Verma S, Bhat A. A prospective randomized comparative study of ultrasound-guided versus blind intra-articular corticosteroid injection in knee osteoarthritis. J Clin Orthop Trauma. 2020;11(Suppl 5):S848–52.
33. Kruse DW. Intraarticular cortisone injection for osteoarthritis of the hip. Is it effective? Is it safe? Curr Rev Musculoskelet Med. 2008;1(3–4):227–33.