Retrospective Study

The Ultrasound-guided Anteromedial Joint Line Approach: A Targeted Corticosteroid Injection Technique for Patients With Medial Knee Pain

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Background: Medial knee pain is a common complaint in the adult population. When conservative measures fail, intraarticular knee corticosteroid injections are often offered through the superolateral approach into the suprapatellar recess to provide short-term relief. However, some patients fail to respond and require alternative approaches. The anteromedial joint line (AMJL) approach, which targets the medial compartment, may be more effective when pain-generating pathologies such as synovitis are located in the medial compartment. To date, there have been no dedicated studies evaluating ultrasound-guided (USg) corticosteroid injections through the AMJL approach to reduce medial knee pain.

Objectives: The current study aims to assess the clinical characteristics, ultrasound findings, and clinical outcomes for patients with medial knee pain who received USg corticosteroid injections via the AMJL approach.

Study Design: Retrospective study.

Setting: This study took place at one academic musculoskeletal ultrasound clinic at an urban tertiary care center.

Methods: Sixty-five patients (76 knees; 11 patients with bilateral injections) with medial knee pain who had received USg-AMJL corticosteroid injections from January 2016 through March 2020 were reviewed for inclusion. Baseline demographic information and clinical characteristics from one year prior to 6 months following USg-AMJL injection were analyzed for each patient. Responders were defined as those who reported pain relief, decreased usage of analgesic medications, or increased physical activity. Nonresponders were defined as those not meeting any of the responder endpoints.

Results: Within one year prior to receiving a USg-AMJL injection, 51.3% (39/76 knees) had attempted superolateral knee injections without relief. Immediately following a USg-AMJL injection, 98.7% (75/76) experienced symptomatic relief. Follow-up visits took place on average at 11 weeks postinjection with 92.3% (60/65 patients) responding positively. In comparison to the responder group, the nonresponder group had a significantly older mean age ($P = 0.009$), lower mean body mass index ($P = 0.007$), and higher burden of morbidities as measured by the Charlson Comorbidity Index ($P = 0.044$). One patient reported a steroid flare within one week of injection. The most common diagnoses contributing to medial knee pain for these patients were osteoarthritis, medial meniscal injury, crystal arthropathy, and medial collateral ligament injury, which were supported by point-of-care ultrasound findings.

Limitations: This study was limited by its sample size and retrospective observational design.

Conclusions: USg AMJL injection is a safe and effective procedure for targeting medial knee pain, particularly in the settings of obesity and prior failed superolateral and suprapatellar knee injections. Further investigation is required to assess long-term clinical outcomes of this injection approach.

Key words: Medial knee pain, anteromedial joint line, corticosteroid injection, point-of-care ultrasound, osteoarthritis, synovitis, chondrocalcinosis, medial collateral ligament injury, medial meniscal injury, crystal arthropathy

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Knee pain is one of the most common musculoskeletal complaints in the adult population (1). The societal impact of knee pain is significant, with knee osteoarthritis (OA) alone accounting for nearly $27 billion in annual US health care costs and is associated with increased disability, sick leave, and functional impairment over time (1-3). OA, along with medial collateral ligament injury, medial meniscal injury, and inflammatory arthropathy, are the most common causes of medial knee pain (4-8). Medial knee pain is a clinical diagnosis but is often supported with the use of x-ray, point-of-care ultrasonography (POCUS), and/or magnetic resonance imaging (MRI) to identify specific mechanical or inflammatory etiologies (9).

POCUS has been increasingly utilized to expedite the diagnosis and management of knee pain given that it is relatively inexpensive, can be performed in a short period of time, provides excellent visualization of soft tissue structures, and has strong concordance with MRI findings (5,10-12). In addition, many studies have also shown that utilizing ultrasonography leads to improvements in clinical outcomes such as: 1) reductions in procedural pain in arthrocentesis and corticosteroid injections compared to palpation-guided, 2) increased detection of joint fluid and the volume of aspirated fluid, and 3) increased accuracy of intraarticular corticosteroid injections compared to palpation-guided, even among patients who are obese (12,13). Under ultrasound guidance, intraarticular corticosteroid injection through the suprapatellar approach is commonly used to provide short-term relief for medial knee pain when conservative measures fail (14-22). However, debate still exists regarding the optimal injection portal to provide the best outcome, and prior research suggests that there may be a difference in the intraarticular distribution of injectate based on the route of drug delivery (23). In the context of treating acute and chronic medial knee pain, the ultrasound-guided anteromedial joint line (USg-AMJL) approach, which enters through the medial knee, may be more effective when pain-generating pathologies such as synovitis are in the medial compartment (5,23,24). To date, there have been no dedicated studies evaluating USg corticosteroid injections through the AMJL approach to reduce medial knee pain. We report a retrospective study examining patient characteristics, POCUS findings, and clinical outcomes for patients with medial knee pain who subsequently received USg-AMJL corticosteroid injections.

Methods

Study Population and Clinical Data

With approval of the Institutional Review Board, the study population data was identified using a research patient data repository; the requirement for written informed consent was waived (25). Three authors systematically performed a retrospective review of medical records on patients who presented to one academic rheumatology musculoskeletal ultrasound (MSUS) clinic at an urban tertiary care center from January 1, 2016 through April 30, 2020. Inclusion criteria were: 1) aged 18 years and older, 2) presence of medial knee pain, and 3) received at least one USg-AMJL knee corticosteroid injection in one or both knees. Exclusion criteria included those who were hospitalized for a major health event unrelated to the knee pain within 6 months after the injection, such as stroke, heart failure, or asthma exacerbation. For patients who had received multiple USg-AMJL injections, only the first injection for each knee during the aforementioned time frame was used for analysis. For bilateral injections, each knee was analyzed separately. Diagnostic POCUS examination was performed and interpreted by an expert MSUS-trained rheumatologist. Injections were performed by either a physiatry resident or rheumatology fellow in training (with supervision) or by the rheumatologist.

Demographic information was collected. The clinical diagnosis for knee pain was established through a comprehensive history and physical examination supported by laboratory tests, POCUS, and/or other imaging studies. From one year prior to 6 months following the USg-AMJL injection, knee MRI, alternative forms of knee injection, and clinical visits to other providers for knee pain management were recorded for each patient. Any knee surgery within the 4-year period after USg-AMJL injection was documented.

Pain Relief

Subjective reports of baseline pain and immediate postinjection pain were obtained from clinical notes written by the providers who performed the USg-AMJL injections. To assess a patient's response at follow-up, an electronic chart review was conducted on all clinical encounters with primary care, orthopedic surgery, physical medicine and rehabilitation, pain medicine, rheumatology, and an emergency department within 6 months after injection. Patients were categorized as responders or nonresponders. Responders were defined as those who reported pain relief, decreased usage of analgesic medications, or increased physical activity.

Nonresponders were defined as those not meeting any of the responder endpoints.

USg Injection Technique

With the patient sitting on the exam table and the knee in slight (20° to 30°) flexion, the ultrasound probe was placed on the anteromedial knee in longitudinal view to visualize the junctions of the medial femoral condyle, medial meniscus, and medial tibial condyle (Fig. 1). After sterile prep and skin anesthesia, a 25G 1.5-inch needle was advanced through an out-of-plane approach into the synovium at the distal end of the medial femoral condyle without injuring the meniscus (Figs. 1 and 2). An injection consisting of one mL of methylprednisolone 40 mg and 2 mL of 0.5% bupivacaine was then delivered into the medial compartment with confirmation of intraarticular flow on ultrasound (Fig. 2). A 22G 3.5-inch spinal needle was used for patients who were obese when a 1.5-inch length needle was insufficient to reach the synovium. If clinically indicated, a USg suprapatellar (USg-SP) arthrocentesis with corticosteroid injection was also performed during the same office visit if an effusion was present. The knee was aspirated if an effusion was present.

Statistical Analysis

Descriptive statistics were performed for demographic and clinical variables. The responder and nonresponder groups were compared on several selected variables based on the number of knees, using 2-sided Student's t-test for continuous variables and 2-sided Fisher's exact test for categorical variables. All analyses were performed using RStudio IDE software (RStudio, PBC). A *P* value less than 0.05 was considered statistically significant.

Results

The research patient data repository query identified 733 patients; 177 duplicates were removed. After chart review, 65 patients (11 bilateral USg-AMJL injections) totaling 76 knees met all inclusion criteria and were included for final analysis (Tables 1 and 2). Injections occurred from January 2016 through March 2020. Most patients were white (81.6%) and women (90.8%) with a mean body mass index (BMI) of 31.0 ± 7.2 kg/m^2. Mean age at the time of USg-AMJL injection was 65.3 ± 12.6 years. The most common Charlson Comorbidity Index diagnosis was a localized solid tumor of less than 5 years (25%).

At least one injection had been administered in 39 of 76 knees (51.3%) before the initial USg-AMJL injection, including palpation-guided superolateral injection (Pg-SL) (n = 13), USg-SP injection (n = 25), and/or fluoroscopic-guided injection (n = 1). Among these 39 knees, the median number of past injections per knee was one, with USg-SP injections being the most common. Only 4 knees received the last injection (Pg-SL, USg-SP, or fluoroscopic-guided) within 6 weeks prior to

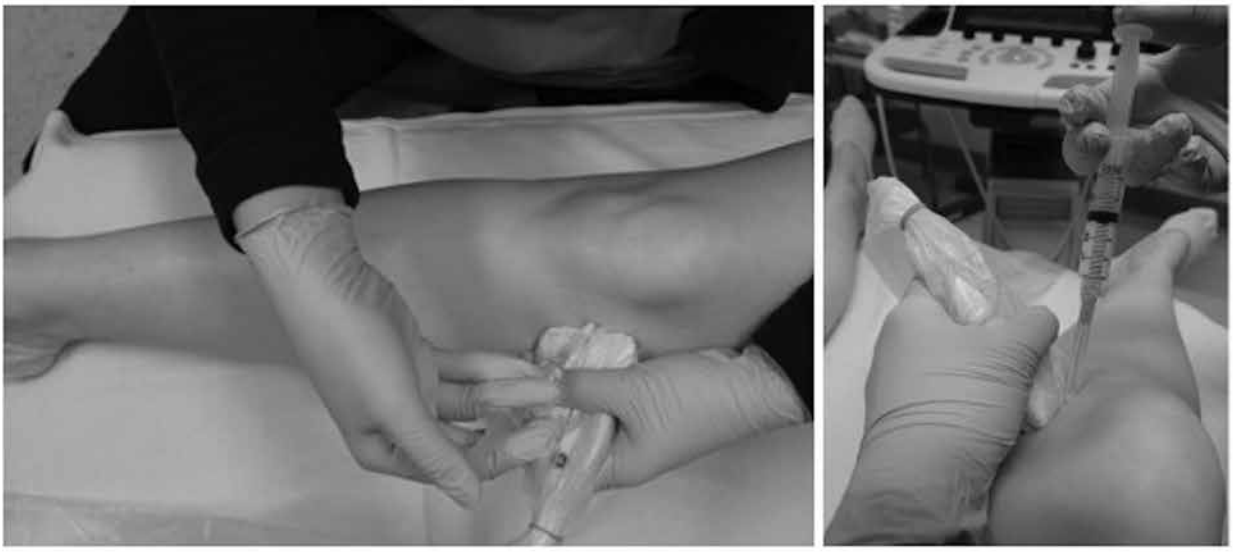

Fig. 1. *Positioning of the patient, ultrasound probe, and needle for the ultrasound-guided knee anteromedial joint line corticosteroid injection using the out-of-plane approach.*

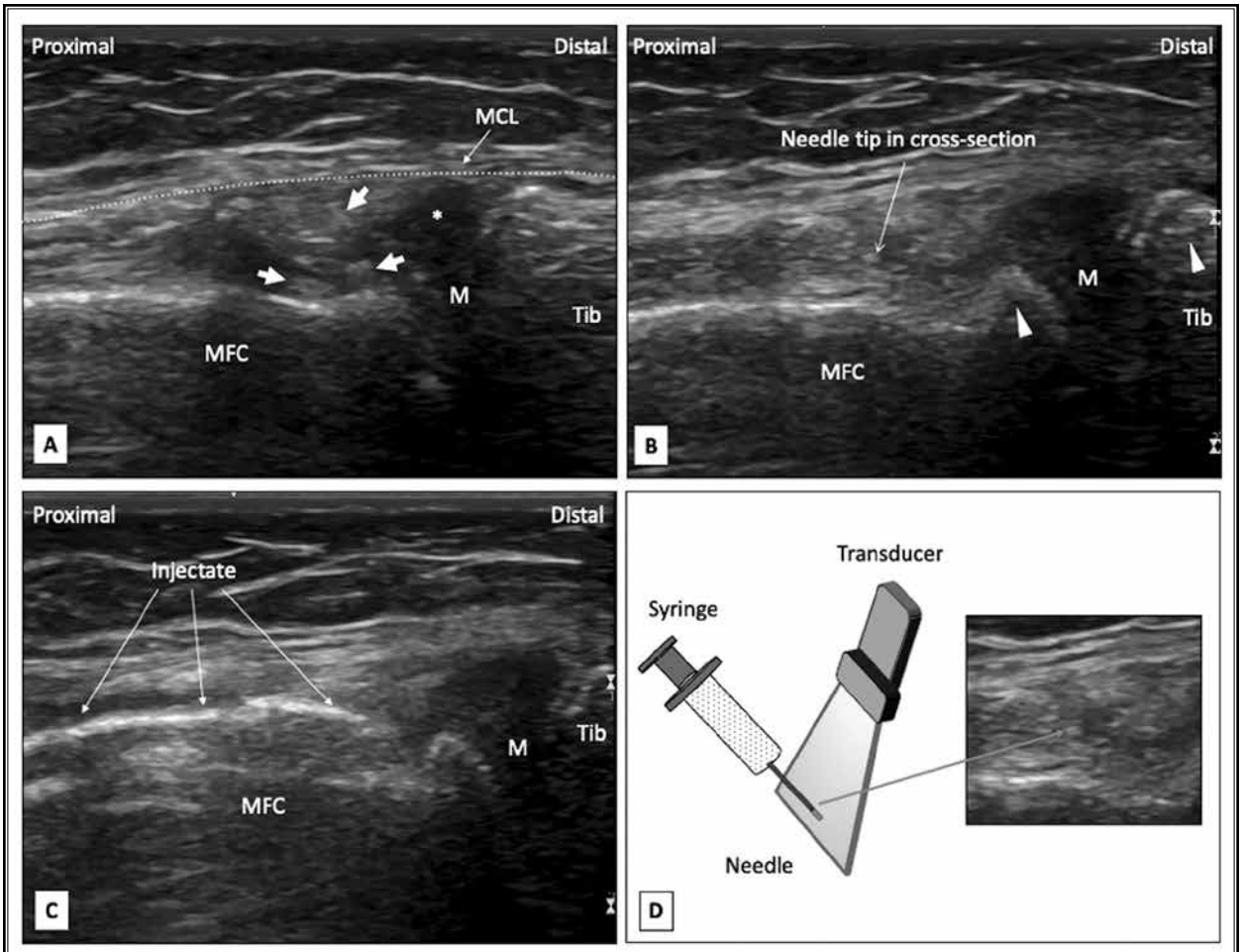

Fig. 2. (A) *Pre-injection ultrasound image showing longitudinal axis view of the anteromedial aspect of a knee with visualized medial knee pathologies including chondrocalcinosis (arrows), distension of the medial compartment with synovial thickening (dashed line), and medial meniscal protrusion (asterisk).* (B) *Injection ultrasound image of the same view showing the cross-section of the needle tip via the out-of-plane approach at the anteromedial joint line. The needle was targeted at the synovial thickening and chondrocalcinosis correlating with the patient-identified pain. Osteophytes (white arrowheads) are seen in this image.* (C) *Postinjection ultrasound image showing the hyperechoic injectate spreading along the medial compartment within the synovial cavity, confirming accurate delivery of the corticosteroid.* (D) *Schematic showing the out-of-plane view of the needle tip as the ultrasound probe beam takes a cross-section image of the needle. MCL = medial collateral ligament. MFC = medial femoral condyle. M = meniscus. Tib = tibia.*

the initial USg-AMJL injection. All these patients were referred to this clinic for USg-AMJL injection due to a lack of relief from prior injections.

Clinical Diagnoses and POCUS Findings

The final primary clinical diagnoses for knee pain included 60 for OA, 5 for medial meniscal injury (MMI), 3 for gout, 3 for pseudogout, 3 for medial collateral ligament injury (MCLI), one for psoriatic arthritis, and one for patellar tendon injury (Table 2). In addition to the primary clinical diagnoses, 24 knees had secondary clinical diagnoses which consisted of 6 for OA, 5 for pseudogout, 4 for MMI, 4 for MCLI, 3 for rheumatoid arthritis , and 2 for seronegative arthropathy. The one patient with patellar tendon strain also had coexisting OA.

A total of 10 knees (13.2%) had no prior OA diagnosis and were found to have gout, pseudogout, psoriatic arthritis, MMI, MCLI, or patellar tendon strain. As part of the diagnostic work-up, 39.5% (30/76 knees) acquired plain radiographs, and 5 had an MRI within the 6 months prior to the USg-AMJL injections.

A localizing preinjection POCUS image was performed for all included knees. The documentation of POCUS findings were available for 63 knees (82.9%) and are summarized in Table 3. The most commonly identified pathologies via ultrasound were synovial thickening or effusion (62.3% in the medial compartment; 28.3% in the suprapatellar compartment; 30.2% in an unspecified compartment), meniscal protrusion or abnormality (34.0%), MCL thickening or sprain (22.6%), osteophyte (15.1%), and chondrocalcinosis (13.2%).

Injection Response

Immediately after the USg-AMJL injection, 98.7% (75/76 knees) experienced symptomatic relief. Follow-up visits were completed on average 11 weeks following injection. Sixty patients (69 knees) were responders, while 6 patients (7 knees) were categorized as nonresponders. Throughout the medical chart review process, patients' responses to the USg-AMJL injections were determined by their descriptions of pain relief in the form of a subjective history that was part of a clinical note or patient communication documentation, including subjective reports of pain improvement, decreased usage of analgesic medications, and increased physical activity after the USg-AMJL injection.

At baseline, the proportions of those who were white, women, diabetic, had a localized solid tumor, used opioids, had prolonged knee pain (> 1 year), and a prior injection history did not differ significantly between the responder and nonresponder groups. The rate of receiving the USg-AMJL injection with a concurrent USg-SP injection +/- aspiration at the time

Table 1. *Baseline demographic and knee pain characteristics between responders and non-responders.*

	All knees n = 76		**Responders n = 69**		**Non-responders n = 7**		***P* value**
Age in years, mean ± SD (range)	65.3 ± 12.5 (32-93)		64.4 ± 12.5 (32-93)		74.4 ± 7.4 (62-80)		0.009
BMI in kg/m^2, mean ± SD (range)	31.0 ± 7.2 (20.7-51.7)[α]		31.5 ± 7.3 (20.7-51.7)[γ]		26.9 ± 2.3 (24.8-32.2)		0.007
CCI, mean ± SD (range)	3.2 ± 2.1 (0-8)		3.0 ± 1.9 (0-8)		5.1 ± 2.6 (2-8)		0.044
	n	%[†]	n	%[†]	n	%[†]	*P* value
Women	69	90.8	63	91.3	6	85.7	> 0.5
White	62	81.6	58	84.1	4	57.1	0.112
Hispanic	5	6.6	5	7.2	0	0	-
African American	6	7.9	6	8.7	0	0	-
Asian	3	3.9	0	0	3	42.9	-
History of diabetes	9	11.8	9	13.0	0	0	> 0.5
History of localized solid tumor	19	25.0	15	21.7	4	57.1	0.061
Connective tissue disease	8	10.5	7	10.1	1	14.3	-
Left knees	27	35.5	25	36.2	2	28.6	-
Right knees	27	35.5	24	34.8	3	42.9	-
Bilateral knees	22	28.9	20	29.0	2	28.6	-
Length of medial knee symptoms							
Acute (< 6 weeks)	8[¥]	10.7[¥]	8[β]	11.8[β]	0	0	-
Subacute (6-12 weeks)	7[¥]	9.3[¥]	7[β]	10.3[β]	0	0	-
Chronic (> 12 weeks-one year)	9[¥]	12.0[¥]	7[β]	10.3[β]	2	28.6	-
Prolonged (> 1 year)	51[¥]	68.0[¥]	46[β]	67.6[β]	5	71.4	> 0.5
Additional knee pain locations							
Lateral	9	11.8	8	11.6	1	14.3	-
Supra-anterior	23	30.3	21	30.4	2	28.6	-
Infra-anterior	5	6.6	5	7.2	0	0	-
Anterior	6	7.9	5	7.2	1	14.3	-
Posterior	2	2.6	2	2.9	0	0	-
Global/diffuse	2	2.6	1	1.4	1	14.3	-
Baseline use of pain medications							
Oral NSAIDs	36	47.4	36	52.2	0	0	-
Oral opioids	12	15.8	9	13.0	3	42.9	0.074
Oral acetaminophen	31	40.8	30	43.5	1	14.3	-
Topical diclofenac gel	17	22.4	15	21.7	2	28.6	-
Using at least one medication	63	82.9	58	84.1	5	71.4	-
Patient referral source referral							
Established/returning patient	47	61.8	42	60.9	5	71.4	-
PCP	17	22.4	17	24.6	0	0	-
Other rheumatologists	7	9.2	7	10.1	0	0	-

Table 1 (cont.). *Baseline demographic and knee pain characteristics between responders and non-responders.*

	All knees n = 76		Responders n = 69		Non-responders n = 7		*P* value
PM&R	1	1.3	1	1.4	0	0	-
Orthopedic surgeon	1	1.3	1	1.4	0	0	-
Other specialists	3	3.9	1	1.4	2	28.6	-

[α]Based on 75 knees as one patient did not have BMI documented near the time of USg-AMJL injection
[γ]Based on 68 knees as one patient did not have BMI documented near the time of USg-AMJL injection
[†]Based on the number of knees for each group (all knees, responders, and non-responders)
[¥]Based on 75 knees as one knee did not have documented length of symptoms
[β]Based on 68 knees as one knee did not have documented length of symptoms
USg-AMJL = Ultrasound-guided knee anteromedial joint line corticosteroid injection; SD = Standard deviation; CCI = Charlson Comorbidity Index Score; NSAIDs = Nonsteroidal anti-inflammatory drugs; PCP = Primary care physicians; PM&R = Physical medicine and rehabilitation physicians

Table 2. *Clinical diagnoses, imaging, prior treatments, and clinical outcomes.*

	All knees n = 76		Responders n = 69		Non-responders n = 7		*P* value
	n	%[†]	n	%[†]	n	%[†]	
Primary knee pain clinical diagnosis							
OA	60	78.9	54	78.3	6	85.7	-
Gout	3	3.9	3	4.3	0	0	-
Pseudogout	3	3.9	2	2.9	1	14.3	-
Meniscus injury	5	6.6	5	7.2	0	0	-
MCL strain or sprain	3	3.9	3	4.3	0	0	-
Psoriatic arthritis	1	1.3	1	1.4	0	0	-
Patellar tendon strain	1	1.3	1	1.4	0	0	-
Secondary knee pain clinical diagnosis							
OA	6	7.9	5	7.2	1	14.3	-
Pseudogout	5	6.6	4	5.8	1	14.3	-
RA	3	3.9	3	4.3	0	0	-
Meniscus injury	4	5.3	4	5.8	0	0	-
MCL strain or sprain	4	5.3	4	5.8	0	0	-
Seronegative arthropathy[Ω]	2	2.6	2	2.9	0	0	-
Use of knee radiograph							
+ x-ray within 6 months prior[λ]	30	39.5	27	39.1	3	42.9	-
+ x-ray within 1 year after[λ]	20	26.3	18	26.1	2	28.6	-
Use of knee MRI							
+ MRI within 6 months prior[λ]	6	7.9	5	7.2	1	14.3	-
+ MRI within one year after[λ]	2	2.6	1	1.4	1	14.3	-
Use of physical therapy							
+ PT within 6 months prior[λ]	25	32.9	20	29.0	5	71.4	-
+ PT within one year after[λ]	21	27.6	19	27.5	2	28.6	-

of visit also did not differ significantly between the 2 groups. Only one patient in this study reported a steroid flare within one week of the injection that self-resolved. During the 6-month follow-up period, 22.4% (17/76 knees) also had a repeat USg-AMJL injection with corresponding reported relief. Physical therapy after USg-AMJL injection was continued by 21 of 76 patients (27.6%). Among the responders, one patient underwent additional advanced imaging with MRI that confirmed medial meniscal abnormalities and did not require surgery.

Among the nonresponders, all reported immediate relief after the USg-AMJL injection, but relief did not last during the follow-up period. No complications were observed. In contrast to the responders, the nonresponders were on average older ($P = 0.009$) with a lower mean BMI ($P = 0.007$) and a higher mean Charlson Comorbidity Index score ($P = 0.044$). All nonresponders had established knee OA, and 2 had coexisting pseudogout. Two knees received prior Pg-SL injections, and 2 knees had prior USg-SP injections from other providers: all without relief. After USg-AMJL injections, only one nonresponder received an MRI which confirmed advanced OA with medial meniscal degeneration. A total of 3 nonresponders required knee replacement within the following 3 years.

Discussion

A literature review revealed a limited number of studies describing the anteromedial knee approach, with the focus primarily being on injection accuracy under palpation guidance (26-28). To our knowledge, this is the first study

Table 2 (cont.). *Clinical diagnoses, imaging, prior treatments, and clinical outcomes.*

	All knees n = 76		Responders n = 69		Non-responders n = 7		*P* value
	n	%†	n	%†	n	%†	
History of prior knee injections							
At least one type of injection◊	39	51.3	35	50.7	4	57.1	> 0.5
Palpation-guided superolateral	13	17.1	11	15.9	2	28.6	-
US-guided suprapatellar	25	32.9	23	33.3	2	28.6	-
Fluoroscopy-guided	1	1.3	1	1.4	0	0	-
Genicular nerve block	0	0	0	0	0	0	-
USg-AMJL injection outcome							
Immediate relief to USg-AMJL	75	98.7	68	98.6	7	100	-
+ USg-AMJL + USg-SP - ASP	17	22.4	17	24.6	0	0	0.238
+ USg-AMJL + USg-SP + ASP	24	31.6	22	31.9	2	28.6	> 0.5
+ Complications S/P USg-AMJL	1	1.3	1	1.4	0	0	-
+ Repeat USg-AMJL during FUφ	17	22.4	17	24.6	0	0	-
+ Surgery during FU∂	12	15.8	9	13.0	3	42.9	-

†Based on the number of knees for each group (all knees, responders, and non-responders).
ΩIncluding psoriatic arthritis.
λPrior to or after the USg-AMJL injection.
◊Including palpation-guided superolateral, US-guided suprapatellar, and fluoroscopic-guided injections.
φWithin 4-26 weeks after USg-AMJL injection.
∂Within 4 years after USg-AMJL injection.
USg-AMJL = Ultrasound-guided knee anteromedial joint line corticosteroid injection; OA = Osteoarthritis; RA = Rheumatoid arthritis; MCL = Medial collateral ligament; MRI = Magnetic resonance imaging; PT = Physical therapy; USg-SP = Ultrasound-guided suprapatellar knee joint corticosteroid injection; ASP = Intra-articular aspiration via the suprapatellar approach; S/P = Status post; FU = Follow-up

to examine the clinical characteristics, POCUS pathologies, clinical outcomes, and use of diagnostic and therapeutic services among patients who received USg-AMJL corticosteroid injection for treatment of medial knee pain.

The majority of patients were older, obese, and women with OA, reflecting the general prevalence of the disease (5,29,30). Overall, this study's findings support previous studies that found POCUS useful in identifying medial compartment knee pathologies such as MMI, crystal arthropathy, and MCLI in the clinical setting (5,31-35). Similar to the recently published scoring atlas for ultrasound features related to knee OA by Yerich et al (5), the most common POCUS pathologies related to knee OA in our study were synovial thickening/effusion (medial compartment greater than suprapatellar compartment), medial meniscal protrusion, osteophytes, and MCL thickening/sprain (Table 3). Most of our patients with crystalline arthropathy (8/11 knees) had identifiable gout or pseudogout crystals on ultrasound as well. It is clinically relevant to establish these sonographic findings as they all have been correlated with worse knee OA pain and impaired function (5-8,34,36-38). POCUS's diagnostic value in evaluating ligaments, synovium, meniscus, bony irregularities, and crystal deposition was also reinforced by the relatively low utilization of MRI and radiographs in this study population (20,39). Thus, using POCUS may potentially expedite the clinical decision-making process for managing medial knee pain, especially when access to advanced imaging studies and elective surgeries is restricted in cases such as during the COVID-19 pandemic (5,20,39-41).

Overall, the USg-AMJL injections were well-tolerated among the 65 patients and brought short-to-medium term relief to many who had failed Pg-SL and/or USg-SP injections. Multiple studies have found that the presence of ultrasound effusion/synovitis and the severity of medial osteophytes strongly correlated with knee pain and reduced function, and that the synovial improvement seen on joint MRI and ultrasound were also associated with a sustained decrease in pain up to 12 weeks after intraarticular steroid injections (5,42-44). These results suggest that the identified ultrasound pathologies, such as synovitis and osteophytes, should be the therapeutic targets for steroid injections. Based on our report, the USg-AMJL approach leads to an improved therapeutic outcome for patients with medial knee pain when the medication is delivered accurately with a higher concentration into the compartments closest to the sites of inflammation corresponding with the patient's pain, as manifested by localized synovitis, effusion, and other medial structural abnormalities (5,10,23,24,45-48).

It may be worthwhile for clinicians to consider performing USg-AMJL injection after patients have failed other types of injections, as an adjunct to, or even as an alternative to the standard suprapatellar/superolateral injection. It is possible that with the suprapatellar/superolateral approach alone, the injectate

Table 3. *Pre-injection POCUS findings for the most common knee pain diagnoses among study patients.*

	OA (n* = 53)		Gout (n* = 3)		Pseudogout (n* = 8)		Meniscal injury (n* = 8)		MCL injury (n* = 7)	
Abnormal POCUS findings	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Synovial thickening/effusion										
Medial compartment	33	62.3	2	66.7	2	25.0	6	75.0	6	85.7
Suprapatellar compartment	15	28.3	2	66.7	2	25.0	2	25.0	2	28.6
Unspecified compartment	16	30.2	1	33.3	5	62.5	3	37.5	2	28.6
Osteophytes	8	15.1	2	66.7	2	25.0	2	25.0	2	28.6
Meniscal abnormality	18	34.0	2	66.7	5	62.5	7	87.5	3	42.9
MCL thickening/tear	12	22.6	1	33.3	2	25.0	2	25.0	6	85.7
Gout	0	0.0	2	66.7	0	0.0	0	0.0	0	0.0
Chondrocalcinosis	7	13.2	0	0.0	6	75.0	0	0.0	0	0.0
Unspecified[δ] crystal type	0	0.0	2	66.7	0	0.0	0	0.0	0	0.0

*Number of knees that had the specified condition as either the primary or secondary clinical diagnosis and had documented preinjection ultrasound findings. Note: A total of 24 knees in this study had both primary and secondary clinical diagnoses.
[δ]"Unspecified" was recorded when "crystal" or "synovial thickening/effusion" were mentioned in the note without documentation of the type or location of the ultrasound finding.
POCUS = Point-of-care ultrasound; OA = Osteoarthritis; MCL = Medial collateral ligament

may not reliably distribute to the medial compartment where the reactive synovial thickening may be the primary pain generator, or the intraarticular flow of the medication may be suboptimal due to the chronic structural changes in those with advanced knee conditions (23,24,48). Additionally, for patients who are obese, it may be technically more challenging to place the needle correctly into the suprapatellar compartment than through the superficial AMJL. In this study, the higher average BMI in the responder group could also suggest worse medial compartment structural deterioration due to the increased weightbearing effect and enhanced inflammatory state from obesity (49). Thus, this preferential involvement of the medial compartment may have made these individuals more responsive to the USg-AMJL injection.

Repeat USg-AMJL injection within 6 months was also requested for 17 knees in the responder group. Since intraarticular corticosteroid injection's clinical benefit has been reported to be short-term (50-52), this repeat administration may reflect patient preference as well as this approach's potential to provide adequate relief. Currently, the long-term benefit of knee intraarticular corticosteroid injection has yet to be established given the quality of existing evidence and the heterogeneity between studies (50). In comparison to the responders, the small group of nonresponders appeared to be characterized by a higher burden of co-morbidities and older age, which could suggest the presence of advanced knee OA disease that may be less responsive to corticosteroid injections. In addition to the local tissue pathologies, contributing factors to the refractory knee pain may also be the presence of chronic comorbid conditions, such as diabetes, inflammatory rheumatological diseases, and cancer (53-57).

The goal of this study was to focus on the USg-AMJL injection technique and the patients' clinical characteristics. Our study limitations included the small sample size and the use of unvalidated outcome measures given the nature of the retrospective design. Due to the low power related to the small sample size, a statistical comparison between the responder and nonresponder groups was not conducted for several clinical characteristics (such as the rate of pursuing knee surgery after USg-AMJL injection). While reported relief may be confounded by some patients needing both USg-AMJL and USg-SP injections with aspiration, the results demonstrated the feasibility of delivering corticosteroid either solely through the AMJL or as a targeted adjunct to other approaches (58,59). It was noted that very few responders (4/69 knees) received their first USg-AMJL injection within 6 weeks of their prior conventional intraarticular corticosteroid injection due to persistent pain. As corticosteroid injections have been reported to provide short-term relief between one to 6 weeks (50,51), it is possible that a small number of patients may have experienced effects from a previous non-USg-AMJL injection. Other potential confounders include the use of analgesics and physical therapy services. For

bilateral knee injections, though there could be similarities between these knees' baseline characteristics, each knee was treated individually in the data analysis because the clinical history of each knee may be unique. Additionally, the study's generalizability was limited by reviewing data from one clinic, the higher percentages of white and women patients, and the relatively high number of patients with cancer due to the clinic being a referral center for palliative musculoskeletal pain management for patients with cancer (60). Further prospective studies with larger sample sizes and randomized treatment arms would be helpful to investigate the long-term clinical impact of USg-AMJL injections on reducing medial knee pain in comparison to other injection approaches.

Conclusions

The use of POCUS allows clinicians to expedite the clinical diagnosis of medial knee pain and to target the most symptomatic compartment with USg corticosteroid injections. The USg-AMJL corticosteroid injection is a safe and feasible procedure that provides effective short-to-medium term relief for those with medial knee pain, particularly in the settings of obesity and prior failed superolateral and/or suprapatellar knee injections. Further investigation is required to assess long-term clinical outcomes from this injection approach.

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