Comparison of Sonographically Guided Intra-articular Injections at 3 Different Sites of the Knee

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Objectives—Sonographically guided injections show more accuracy than blind injections, but there are no reports comparing sonographically guided intra-articular injection approaches. This study examined the accuracy of sonographically guided intra-articular injections at 3 different sites of the knee using medial, midlateral, and superolateral portals.

Methods—Sonographically guided intra-articular injections and radiology evaluations were performed on 126 knees with osteoarthritis (Kellgren-Lawrence grade 2 or 3). Six milliliters of mixed material containing 1% lidocaine (1 mL), 20 mg of triamcinolone (1 mL), and a nonionic contrast agent (4 mL) was injected into the intra-articular space of the knee through the medial, midlateral, and superolateral portals. After the sonographically guided intra-articular injection into the knee joint, a radiographic image was taken to determine whether the injected material had reached the intra-articular space or infiltrated into the soft tissue.

Results—Sonographically guided intra-articular injections in the midlateral portal (95%; $P < .05$) and superolateral portal (100%; $P < .05$) showed significantly higher accuracy than injections in the medial portal (75%).

Conclusions—Sonographically guided intra-articular injections in the midlateral or superolateral portal may increase the accuracy of knee joint injections.

Key Words—intra-articular injection; knee; osteoarthritis; sonography

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Abbreviations
BMI, body mass index; CI, confidence interval

Knee osteoarthritis is characterized by inflammation in the intra-articular space or synovial membrane, breakdown of articular cartilage, and sclerosis of the subchondral bone.[1,2] The patient may have more severe joint symptoms, such as pain, swelling, stiffness, and limitations in their activities of daily living, if this condition leads to increasingly degenerative changes to the articular cartilage.

An intra-articular corticosteroid injection is commonly recommended for the treatment of acute monoarthritis and osteoarthritis with inflammation or swelling.[3] On the other hand, if the injected corticosteroid leaks into the soft tissues, it might be associated with complications such as fat tissue atrophy and changes in skin color.[4] Therefore, it is very important to inject it into the intra-articular space accurately.

Anterior, medial, and lateral approaches are used mainly for intra-articular injections into the knee joint. The anterior approach is useful for patients with severe osteophytes or obesity instead of the

midlateral and medial approaches. On the other hand, this approach might make it difficult to aspirate the effusions and allow easy injection into the infrapatellar fat pad or patellar tendon because the large amount of subcutaneous fat tissue increases the distance between the skin and joint space in obese patients.[5] Because the medial femoral condyle is smaller and shorter than the lateral femoral condyle in terms of the anteroposterior length, the medial space of the knee joint is wider than the lateral space, and the medial approach enables easy needle insertion.[6–8] Midlateral and superolateral approaches are used most commonly for lateral techniques. The midlateral approach is basically the same as the medial approach. The superolateral approach is preferred when the effusion extends into the suprapatellar bursa, and the needle is inserted from the upper lateral border of the patella down into the quadriceps tendon.[5–7]

In blind knee intra-articular injections, these approaches are used easily and popularly. On the other hand, these blind knee injection methods showed more accurate intra-articular injections in cases of severe joint effusion than a "dry knee" because the effusion can be identified easily by aspiration. Therefore, in a dry knee, a knee injection may require additional techniques, such as sonography, to position the needle in the intra-articular space more accurately.[9] Indeed, Im et al[8] reported that sonographically guided injections showed greater accuracy than blind injections, and sonographically guided intra-articular injections have recently been used. On the other hand, there are no reports comparing sonographically guided intra-articular injection approaches in terms of their accuracy. Therefore, this study examined the accuracy of sonographically guided intra-articular injection in knees with Kellgren-Lawrence grade 2 or 3 osteoarthritis with the aim of developing sonographically guided injection techniques with high accuracy.

Materials and Methods

Participants

After gaining approval from the Institutional Review Board, informed consent was obtained in each case. The study sample included 126 knees that had a diagnosis of knee joint osteoarthritis based on the clinical and radiologic criteria proposed by the American College of Rheumatology,[10] were assigned Kellgren-Lawrence grade 2 or 3 in a radiologic examination, and had a dry knee joint. Dry knee joints were defined sonographically as cases in which the maximum anteroposterior diameter of effusion in the suprapatellar recess was 4 mm or less with the probe oriented longitudinally and the knee extended.[11]

The injection approach in all cases was assigned by a computer-generated randomization method using sealed envelopes. On the other hand, the following knees were excluded: knees with a history of mechanical derangement, fibromyalgia, inflammatory arthritis, microcrystalline arthropathy, or knee trauma/surgery and cases with a greater reduction in the width of the lateral joint space compared to that of the medial femorotibial joint space (concomitance with lateral knee osteoarthritis).[12]

Sonographically Guided Intra-articular Injection Preparations

For sonographically guided intra-articular injections, the patients were placed in the supine position with the knee fully extended and the quadriceps relaxed on the examination table. This position was selected because the tension of the quadriceps and patella tendon is minimized, and the patella can be tilted easily.

An Accuvix XQ ultrasound machine (Medison Co, Ltd, Seoul, Korea) with a 5- to 10-MHz linear array probe was used. Initially, the overlying skin was cleaned with an alcohol swab.[6] A sonogram was taken and evaluated, and the injection point on the skin was recleaned with alcohol.

The intra-articular injection was performed in the knee joint space using a 25-gauge, 1.5-in (3.8-cm) needle with a 6-mL mixture of 1% lidocaine (1 mL), 20 mg of triamcinolone (1 mL), and a nonionic contrast agent (Omnipaque 300; GE Healthcare, Carrigtwohill, County Cork, Ireland; 4 mL). All injections were performed by a single physician (Y.B.P.) with more than 7 years of experience in musculoskeletal sonography and osteoarthritis.

Sonographically Guided Intra-articular Injection Techniques

The injection approaches were performed under sonographic guidance through the medial, midlateral, and superolateral portal. The medial and midlateral injections were administered using a freehand technique, and the needle was advanced coaxially to an ultrasound probe with the patellofemoral joint space widened to the maximum allowable at the midpoint of the patella after another investigator everted the patella with a counterforce (Figures 1–3). In addition, in the medial and midlateral injection procedures, the needles were inserted carefully to avoid injuring special structures such as the patella retinacula, periosteum, retropatella cartilage, and fat pad.

The superolateral approach was also performed using a freehand technique. Sonography was used to evaluate the junction of the upper and lateral margins of the patella. The ultrasound probe was placed obliquely toward the cen-

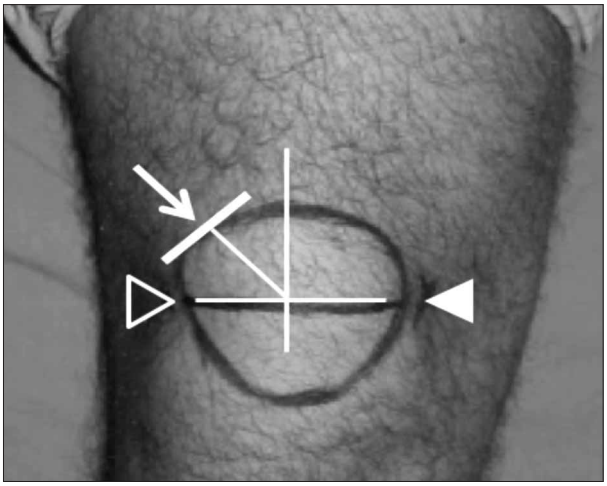


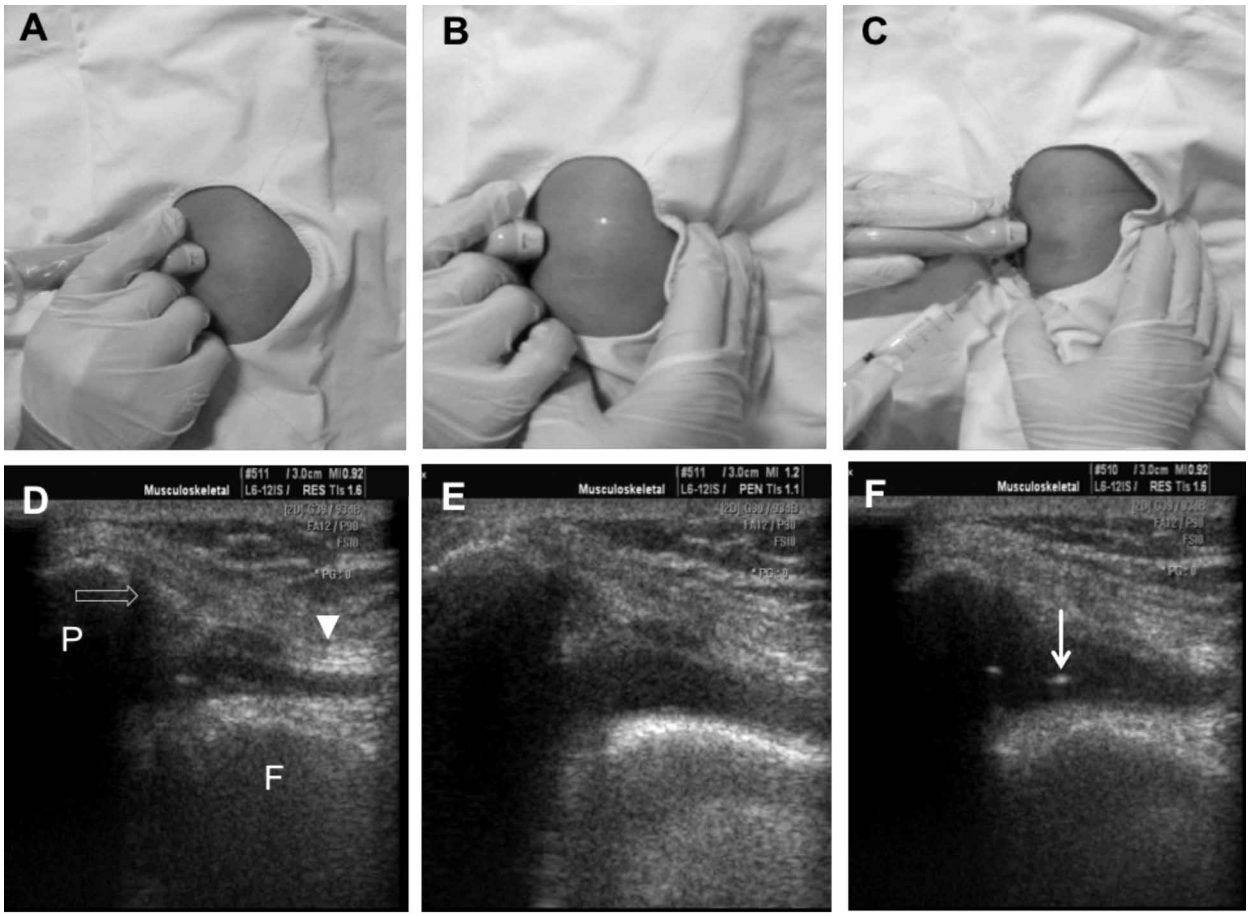
Figure 1. Intra-articular knee joint injection approaches. Arrow indicates superolateral approach; white arrowhead, medial approach; and open arrowhead, midlateral approach.

ter of the joint with a counterforce of the patella. The needle was advanced toward the center of the joint and longitudinally to an ultrasound probe with the joint effusion observed maximally, and an attempt was made to avoid injuring the quadriceps tendon, retropatella cartilage, prefemoral fat pad, and suprapatella fat pad (Figures 1 and 4).[13]

Confirmation of Accurate Injections

After the sonographically guided intra-articular injection, lateral and anteroposterior radiographs were taken to confirm that the intra-articular injection had been performed correctly. A radiologist, who was blinded to the injection methods, judged all radiographic findings as either positive or negative. The result was considered positive when the nonionic contrast material was observed only within the suprapatella pouch or meniscus and negative if the contrast material was visible in the fat pad or subsynovial tissue layers (Figure 5).[5,14]

Figure 2. Sonographically guided intra-articular knee injection via the midlateral approach. **A** and **D**, Ultrasound probe placed on the midlateral portion of the knee joint. **B** and **E**, Patella tilted to the lateral side. **C** and **F**, Needle injection and visible needle tip (white arrow). Arrowhead indicates patella retinaculum; F, femur; open arrow, retropatella cartilage; and P, patella.



Statistical Methods

The data were analyzed using SPSS version 11.0 software (SPSS Inc, Chicago, IL). Analysis of variance was used to compare the demographic and clinical characteristics of the patients, and a χ^2 test was used to compare the accuracy of the intra-articular-injection procedures. $P < .05$ was considered significant.

Results

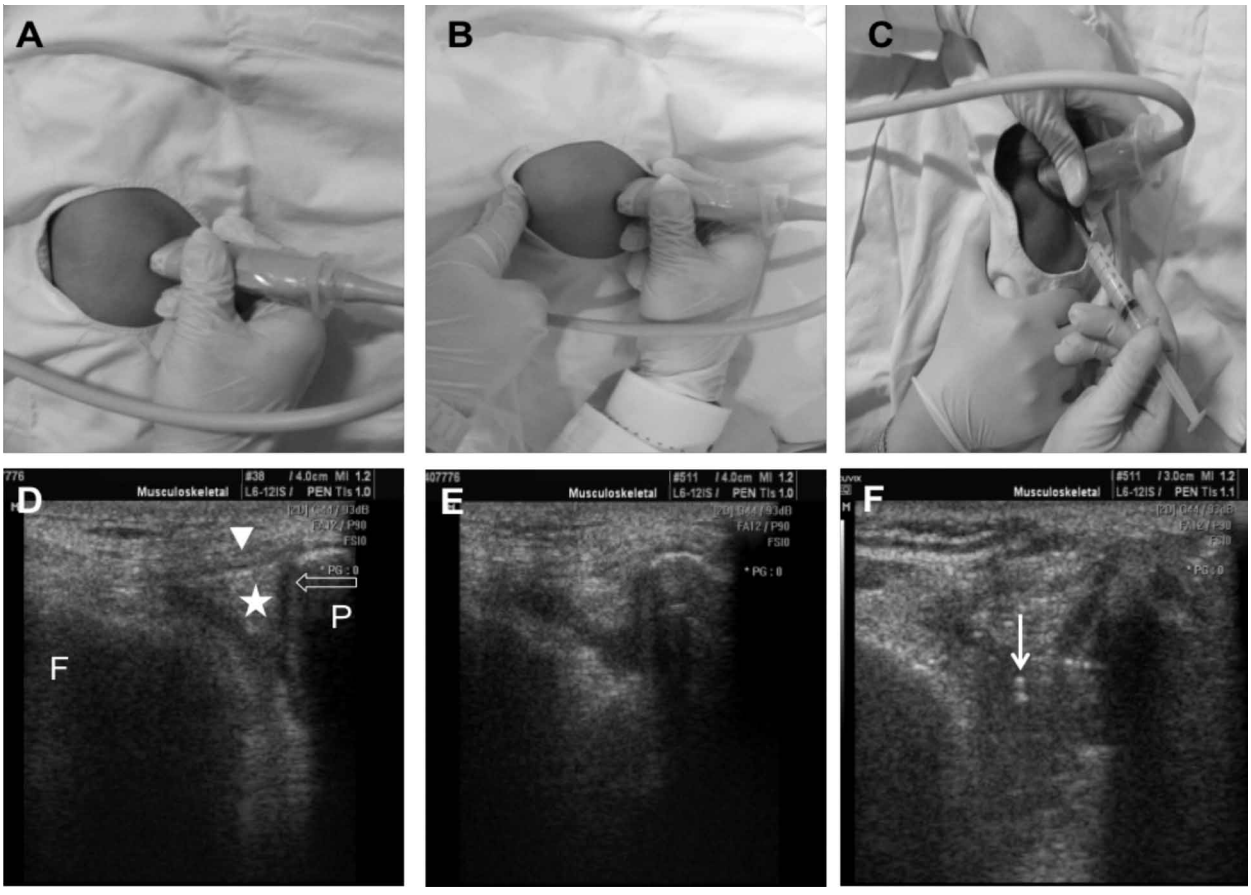
Demographic Data

The medial portal group included a total of 40 knees from 8 men and 32 women with a mean age of 64.8 years (95% confidence interval [CI], 61.6–67.9 years) and a mean body mass index (BMI) of 24.3 kg/m^2 (95% CI, 22.9–25.7 kg/m^2). Of these, 31 and 9 patients had Kellgren-Lawrence grade 2 and 3 knees, respectively. The midlateral portal group included a total of 43 knees from 8 men and 35 women with a mean age of 64.8 years (95% CI, 61.6–67.9 years) and a mean BMI of 24.9 kg/m^2 (95% CI, 61.8–67.8 kg/m^2). Of these, 33 and 10 patients had Kellgren-Lawrence grade 2 and 3 knees. The superolateral portal group consisted of 43 knees from 9 men and 34 women with a mean age of 65.8 years (95% CI, 62.9–68.7 years) and a mean BMI of 25.2 kg/m^2 (95% CI, 24.0–26.4 kg/m^2). Of these, 31 and 12 had Kellgren-Lawrence grade 2 and 3 knees. There were no significant differences in the demographic data between the groups.

Accuracy Rates of Intra-articular Injections

The Kellgren-Lawrence grade 2 and 3 cases each had accuracy rates of 100% and 100%, 97% and 90%, and 77% and 67% for the superolateral, midlateral, and medial approaches, respectively. Combined, the Kellgren-Lawrence grade 2 and 3 cases together had accuracy rates of 100%, 95%, and 75% for the superolateral, midlateral, and medial approaches (Table 1).

Figure 3. Sonographically guided intra-articular knee injection via the medial approach. **A** and **D**, Ultrasound probe placed on the medial portion of the knee joint. **B** and **E**, Patella tilted to the medial side. **C** and **F**, Needle injection and visible needle tip (white arrow). Arrowhead indicates patella retinaculum; F, femur; open arrow, retropatella cartilage; P, patella; and star, parapatella fat pad.



Complications of Intra-articular Injections

The needles touched the patella cartilage or periosteum at least once in 3 cases on the medial side and 2 cases on the lateral side because of an incorrect location of the needle tip. On the other hand, no major complications, such as infection or fat atrophy, were observed after the steroid injections. One case of hot flushing of the knee of approximately 1 week's duration occurred in the midlateral group.

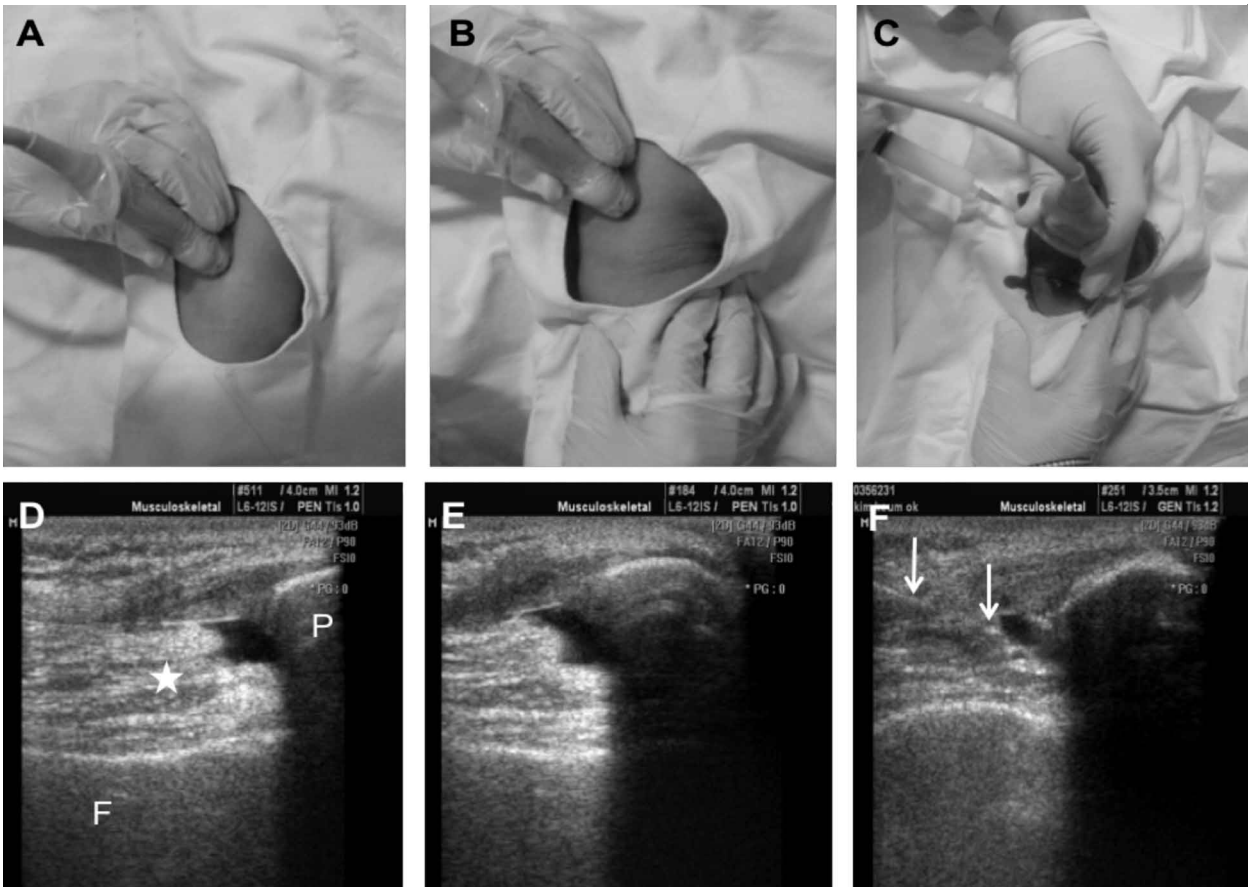
Discussion

Intra-articular injections of corticosteroids are used widely in patients with knee osteoarthritis, but an accurate injection is important because it helps increase the effectiveness and minimize complications. In particular, in a dry knee, a blind injection is less likely to locate the needle accurately and can cause pain and discomfort if any of the tissues are damaged.[15] The disadvantages of blind injection approaches can be overcome by sonography, which allows the joint space to be observed on a screen, even in obese patients. Therefore, sonographically guided injections are easier than blind injections and can help relieve discomfort.

Recently, sonographically guided injections have been used for dry knee diseases (Kellgren-Lawrence grades 2 and 3) because of their higher accuracy than blind injections.[8] In this study, the accuracy of sonographically guided intra-articular injection approaches was evaluated in knee osteoarthritis (Kellgren-Lawrence grades 2 and 3). The results revealed total accuracy of 75%, 95%, and 100% for the medial, midlateral, and superolateral portals, respectively; therefore, the superolateral and medial portals had the highest and lowest accuracy.

The definition of injection failure can include not only a direct extra-articular space injection but cases in which the nonionic contrast material is visible in the fat pad or subsynovial tissue layers due to drug leakage after an intra-articular space injection. In these results, the 13 cases confirmed to have failed were cases of leakage. There may have

Figure 4. Sonographically guided intra-articular knee injection via the superolateral approach. **A** and **D**, Ultrasound probe placed on the superolateral portion of the knee joint. **B** and **E**, Counterforce provided to the patella. **C** and **F**, Needle injection and visible needle (arrows). F indicates femur; P, patella; and star, prefemoral fat pad.



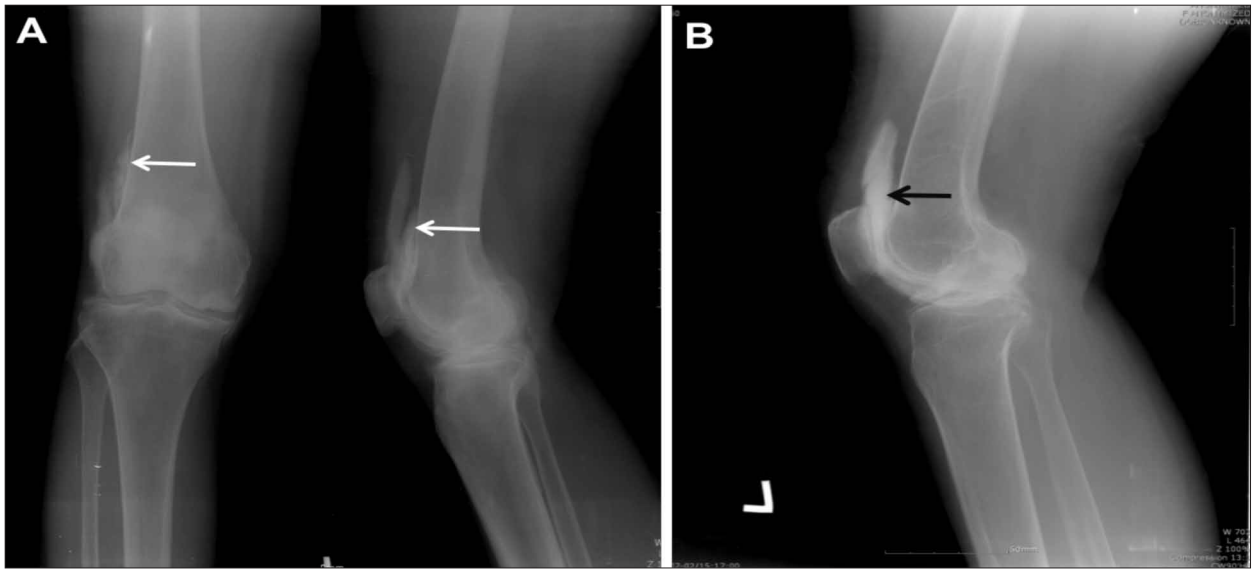


Figure 5. A, Visible leakage of nonionic contrast material (arrows) in the soft tissue. **B**, Successful intra-articular injection (arrow).

been 3 reasons for such injection failure: (1) technically controlling the needles was difficult with the coaxial approach compared to the longitudinal approach; (2) the medial area was anatomically more narrow than the lateral area; and (3) the needles may not have been fixed correctly because a freehand technique was used in this study.

In the superolateral approach, the width of the joint space is increased partially by providing a counterforce, and the operator can observe the entire needle, unlike in the coaxial needle approach to the probe. Therefore, it is easy for the operator to confirm the needle tip via the superolateral approach and inject the material effectively into the joint space. Indeed, Schmidt et al[16] performed sonography in healthy adults and reported fluid rates of 77% and 6% in the suprapatellar recess and deep infrapatellar recess, respectively, as well as a greater diameter of the suprapatellar recess. On the other hand, this study did not include objective data on the joint space width on the medial, midlateral, and superolateral sides. Therefore, further studies will be needed to provide such data.

With the superolateral approach, it is ideal that patients be asked to naturally bend their knees slightly to observe the suprapatella bursa because the dependent position allows the observer to see the bursa clearly. In this study, we conducted all injections with the patients in the supine position with the knee fully extended. Hence, there may be no difference in outcomes with variations in knee positioning. On the other hand, it is possible that an approach in which the joint fluid can be observed more with a specific degree of knee flexion can reveal higher accuracy. Therefore, further studies will be needed to examine differences in how much joint fluid is observed on sonography when the same injection approach is applied with varying degrees of knee flexion and differences in the accuracy of varying degrees of flexion when the medial, midlateral, and superolateral approaches are applied.

In this study, intra-articular injections were performed using the coaxial needle approach to the probe when the medial and midlateral approaches were used. In the coaxial needle approach, the needle is observed as a small dot, and the needle tip may go out of sight easily on sonography. Therefore, the drug might not be delivered to the joint space, or it may enter the surrounding fat pad or other tissues.[8] Consequently, the coaxial needle approach requires

Table 1. Accuracy Rates of Intra-articular Injection Methods in Patients With Knee Osteoarthritis

Successful Injections	Medial Portal	Midlateral Portal	Superolateral Portal
Total, n (%)	30/40 (75)[a]	41/43 (95)	43/43 (100)
Kellgren-Lawrence grade 2, n (%)	24/31 (77)[a]	32/33 (97)	31/31 (100)
Kellgren-Lawrence grade 3, n (%)	6/9 (67)[a]	9/10 (90)	12/12 (100)

[a] $P < .05$.

more experience and takes longer than the longitudinal needle approach because there is a need to tilt the probe to observe the needle tip.[17] In addition, we attempted to improve the accuracy at the maximum by confirming the visible steroid particles in the joint space and joint distension with color Doppler imaging (Figure 6).

In this study, the level of comfort or discomfort of the patients was not examined according to the injection method. Nevertheless, when the injections were conducted, the superolateral approach did not induce events that might have injured surrounding painful structures, whereas there were some cases in which the painful structures were injured when the medial and midlateral approaches were applied. In all cases in which the injections had failed, the injection into the extra-articular space was not shown from the beginning, but the leakage into the intra-articular and extra-articular spaces was simultaneously present. In the cases of injection failure, however, there was only 1 case of hot flushing in the midlateral approach but no major complications, such as infection or fat atrophy, after the steroid injections.

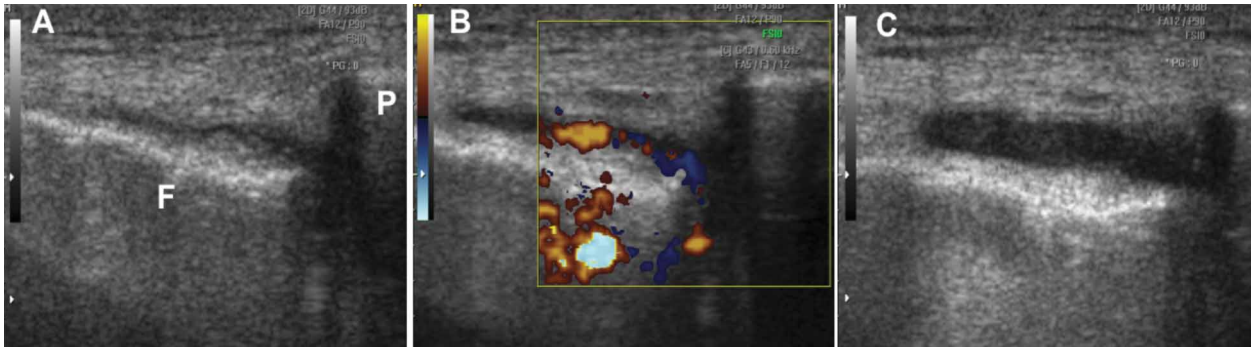
The coaxial needle approach had less accuracy than the longitudinal approach in this study. On the other hand, the accuracy rates for the medial and midlateral approaches were different even when the same coaxial needle approach was used. In the midlateral area, the injected drug rarely spreads to the surrounding tissues other than the joint space because there is little soft tissue around the joint space, and the drug is seldom injected into other tissues, even when the needle tip moves during the injection process. In this study, a 25-gauge needle was used, although it may be difficult for needle tips to be confirmed by sonography. Nevertheless, the effects of needle size may not substantial because needle tips of different sizes, observed as dots in the coaxial approach, may be similar on sonography.[17]

This study examined effective approaches for sonographically guided intra-articular injections in the knee joint but did not evaluate the longitudinal needle approach to the probe in the midlateral and midmedial portals. In this preliminary study, the longitudinal needle approach in the midlateral and midmedial portals could have allowed the entire needle to be observed, in contrast to the coaxial needle approach. On the other hand, with the longitudinal needle approach, accurate identification of other anatomic landmarks on sonography is difficult, and this approach might be unsafe. Therefore, the longitudinal approach in the midlateral and midmedial portals was excluded. The anterior approach was also excluded because it has lower satisfaction and accuracy rates than the midmedial and midlateral approaches, an guiding an ultrasound probe via this approach is difficult.[5,18]

A freehand technique and a 25-gauge needle were used in this study. As Im et al[8] suggested, if the injection pressure of the syringe is elevated, the needle might not be fixed and might tend to rise slightly. As a result, it would be possible for injected material to leak into the fat pad or surrounding tissues. In this study, the injection pressure with the 25-gauge needle might have been higher, but the needle would have been almost fixed because sonographic guidance was used. Therefore, the possibility of back leakage would have been less than for blind injections. All intra-articular injections used the same-size needle and the same amount of injectate. Therefore, the needle size and intra-articular pressure would have had similar effects on the different injection methods.

In this study, a total of 6 mL of material was injected, but according to Hong et al,[19] effusion was visible in only approximately 14% of lateral longitudinal scans and 7% of lateral transverse scans with infusion of 5 mL. Therefore, the infusion of 6 mL in this study might not have increased

Figure 6. A, Before sonographically guided injection via the midlateral approach. **B**, Color Doppler image showing accurate intra-articular injection. **C**, After injection. The steroid particles are visible, and the fat pad is elevated upward because of the injected fluid. F indicates femur; and P, patella.



the intra-articular pressure and caused back leakage. Cardone and Tallia[20] recommended knee injections of 7 to 10 mL, which may be another reason why the intra-articular pressure might not have been elevated enough to cause leakage. In addition, all of the injections were performed in patients with a BMI of less than 30 kg/m^2. In obese patients, a large amount of subcutaneous fat would increase the distance from the skin to the joint space, necessitating a longer needle. Therefore, more practical research on these limitations will be needed.

In conclusion, sonographically guided intra-articular knee joint injections in the midlateral and superolateral portals were more accurate than injection in the medial portal.

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