Feasibility of Sonography for Intra-articular Injections in the Knee Through a Medial Patellar Portal

Sang Hee Im, MD, Sang Chul Lee, MD, PhD, Yong Bum Park, MD, Sung-Rae Cho, MD, PhD, Jong Chan Kim, MD

Objective. The purpose of this study was to investigate the feasibility of using real-time high-resolution sonography to guide an injection needle into the intra-articular space within the knee. ***Methods.*** Eighty-nine patients with radiographically confirmed knee osteoarthritis (Kellgren-Lawrence grade 2 or 3) without an effusion were included. After sonographically guided or blind injection of hyaluronic acid (HA) and contrast dye through a medial patellar portal (MPP) into the knee joint, a radiographic image was made to ascertain whether the injected material had reached the intra-articular space. ***Result.*** Sonographically guided injections of HA into the knee joint had a significantly greater accuracy rate (95.6%) than blind injections (77.3%; $P = .01$). ***Conclusions.*** Intra-articular injections via an MPP using sonographic guidance may raise the accuracy rate in knee joint injections. ***Key words:*** injection; knee; sonography.

The use of an intra-articular injection of hyaluronic acid (HA) has recently become widely accepted as a therapy for pain accompanying osteoarthritis (OA) of the knee.[1] In OA, there is a reduction in the elastoviscosity of the synovial fluid secondary to a decrease in the molecular weight and concentration of HA. Viscosupplementation is a therapeutic technique that addresses the decrease in synovial viscosity with the injection of exogenous high-molecular-weight hyaluronan molecules.[2] However, incorrect placement of an extra-articular HA injection causes discomfort to the patient and a reduced effect of HA.[3]

A number of factors emphasize the importance of accurate intra-articular injections of HA. First, a small volume (2–3 mL) of HA may not be expelled as easily as a larger volume of HA, which may dissipate into the joint through the soft tissues secondary to the injection pressure of the syringe.[4] Second, local corticosteroids may have an effect on nonspecific knee pain, even if administered periarticularly.[5] However, HA would not be expected to have any effect when applied to the tissue surrounding the joint.[6] Third, the substantially higher cost of HA injections and the requirement for multiple injections increase the desirability that the preparation is delivered intra-articularly for a maximum effect.[4] Finally, incorrect placement of a soft tissue injection causes more discomfort to the patient during and after the procedure.

Abbreviations
HA, hyaluronic acid; MPP, medial patellar portal; MRI, magnetic resonance imaging; OA, osteoarthritis

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Address correspondence to Sang Chul Lee, MD, PhD, Department of Physical Medicine and Rehabilitation, Myongji Hospital, Kwandong University College of Medicine, 697-24 Hwajung-dong, Dokyang-ku, Koyang, Kyunggi 412-270, Korea.

E-mail: bettertomo@naver.com

Needle placement is easily confirmed when an effusion is present. During knee joint aspiration for an effusion, the return of synovial fluid confirms the intra-articular placement of the needle. On the other hand, accurate intra-articular placement of HA is difficult without guidance by real-time fluoroscopic imaging or a sonographic method for "dry" knee disease.[7] There are only a few studies that have evaluated the accuracy of needle placement into the intra-articular space of the knee joint in the absence of an effusion.[6,8,9]

The use of fluoroscopy for intra-articular injections in the knee has considerable importance because this technique helps minimize the chance of injury associated with the injection and elevates the accuracy of the injection.[6,9] However, contrast media are costly and may not always be mixed with other substances for injection,[10] and repeated injections under fluoroscopy should be avoided because of the accumulated radiation.

Although a previous study showed the feasibility of using sonography to guide intra-articular injections in the knee,[10] a need exists to further show its advantages, such as the accuracy rate and operability. Driven by a need for more accurate, safer, and less costly methods for intra-articular injections, this study was undertaken to investigate the feasibility of using real-time high-resolution sonography to guide an injection needle into the intra-articular space within the knee.

Materials and Methods

Eighty-nine patients with radiographically confirmed knee OA (Kellgren-Lawrence grade 2 or 3) without an effusion who were symptomatic for at least 6 months and reported pain on most days for the previous 3 months were considered for enrollment in this study. To be eligible, the patients could not have inflammatory joint disease, chondrocalcinosis (evidence from radiographs or synovial fluid analysis), or an infection in or around the study knee, and they could not be receiving anticoagulant therapy and could not have had viscosupplement treatment within the past 6 months. Only dry knees with no clinically detectable effusion and patients in whom the suprapatellar bursa was not discernible on sonography by the method reported in a previous study[10] were included. Patients were individually randomized into sonographically guided and blind injection groups by a table of random numbers.

Approval from the Institutional Review Board was obtained at the outset of the study. The nature of the study was explained to the patients before the procedures, and informed consent was obtained in each case. The clinical efficacy of the intra-articular knee injection procedure was not the aim of this study; therefore, no attempt was made to correlate the treatment outcomes with any of the variables defined in the study. All of the patients underwent a clinical evaluation, a radiographic imaging study, and an intra-articular injection in the knee.

Preliminary Magnetic Resonance Imaging Study

To estimate the optimal medial patellar portal (MPP) for injection, we evaluated the size of the fat pad and joint cavity using magnetic resonance imaging (MRI) of the medial part of the patellofemoral joints of 5 patients. On the basis of these preliminary data, we found potential MPPs for injection with small fat pads, which allow easier access to the joint cavity during sonographically guided injections (Figure 1).

Sonographic Examination

The procedure was performed by the sonography system operator, 1 physiatrist, and 1 assistant. The patients in the sonographically guided injection group were placed in the supine position with a fully extended knee on the examination table. We used an ultrasound machine (L12-5/38 mm, HDI 5000; Philips Healthcare, Bothell, WA) with a 7- to 12-MHz linear array probe. Before proceeding with an injection procedure, an accurate sonographic examination of the medial side of the knee was repeated to identify the most adequate MPP while shifting the probe up and down between the articular surfaces of the patellofemoral joint near the midpoint of the patella. An MPP was selected in which the intra-articular space was visible with less of a fat pad.

For injections into the joint cavity, an adequate needle length is an essential requirement. The distance was measured from the surface to the target area by a built-in manual measurement of the sonographic image.

Injection Procedure

The treatment involved 3 intra-articular injections of high-molecular-weight HA (2 mL of 1% HA; molecular weight, 940–1020 kDa) into the affected knee at weekly intervals, according to the manufacturer's recommended protocol (Hyalforte; Shin Poong, PhD, Kyunggi, Korea). Only the first injection of each case and its result were analyzed for this study.

A wide area of knee skin was prepared and draped. In the sonographically guided injection group, injections were performed with a 1.5-in (3.8-cm) or 2-in (5.1-cm) 21-gauge needle after estimation of the needle length by sonography. The probe was placed in close proximity to the puncture site, and the needle was advanced under direct sonographic guidance. The needle was aligned with the small side of the probe during insertion. Combined color Doppler imaging allowed a more precise assessment of the needle tip with detection of the flow of the solution as a bright color.

In the blind injection group, injections were performed with a 1.5-in (3.8-cm) 21-gauge needle at the physician's preference. The patellar border was outlined with a marking pen, and the injection was done at the point where the mid horizontal line of the patella met the medial border of the patella (Figure 2).[11]

A 3-way stopcock was used for the study injections, which allowed the passage of both the contrast dye solution and the HA through the same needle with only a single needle placement. When the needle was positioned in the target area, 2 mL of HA was injected (Figure 3). After injection of HA, the stopcock was opened, and a small amount (0.5 mL) of contrast dye solution in the other syringe was injected to confirm the position of the needle tip by radiography.

Assessment

To assess the accuracy rate of sonographically guided intra-articular injections through the MPP, a radiographic imaging study was undertaken. A postinjection radiographic evaluation was performed 10 to 15 minutes after the injection procedure. From the imaging results, we concluded whether the injected material had reached the intra-articular space. Any contrast material appearing in the extra-articular space was defined as a "failed" case.

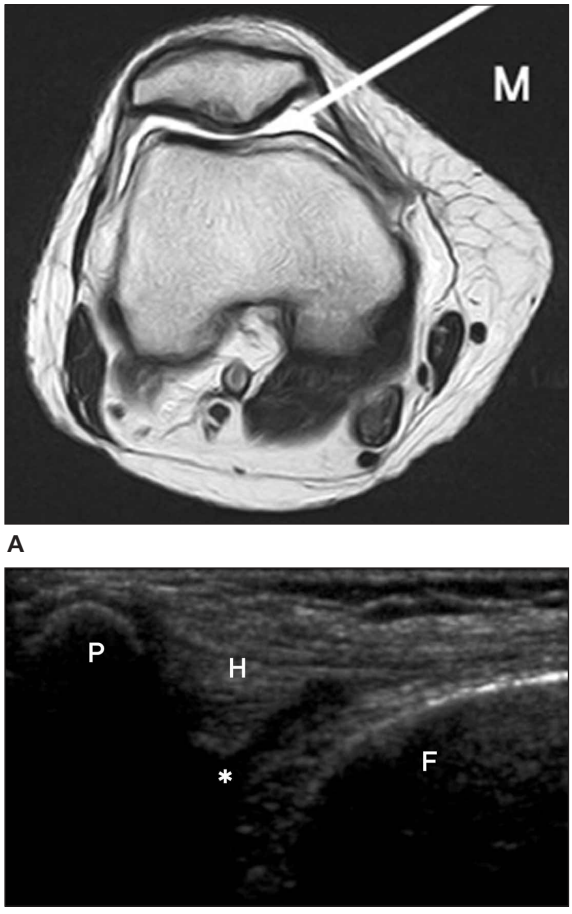


Figure 1. Axial T2-weighted MRI of the knee joint (**A**) and correlative transverse sonogram (**B**). Asterisk indicates the targeted area; F, femur; H, Hoffa fat pad; M, medial side; and P, patella.

Figure 2. All landmarks were outlined with a marking pen, and blind MPP injections were performed with the lower limb extended on the examination table. The needle was advanced transversely between the articular surfaces of the patellofemoral joint at the midpoint of the patella.

Statistics

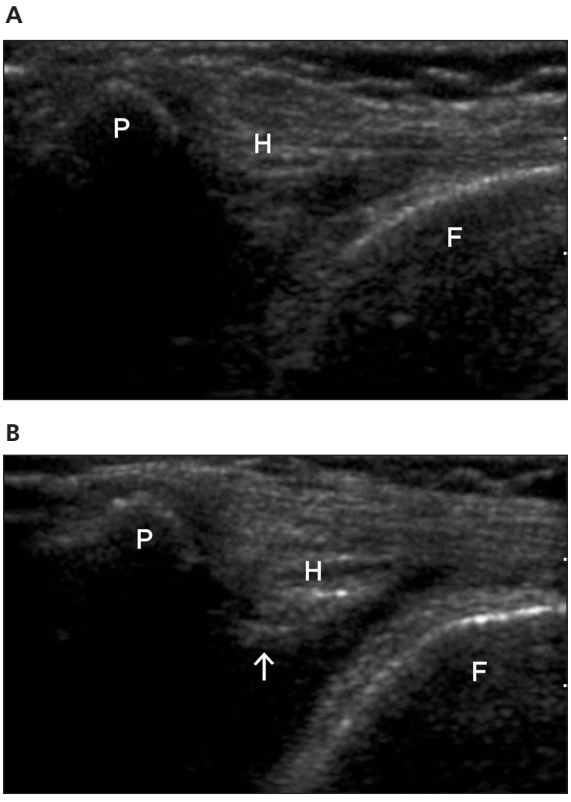
Statistical analysis was performed with SPSS version 13.0 software for Windows (SPSS Inc, Chicago, IL). An independent *t* test and Mann-Whitney *U* test were used to compare the demographic and clinical characteristics of the patients. The χ^2 test was used for the comparison of success rates of the injection procedures. $P < .05$ was considered statistically significant.

Results

Patient Characteristics

After being randomly assigned to 1 of 2 groups, 45 patients were included in the sonographically guided injection group, and 44 were included in the blind injection group. The demographic and clinical characteristics of the patients in the 2 groups were comparable (Table 1).

Figure 3. Before (**A**) and after (**B**) a sonographically guided injection. The fat pad is elevated upward because of the injected fluid. F indicates femur; H and arrow, Hoffa fat pad; and P, patella.



Success Rate of the Injection Procedure

The sonographically guided injection group had a significantly higher success rate of injections compared with the blind injection group ($P = .01$). Forty-three of 45 knees (95.6%) in the sonographically guided injection group had successful injections into the joint cavity on radiography, which revealed the presence of contrast dye in the joint cavity. The 2 failed cases had some contrast material in the extra-articular space. Thirty-four of 44 knees (77.3%) in the blind injection group had successful injections into the joint cavity.

Discussion

Jones et al[8] reported that 66% of knee joint blind injections were intra-articular, and almost one-third were extra-articular; the response to steroid therapy was similar regardless of whether the injection was intra- or extra-articular. However, to achieve a maximal potential therapeutic benefit, HA-based preparations should be delivered directly into the intra-articular space and not into the fat pad or the subsynovial tissue layers.[3] Because HA has a high viscosity, it is difficult for the clinician to perceive whether the dose of HA is passing into the soft tissue or the joint space because of its flow resistance in the needle.[12] Therefore, there might be a greater possibility of extra-articular injections of HA than other drugs with less viscosity.

A recent study suggested that sonography could be used as an adjuvant tool for intra-articular injections in the knee instead of fluoroscopy.[10] With sonographic guidance, HA was injected into the intra-articular space via the suprapatellar bursa. When the bursa was not discernible on sonography, air was injected into the lateral point of the knee just under the patella, and the visible air on sonography was regarded as a successful injection into the suprapatellar bursa. However, we cannot conclude that this was an injection procedure under sonographic guidance but rather a blind injection with confirmation by sonography.

Although a number of clinical trials are being performed regarding the efficacy of intra-articular HA injections, there is little consensus in the literature on the appropriate technique.[4,7,8] Esenyel

et al[11] evaluated the accuracy rate of intra-articular blind knee injections using anteromedial, anterolateral, lateral midpatellar, and medial midpatellar portals in cadavers and reported that the accuracy obtained with the use of a medial midpatellar portal was significantly lower (accuracy rate, 56%) than other portals. However, this study did not explain the basis of the lower accuracy rate with the medial midpatellar portal approach. Furthermore, the injection procedure was undertaken only by surface landmarks.

Involvement of the lateral patellofemoral joint in OA is more common than the medial patellofemoral joint,[13] and many cases show lateral tilting of the patellofemoral joint.[14] This supports the idea that there is sufficient intra-articular space for an injection approach through an MPP. In addition, extension of the knee joint induces external rotation of the hip joint, which results in an easier approach for the medial side of the knee. The medial approach to the knee also has an advantage for patients with strokes or spinal cord injuries who have difficulty with internal rotation of the hip due to severe spasticity or cooperation problems. As the results of our preliminary MRI study showed, not only the lateral side but also the medial side of the knee had enough space for the injection of HA (Figure 1), and there was no structure that could be injured during injection except the fat pad on the medial side of the knee. Therefore, we chose the medial approach through an MPP, which was shown to have a lower accuracy rate in a previous study,[8] and expected that the approach through an MPP might affirm the feasibility of sonography for intra-articular injections in the knee.

With a sonographically guided knee injection, we avoided injection into the fat pad between the skin and joint space. In the cases with an incorrectly placed needle, we could correct the direction of the needle under sonographic guidance and minimize the chance of injury associated with the injection. When the needle became less evident or when the needle tip was not detectable with increasing obliquity,[15] color Doppler imaging was useful to monitor the accurate placement of the needle tip. In the practical procedure of injection of a mixture of HA and a small amount of saline or lidocaine, it was possible to detect the needle tip with color Doppler imaging. In addition, all vessels could be visualized easily by color Doppler imaging and were distinguishable from anechoic cavities.

Table 1. Patient Characteristics

Characteristic	Sonographically Guided Injection (n = 45)	Blind Injection (n = 44)	*P*
Sex, male/female, n	11/34	13/31	
Age, y	60.6 ± 7.9	59.6 ± 9.9	.69
Disease duration, y	5.2 ± 1.9	4.6 ± 1.8	.59
Kellgren-Lawrence scale	2.3 ± 1.5	2.3 ± 0.5	.74
Body mass index	23.7 ± 1.5	23.8 ± 1.3	.58

Values are mean ± SD or as otherwise indicated.

This study was designed to clarify whether an injection from the medial aspect of the patellofemoral joint under sonographic guidance could raise the accuracy rate of this procedure over that of the blind technique, which had a low accuracy rate in previous reports. We achieved good results with a higher accuracy rate than the blind method; however, we still do not know which approach is most accurate. Therefore, further studies comparing the accuracy rates of different approaches under sonographic guidance are needed to find the optimal portal for intra-articular injections in the knee.

In conclusion, intra-articular injections via an MPP using sonographic guidance resulted in good intra-articular delivery with a 95.6% accuracy rate and a lower incidence of soft tissue infiltration. This approach has advantages, such as convenience and lack of radiation hazards, which makes sonography preferable to fluoroscopy. Furthermore, intra-articular injections via an MPP using sonographic guidance might be more useful in cases in which the suprapatellar bursa is not discernable on sonography without a joint effusion or with a small joint effusion.

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