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Original Article

The effects of ultrasound-guided genicular nerve block on proprioception and static balance in knee osteoarthritis patients

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ABSTRACT

Objectives: This study aims to evaluate proprioception and static balance after ultrasound-guided genicular nerve block (GNB) in patients with knee osteoarthritis (KOA).

Patients and methods: The observational study included 22 patients (8 males, 14 females; mean age: 61.9±7.7 years; range, 50 to 70 years) with Kellgren-Lawrence Grade 2 or 3 KOA between January 2024 and June 2024. At baseline and 24 h after the application of GNB, pain was evaluated using a Visual Analog Scale, and HUR SmartBalance assessments were performed.

Results: Visual Analog Scale pain scores significantly decreased after treatment ($p<0.001$). With the exception of the static balance score, the HUR SmartBalance parameters showed a significant difference after treatment compared to baseline ($p=0.626$). Proprioception disturbance, visual dependency, and vestibular balance scores significantly increased ($p<0.001$) in comparison to pretreatment values.

Conclusion: Contrary to common belief, GNB appears to have a positive effect on proprioception and balance in patients with KOA.

Keywords: Balance, injections, nerve block, osteoarthritis, pain, proprioception.

Osteoarthritis is the most common articular disease worldwide and the knee joint is the most likely joint to be affected.[1] It can cause chronic pain, stiffness, limited range of motion, and functional disability.[1,2] Knee osteoarthritis (KOA) effects activities of daily living.[3] Interventional treatment methods such as genicular nerve block (GNB) provides an innovative option to decrease pain and improve functionality in symptomatic KOA. Genicular nerve blocks are appropriate for patients who are resistant to conservative treatment or those who avoid surgery. The superomedial, inferomedial, and superolateral branches of this nerve are targeted in GNB. Genicular nerve blocks provide midterm pain relief and appear to be safe with repeated injections even in patients with multiple comorbidities.[4] Genicular nerve branches play a fundamental role in innervating the knee joint, provide innervation to the knee joint capsule, and receive afferent stimuli from the proprioceptive receptors in the capsule. Possible functions of proprioceptive receptors in the knee joint are the prevention of excessive movement, stabilization of the knee in static posture, and coordination of complex movements.[4,5] Proprioception appears to be impaired in KOA patients. Proprioceptive receptor defect in KOA has been shown previously.[5]

Therapeutic blocking of the genicular nerve, which plays a role in proprioception, may disrupt proprioceptive feedback and potentially exacerbating knee dysfunction or disrupt defective proprioceptive afferent inputs and contribute to more accurate balance and proprioception.[5-7] Within this context, this study aimed to observe the effect of GNB, used for treatment in patients with KOA, on general balance and proprioception measured with the static balance device, HUR SmartBalance.

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PATIENTS AND METHODS

This observational study was conducted in the University of Health Sciences, Ankara Bilkent City Hospital, Department of Physical Medicine and Rehabilitation between January 2024 and June 2024. Twenty-two patients (8 males, 14 females; mean age: 61.9±7.7 years; range, 50 to 70 years) who were diagnosed with KOA according to the American College of Rheumatology criteria (>50 years of age, morning stiffness <30 min, crepitus in active motion, and osteophytes determined radiologically) were included in the study.[8] The inclusion criteria were *(i)* chronic knee pain lasting >3 months according to the Visual Analog Scale (VAS) and difficulty in function for >3 months; *(ii)* Grade 2 or 3 KOA according to the Kellgren-Lawrence (KL) radiological grading system; and *(iii)* no significant improvement in response to conservative treatments such as analgesics and physiotherapy. The exclusion criteria were *(i)* a history of trauma, fracture, malignancy, surgery, or inflammatory diseases of the knee; *(ii)* limitations in range of motion in the knee joint, unilaterally or bilaterally; *(iii)* known allergy to the pharmacological agents used during the procedure (lidocaine); *(iv)* a history of intra-articular or periarticular injection such as hyaluronic acids, corticosteroids, or collagen supplements in the last six months; *(v)* the presence of other neurological or rheumatological conditions that may lead to vertigo or vestibular dysfunction, or impairment in proprioception such as polyneuropathy; *(vi)* a diagnosis of diabetes mellitus due to the risk of small fiber neuropathy; and *(vii)* any cognitive impairment or uncontrolled systemic conditions. Written informed consent was obtained from all patients. The study was approved by the Ankara Bilkent City Hospital Clinical Research Ethics Committee (Date: 23.08.2023, No: E2-23-3798). The study was conducted in line with the principles of the Declaration of Helsinki. The protocol was registered in the ClinicalTrials.gov database (NCT06527651).

The KL grading was used for the classification of radiographic osteoarthritis according to radiographic features such as joint space narrowing, osteophytes, subchondral sclerosis, and subchondral cysts. The severity of radiographic changes increased from Grade 0 to 4. Grade 0 indicated no radiographic changes, and Grade 4 indicated severe osteoarthritis, large osteophytes, severe sclerosis, nearly disappeared joint space, and bony deformity. Definite osteophytes and possible joint space narrowing were classified as KL Grade 2, and moderate osteophytes, subchondral sclerosis, and definite narrowing of the joint space were classified as KL Grade 3.[9]

The sociodemographic and clinical features of patients diagnosed as Grade 2 or 3 KOA were recorded. The patients were questioned about previously received therapies and smoking status. Pain scores were recorded using a VAS at baseline and 24 h after the procedure. A 10-cm VAS, with known validity and reliability, was used as a self-reported measure for the severity of knee joint pain.[10] Balance and proprioception parameters were assessed with the HUR Smartbalance (HUR Ltd. Kokkola, Finland). Static balance, proprioception disturbance, visual dependency, and vestibular dominant scores measured before the treatment and at 24 h after GNB were compared.

The HUR SmartBalance device is used in both balance assessments and rehabilitative training programs, such as vertigo rehabilitation, balance training for mild gait disorders, and fall prevention in the elderly.[11] The device consists of a Balance Trainer, Support Rail, SmartBalance Software, Touchscreen Computer, and Foam surface

Figure 1. Patient positioning on the HUR SmartBalance device for static balance and proprioception testing.

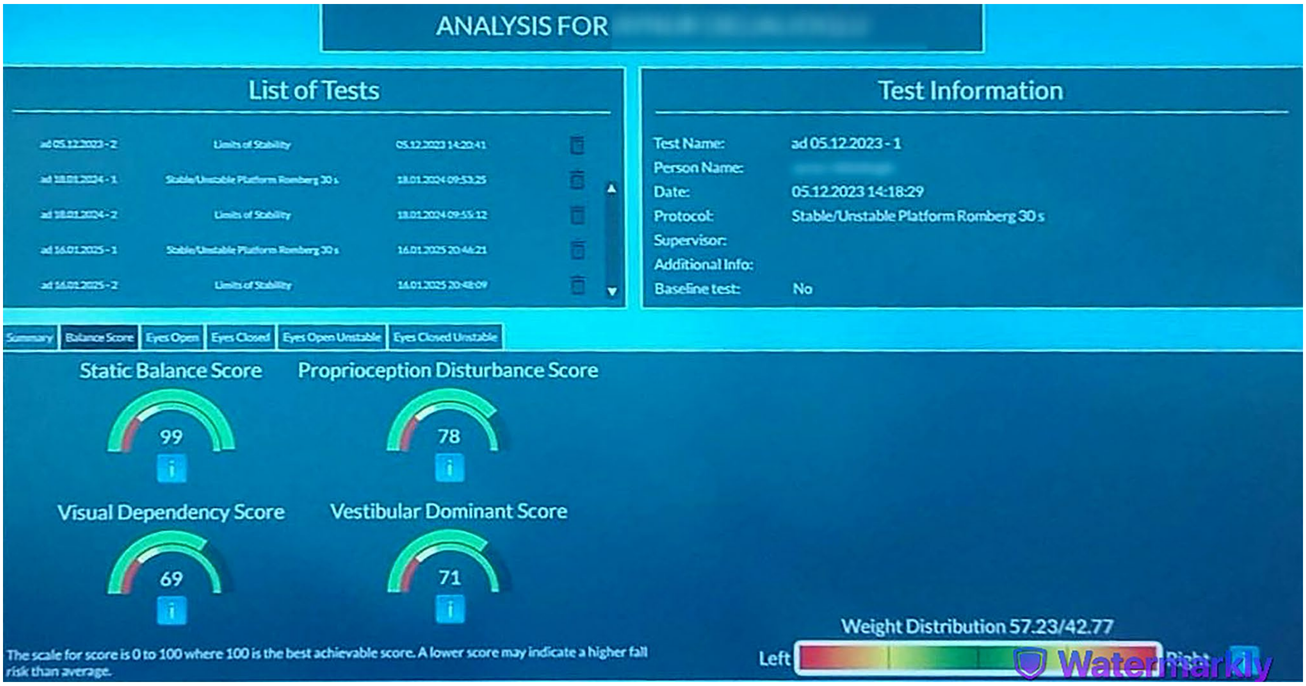

Figure 2. Screen display of the HUR SmartBalance device showing the evaluated parameters. These include static balance, proprioception disturbance, visual dependency, and vestibular balance. Scores range from 0 to 100, with higher scores indicating better balance or proprioceptive ability.

(Figures 1, 2). Balance scores allow assessments and comparisons in terms of static balance, proprioception disturbance, visual dependency, and vestibular dominant proprioception. The static balance score indicates the ability to stand still with eyes open on a firm surface. The proprioception disturbance score shows the ability to stand still with eyes open on a nonrigid surface. The vestibular dominant proprioception score indicates the ability to balance while standing still on a nonrigid surface with eyes closed, and the visual dependency score demonstrates the ability to balance on a firm surface with eyes closed. All the scores are calculated from a maximum of 100, with higher scores indicating better proprioceptive sense and balance. Validity and reliability for the Turkish population have been demonstrated previously.[11]

The balance test was performed in 10 min under the supervision of a physiatrist. The device instructions were followed during the test and the balance scores for the test taken with the eyes open and closed were recorded for each patient. All pre- and posttreatment assessments were performed by the same physiatrist using a HUR SmartBalance device.

Genicular blocks were applied bilaterally by another physiatrist with more than five years of experience in ultrasonographic interventional procedures. A total of 6 mL of solution, consisting of 0.5 mg/2 mL dexamethasone and 4 mL of 1% lidocaine, was separrated into three portions for injection into the superomedial, superolateral, and inferomedial branches of the genicular nerve. Thus a total of 12 mL solution was administered to each patient. Antiseptic precautions were taken and a sterile environment was prepared. A 5 to 12 MHz linear probe (Loqiq P5; GE Medical systems, Logic P5, GE Mediacal Systems, USA) was used for all ultrasonographic evaluations. The probe was positioned in line with the femur shaft. To locate the superomedial genicular nerve, the probe was first moved to the junction of the femur shaft and medial femoral condyle. Color Doppler was used to identify the superomedial genicular artery, and 2 mL of the injection solution was administered around the pulsatile artery region. The same procedures were repeated for the superolateral and inferomedial genicular nerves as described in previous cadaveric and experimental studies (Figure 3).[12,13]

Sample size analysis

The sample size was determined using a power analysis, based on a similar study by Kim et al.,[14]

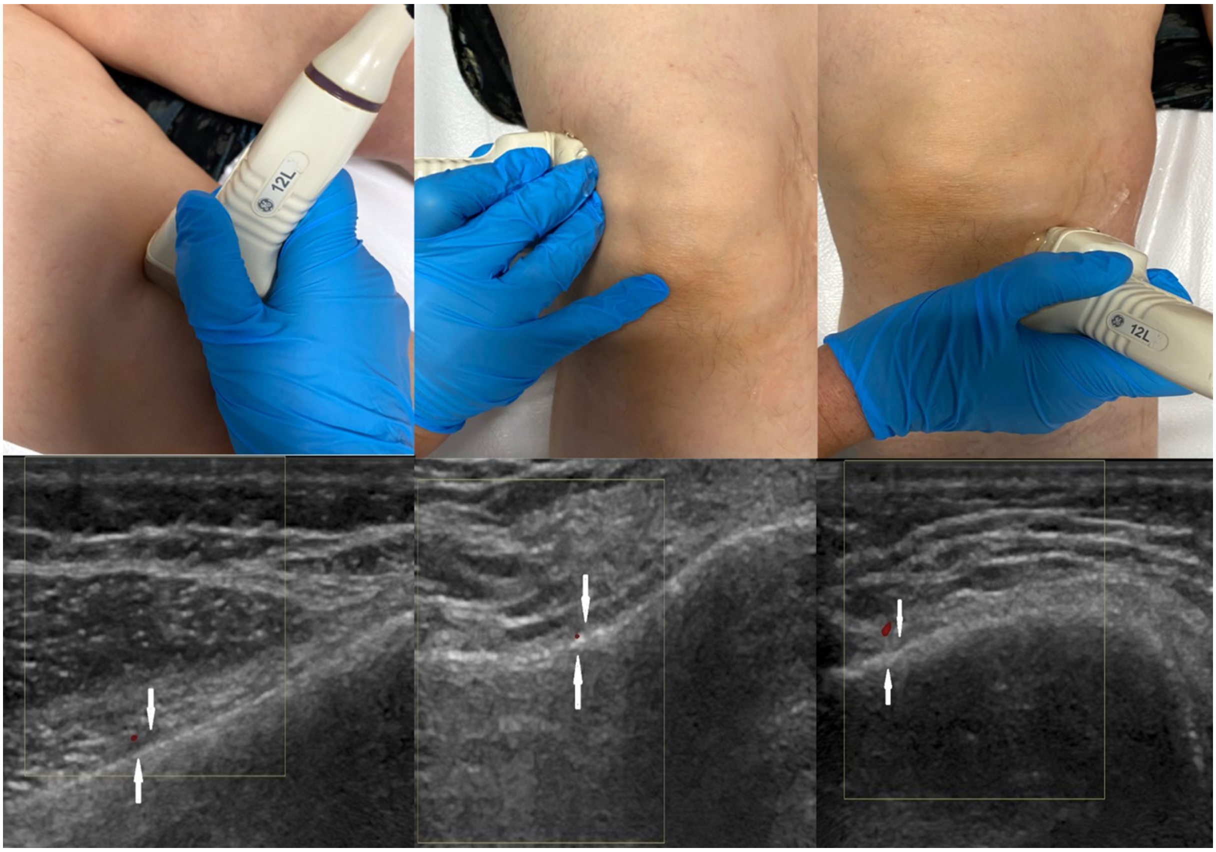

Figure 3. The figure shows the probe and ultrasonographic locations of the superomedial genicular nerve, superolateral genicular nerve, and inferomedial genicular nerve, respectively.

which evaluated the effect of corticosteroids and local anesthesia during ultrasound-guided GNB. The IBM SPSS version 27.0 software (IBM Corp., Armonk, NY, USA) was used for the power analysis. Since there were no directly comparable studies, the effect size from this reference (d=0.939) was used for the analysis, assuming an alpha error (p-value) of 0.05 and 1-beta error (power) of 0.80.[15] This analysis indicated that a minimum of 11 patients were required for statistically significant results.

Statistical analysis

Data obtained in the study were analyzed statistically using IBM SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) values, and categorical data as frequency (n) and percentage (%). In the intergroup analysis of continuous variables, normality analyses were performed using the Kolmogorov-Smirnov test. In the comparisons of data before and after treatment, the paired-samples t-test was used in dependent groups as parametric test. The level of statistical significance level was set at $p<0.05$.

RESULTS

The sociodemographic characteristics and clinical features of the patients are presented in Table 1. The pain scores and HUR SmartBalance parameters assessed before treatment and 24 h after treatment are shown in Table 2. Pain scores decreased significantly from 8.36±0.65 at baseline to 3.45±1.22 after treatment ($p<0.001$).

With the exception of the static balance score ($p=0.626$), the HUR SmartBalance parameters showed a significant difference after treatment in comparison to baseline. A statistically significant increase from pre- to posttreatment was determined in the proprioception disturbance score (63.90±16.35 *vs.* 81.27±10.93, $p<0.001$), in the visual dependency score (53.77±17.39 *vs.* 74.77±14.67, $p<0.001$), and in the vestibular balance score (63.77±9.81 *vs.* 76.31±12.34, $p<0.001$).

TABLE 1
Sociodemographic and clinical characteristics of the participants

	n	%	Mean±SD
Age (year)			61.9±7.7
BMI (kg/m²)			29.27±4.65
Sex			
Female	14	63.63	
Male	8	36.36	
Educational level			
Primary	13	59.09	
High school	9	40.91	
Marital status			
Married	19	86.36	
Single	3	13.64	
Occupational status			
Retired	12	54.54	
Housewife	8	36.36	
Clerical work	2	9.00	
KL grading			
Grade 2	7	31.81	
Grade 3	15	68.18	
Comorbidity*			
Hypertension	15	68.11	
Hyperlipidemia	12	54.54	
CAD	6	27.27	
History of previous treatments			
Physical therapy	11	50.05	
Intra-articular CS	13	27.33	
Intra-articular HA	3	13.66	
Smoking			
Yes	1	4.54	
No	21	95.36	

SD: Standard deviation; BMI: Body mass index; KL: Kellgren Lawrence grading system; CAD: Coroner artery disease; CS: Corticosteroid; HA: Hyaluronic acid supplements.

DISCUSSION

The KOA patients in this study who underwent GNB were reevaluated after 24 h, and a significant improvement was found in pain scores. In the tests performed with HUR SmartBalance, no difference was detected in the balance parameters, whereas a significant increase was detected in other proprioceptive disturbance scores, visual dependency scores, and vestibular balance scores.

It is known that the genicular nerve of the knee does not originate from a single nerve but from the sciatic, femoral, and saphenous nerves. It provides capsular innervation in various parts of the knee joint and receives afferent input from mechanoreceptors, thereby providing the proprioceptive sense of the knee joint. Proprioception is of great importance for the knee joint. It protects the joint from excessive motion and therefore secondary injury, ensuring the stability of the knee during a static posture, and coordinates complex movements.[5,12] Previous studies have identified many issues with knee biomechanics in KOA patients, the most important of which are a significant decrease in muscle strength and impairment in proprioception. These deteriorations can lead to increased laxity in the knee joint and increased passive range of motion in the sagittal plane, resulting in secondary injuries.[5-7] This raises the question of the appropriateness of GNB.

In previous studies, a reduction in pain in the short- and midterm has been repeatedly demonstrated in patients after ultrasound-guided or blinded GNB, whereas GNB has not been effective on pain in the long term.[14,15,18] In the current study, the pain score was measured after 24 h, and the decrease in pain is consistent with those studies. While previous studies have used local anesthetic and corticosteroid combinations for GNB, there are also studies in which only local anesthetic was applied.[16] The findings of studies on this subject are contradictory, and there are studies reporting that the results of GNB combined with local anesthetic alone are very

TABLE 2
Pre- and posttreatment pain, proprioception, and static balance scores

	Pretreatment	Posttreatment	
	Mean±SD	Mean±SD	*p*
Visual Analog Scale	8.36±0.65	3.45±1.22	**<0.001***
Static balance score	96.50±4.75	96.13±3.74	0.626*
Proprioception disturbance score	63.90±16.35	81.27±10.93	**<0.001***
Visual dependency score	53.77±17.39	74.77±14.67	**<0.001***
Vestibular dominant score	63.77±9.81	76.31±12.34	**<0.001***

SD: Standard deviation; p<0.05 considered as significant; * p<0.05.

similar, while others have found lower pain scores and longer effects in patients with the addition of corticosteroid.[14,15,17,19] The amount of solution used in the current study was similar to that of solutions in the literature, containing combined local anesthetic and corticosteroid for GNB. However, the main target of this study was the evaluation of proprioception and balance, and a decrease in pain scores was detected in the very short term.

The HUR SmartBalance device was used to evaluate static balance, visual dependency, and vestibular balance in the current study, as well as to evaluate proprioception disorders in the patients 24 h after GNB. There was no change in the evaluated balance score after GNB. In a review investigating KOA neuronal connections and pathophysiology, Ariel de Lima et al.[18] indicated that the genicular nerve receives proprioceptive inputs and, therefore, GNB may impact on postural control and static balance. However, in the present study, no deterioration in static balance was detected after GNB as expected. In the current study, patients were evaluated after a short time of 24 h; this duration is sufficient for the GNB effect to begin and settle. Nevertheless, this could be considered among the limitations of this study.

In a study in which radiofrequency GNB block was performed, there was also no change in static balance.[19] However, in the evaluation of joint proprioception, contrary to expectations, no worsening of proprioception was detected even in the long term.[19] Contrary to the hypothesis that blocking the genicular nerve could impair proprioception, results of this study showed an improvement in proprioception scores, possibly due to the reduction of pain interference. This could have been due to the rapid decrease in pain since the patients were evaluated on the following day. The significant improvement in proprioception and balance scores following GNB challenges the traditional view that blocking afferent inputs might impair these functions. This suggests that pain relief plays a critical role in proprioceptive function, possibly by allowing patients to engage more fully in proprioceptive feedback mechanisms.[20]

Vestibular balance and visual dependency scores were also examined in the current study. As we know balance and postural control depends on signals that come from motor systems and sensorial inputs of visual, proprioceptive, and vestibular systems. When the Romberg test is applied to patients with their eyes closed, visual stimuli are cut off, and patients can only be evaluated proprioceptively. The visual dependency score can be thought as a numerical evaluation of the Romberg test. Higher scores reflect better proprioceptive control. Although the mechanism is unclear, previous studies attributed the improvement to the decrease in pain.[21]

The reason for this may be the disabling of the genicular nerve, which senses the afferent impulses coming from the already impaired mechanoreceptors and carries them to the central nervous system, significantly reducing pain.[6,7,21] While these studies have reported minimal impact of GNB on proprioception, the findings of this study improved proprioceptive scores align with studies suggesting that pain modulation may enhance sensory feedback. Further research is needed to determine whether these improvements are sustained over time and whether different anesthetic combinations affect outcomes.

The most important limitations of this study were that only short-term evaluation was performed and the small sample size. Other limitations included the lack of a control group. If we assess proprioception in gonarthrosis patients after applying another pain-reducing method to the patients, we can more clearly understand whether the improvement in proprioception is solely due to pain reduction or to the blockade of the genicular nerves. The fact that patients with different activity levels or ages could not be standardized may also be considered a limitation in terms of the heterogeneity of the group. Future studies should address these limitations to better understand the long-term effects of GNB on proprioception and balance. Nonetheless, a strength of this study is that, to our knowledge, it is the first to evaluate balance and proprioception after GNB.

In conclusion, the results of this study demonstrated that GNB had no significant effect on static balance, and proprioception improved. These findings can be of guidance for future studies and could form the basis for the safe implementation of GNB to KOA patients. Further research should focus on larger cohorts with longer follow-up periods to assess the durability of the improvements in proprioception and balance. Additionally, exploring the effects of GNB on dynamic balance and functional outcomes could provide a more comprehensive understanding of its therapeutic potential.

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

Author Contributions: Idea/concept: S.K., A.T.C., H.B.Ş.; Design: E.Y., H.B.Ş.; Data collection: A.T.C., S.K., H.B.Ş.; Literature review: S.K., A.T.C.; Analysis: E.Y., A.T.C., E.A.; Supervision: E.A., E.Y., S.K.; Writing: H.B.Ş., A.T.C.; Ciritical review: E.Y., E.A.; References and funding: H.B.Ş., E.Y., A.T.C., E.A.

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