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CLINICAL RESEARCH

Comparison of three sitting positions for combined spinal - epidural anesthesia: a multicenter randomized controlled trial☆

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Arthroplasty

Abstract
Background and objectives: The aim of this prospective, multi-centered and multi-arm parallel randomized trial was to test the hypothesis that modified sitting positions including hamstring stretch position (HSP) and squatting position (SP) would reduce needle - bone contact events and increase the success rate of combined spinal - epidural anesthesia (CSEA) compared to traditional sitting position (TSP) in patients undergoing total knee or hip arthroplasty.
Patients and methods: Three hundred and sixty American Society of Anesthesiologists (ASA) I-III patients, aged between 45-85 years were randomly allocated to one of three groups using computer-generated simple randomization: group TSP (n = 120), group HSP (n = 120), and group SP (n = 120). Primary outcome measures were the number of needle-bone contact and success rates. Secondary outcome measure was the ease of interspinous space identification.
Results: Seven patients in group SP and four of HSP could not tolerate their position and were excluded. Number of needle-bone contact, success rates, and grade of interspinous space identification were similar between groups ($p = 1.000$). Independent of positioning, the success rates were higher in patients whose interspinous space was graded as easy compared to difficult or

☆ The study was carried out in operating theaters of Private Çankaya Hospital, Ankara, Turkey; University of Medical Sciences Gülhane Training and Research Hospital, Ankara, Turkey; University of Medical Sciences Yildirim Beyazit Training and Research Hospital, Ankara, Turkey; and Balikesir University Medical Faculty Health Practice and Research Hospital, Balikesir, Turkey.

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impossible ($p < 0.001$). Success rates reduced, interspinous space identification became more challenging, and number of needle – bone contact increased as patient's body mass index (BMI) increased ($p < 0.001$). **Conclusion** SP and HSP may be used as alternatives to the TSP. BMI and ease of interspinous space identification may be considered important determinants for CSEA success.

Introduction

The positioning of a patient is one of the major factors contributing to the success of a neuraxial block; other factors include the ease of identifying anatomical landmarks including the midline and interspinous space, and the anesthesiologist's level of experience.[1] The quality of positioning was defined as good or poor according to the ability to flex the spine adequately. Poor positioning leads to multiple attempts for the intervention due to needle – bone contact (NBC), which may result in back pain, hematoma, and paresthesia.[2] The conditions may cause dissatisfaction and cause the patient to refuse the procedure.[3,4] A flexed back and reduced lumbar lordosis are considered to be necessary for optimal positioning in either the sitting or lateral decubitus positions. These maneuvers widen the interspinous space and push the thecal sac into a more superficial position.[3,4]

The traditional sitting position (TSP) is the most common position for spinal or epidural anesthesia where the patient sits on the operating table, with both feet placed on a stool, and both hips and knees maximally flexed (Fig. 1). Four decades ago, a new sitting position was introduced to reduce lumbar lordosis for ''easier'' spinal puncture; this position involved maximum extension of the knees, adduction of the hips, and forward bending.[5] Based on this idea, modified sitting positions have been introduced for spinal or epidural anesthesia. In these positions, the patients are sat up on the operating table, but the legs remain on the table, which is different from the TSP. In the hamstring stretch position (HSP), the knees are maximally extended (Fig. 2), whereas in the squatting position (SP), both the hips and knees are maximally flexed (Fig. 3).[6–8] Similar success rates have been reported in studies comparing TSP with modified sitting positions for epidural or spinal anesthesia.[6–8] However, to the best of our knowledge, this issue has not been previously investigated for combined spinal – epidural anesthesia (CSEA) with the aim for reducing needle – bone contact events and for increasing the success rate of the intervention. CSEA is frequently used in orthopedic lower limb surgery because it provides motor and sensory blocks by the spinal anesthesia component, while indwelling an epidural catheter enables the modification of the block and postoperative analgesia.[9]

The aim of this study was to test the hypothesis that modified sitting positions including hamstring stretch position and squatting position would reduce needle – bone contact and increase the success rate of the needle - through – needle technique combined spinal – epidural anesthesia (CSEA) compared to traditional sitting position in patients undergoing total knee or hip arthroplasty.

Methods

This was a prospective, multi-centered and multi-arm parallel randomized clinical trial. The trial was approved by the hospital's ethics committee (04.16. 2018-49/08). A written informed consent was obtained from all subjects participating in the trial. The trial was registered at ClinicalTrials.gov (http://clinicaltrials.gov), (NCT03541798, date of registration: May 1, 2019) prior to patient enrollment. This manuscript adheres to the Consolidated Standards of Reporting Trials (CONSORT) statement.[10–12] The trial ended after the pre-planned number of patients concluded the intended follow-up period. Patients were randomly assigned to one of three parallel groups, initially in 1:1:1 ratio to receive CSEA in three different sitting positions. It was decided that the patients were dropped out after trial commencement who could not tolerate their position or developed sudden deterioration in vital parameters during the intervention which required emergency treatment.

The inclusion criteria were as follows: American Society of Anesthesiologists (ASA) physical status class I-III patients, aged between 40 and 85 years, scheduled for elective unilateral total hip or knee arthroplasty under combined spinal – epidural anesthesia were enrolled in the study.

The exclusion criteria were patient refusal, history of previous lumbar surgery, neurological disease, obvious lumbar scoliosis, the inability to flex the knees, coagulation disorders, and trauma surgery.

The trial was conducted in the orthopedic operating theatres of two academic training and research hospitals and of a tertiary hospital. Five staff anesthesiologists with more than ten years of experience in regional anesthesia participated in the study who performed more than 500 combined spinal – epidural anesthesia procedures in traditional sitting position and hamstring stretch position. Patients were invited on the day before the surgery. Saline or Ringer's lactate solution (1-3 $mL.kg^{-1}.h^{-1}$, up to 1 L) was intravenously (IV) administered for hydration during the fasting period, which lasted six hours for light meals and two hours for clear fluids. Two milligrams of IV midazolam was administered as the premedication before the patients were transferred to the operating room. After arriving in the operating room, the patients were monitored with noninvasive blood pressure, pulse oximetry, and electrocardiogram equipment. Patient characteristics including sex, age, weight, height, and body

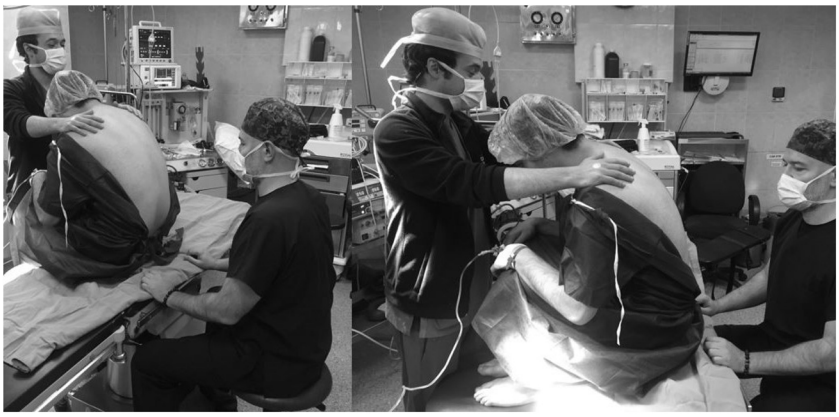

Figure 1 Traditional sitting position. The picture shows the positions of the patient, the nurse anesthetist, and the anesthesiologist.

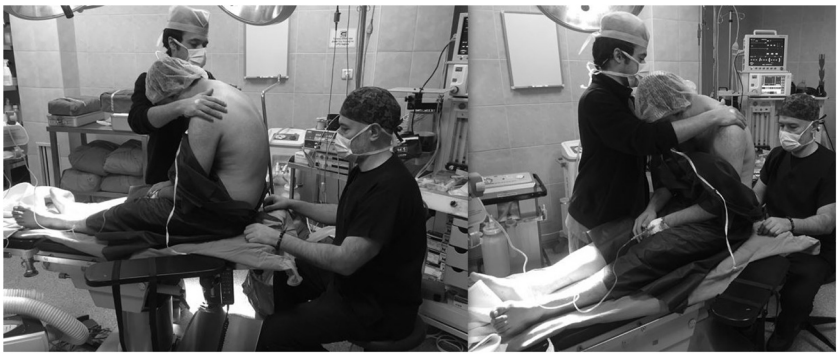

Figure 2 Hamstring stretch position. The picture shows the positions of the patient, the nurse anesthetist, and the anesthesiologist.

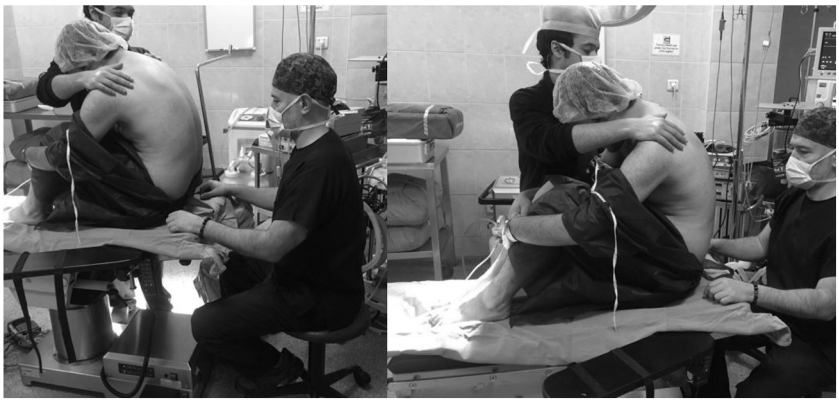

Figure 3 Squatting position. The picture shows the positions of the patient, the nurse anesthetist, and the anesthesiologist.

mass index (BMI) were recorded. Patients were randomly assigned to one of three parallel groups in 1:1:1 ratio to receive CSEA in three different sitting positions: the traditional sitting group (Group TSP, n = 120), the hamstring stretch group (Group HSP, n = 120), and the squatting group (Group SP, n = 120). Patients in group TSP were placed in a sitting position with their legs on a stool at the edge of the operation table, their knees flexed to 90°, and their hips adducted (Fig. 1). Patients in group HSP were seated with their lower extremities placed on the operation table, knees in maximum extension, hips in adduction, and trunk leaning forward (Fig. 2). In group SP, the patients were seated on the operation table with their hip and knee joints flexed. The patients hugged their knees, and both the buttocks and plantar surfaces of the feet were supported by the operating table (Fig. 3). A nurse anesthetist helped support the patients from the ventral side for TSP and from the lateral side for HSP and SP; the nurse held their posture by holding their shoulders. All patients were asked to bend forward and flex their back as much as they could tolerate.

The patient's back was facing the anesthesiologist performing the procedure and the anesthesiologist sat on a stool behind the patient at a level where he/she could easily observe the patients' back (Figs. 1–3). After the patients were positioned, the anesthesiologist graded the ease of the identifying the interspinous space using palpation of the adjacent lumbar spinous processes on a 3-point scale: easy = both adjacent spinous processes are palpable, difficult = one of the adjacent spinous processes is palpable, and impossible = both adjacent spinous processes are impalpable. Two interspinous spaces (the first and second) were selected from the L2-L3, L3-L4, and L4-L5 intervertebral levels to undergo CSEA.

After sterile preparation and dressing, the skin and subcutaneous tissue were infiltrated with a local anesthetic (3 mL of 2% lidocaine). CSEA was performed at the first interspinous space with a midline approach using a CSEA set (B. Braun Melsungen AG, Germany) that contains an 18 gauge (G) Tuohy epidural needle, a 27 G Whitacre spinal needle, and an epidural catheter.

The Tuohy needle was introduced in the midline at the interspinous space and directed slightly cephalad. The epidural space was located with the loss of resistance to the saline technique. Then, the spinal needle was advanced through the epidural needle until it penetrated the dura mater with the distal aperture facing the cephalad (needle -through- needle technique). Following this, 3-3.5 mL of 0.5% hyperbaric bupivacaine (15-17.5 mg) was administered after obtaining of free flow of cerebrospinal fluid through the spinal needle. The spinal needle was withdrawn, and an epidural catheter was inserted 4 cm into the epidural space and secured. The case was termed *''Success at First Try''*. When a bone contact occurred, the Tuohy needle was withdrawn to subcutaneous tissue. It was redirected cephalad, horizontal or caudad. A maximum of three redirections were allowed. If the epidural space was located, spinal anesthesia and epidural catheter placement were performed as described. The case was termed *''Success after Needle Redirection''*. However, the epidural needle was withdrawn after three failed redirections. A new puncture site was not allowed at the same level. The case was then termed *''Failed CSEA at the First Intervertebral Space''*.

At this stage, a second attempt was carried out at the second interspinous space with the same approach that was used for the first attempt. If the attempt was successful without needle bone contact, the case was termed *''Success at the Second Intervertebral Space''*. If the second attempt also failed, the case was recorded as a *''Failed CSEA for the Position''* case and the study was stopped. At this stage, the patients were directed to the following options: a) a spinal anesthesia was attempted using a 27 G spinal needle (B.Braun Melsungen AG, Germany). If the spinal anesthesia was successful, the case was termed ''Failed CSEA, Successful Spinal Anesthesia''. If spinal anesthesia was failed too, general anesthesia was induced. b) In the case of successful location of epidural space with Tuohy needle but of failure of spinal anesthesia using needle – through – needle technique, the epidural catheter was inserted into epidural space and a spinal puncture was attempted using a 27 G spinal needle at an inferior level. If spinal anesthesia was successful, the case was termed as ''Successful CSEA with Separate Level – Separate Needle Technique''. If spinal anesthesia was failed, general anesthesia was induced.

The primary outcome measures were the number of needle-bone contact (NBC) events and success rate of CSEA. The secondary outcome measure was the grade of interspinous space identification. The correlation between the grade of interspinous space identification and success rate was also investigated. The grade of interspinous space identification, number of NBC events, and success rates were compared between different BMI classes to find out whether a relationship exist between BMI and determinants of the intervention. Success of the intervention was modeled using univariate and multivariate logistic regression models with respect to sitting positions, body mass index classes, and ease of intervertebral space identification. In previous studies, the success rate of needle insertion without NBC has been reported to be 50% in traditional sitting position, 60% in the hamstring stretch position and, 70% in the squatting position.[4,6] A power analysis revealed that a minimum sample size of 110 patients per group was needed to achieve a power of 0.8 (80%) with a confidence level of 95%.[13] It was aimed to enroll 360 patients (120 in each arm) to allow withdrawal or loss to follow- up rate of 10%.

Randomization was performed with computer-generated simple random sequence to assign patients to one of three study arms. Allocation concealment was achieved by means of sealed, opaque and continuously numbered envelopes, which were matched with patients according to their order of inclusion in the study. The study coordinator (MÖÖ) was responsible for the generation of the random sequence and for its concealment in opaque, numbered envelopes. A research assistant enrolled the participants and allocated each patient to the next sealed envelope containing the information on the randomized group. The envelopes were opened by the anesthesiologist before the intervention who performed CSEA.

The following parameters were recorded and compared between the study groups: demographic characteristics, grade of intervertebral space identification, number of needle – bone contact events, number of successful and failed cases of combined spinal - epidural anesthesia, and complications.

Statistical analysis

The data were analyzed using IBM SPSS Statistics version 21 (IBM SPSS Inc, Chicago, IL) pocket program. The descriptive statistics calculated for the continuous variables were the mean, and standard deviation (mean ± SD), and those for the categorical variables were the frequency distribution and percentage (n, %). Pearson's chi-square (χ^2) test was used to assess the differences in distributions of the categorical variables between groups. The normality of the data was assessed with the Kolmogorov - Smirnov test. Differences in the non-normally distributed variables between groups were assessed with Kruskal - Wallis variance analysis.[14] The variables which will be included in multivariate logistic regression model were described by univariate logistic regression analysis using Wald statistics.[15] The variables with Wald p values < 0.25 were included in the multivariate model. The p value of the sitting positions was > 0.25,

so the sitting positions were not included in the multivariate model. $p < 0.05$ was considered statistically significant for all tests.

Results

A total of 360 patients were included in the study. There were 201 (55.8%) female and 159 (44.2%) male patients. The mean age was 68.29 ± 7.40 years. Seven patients (5.8%) in group SP and 4 patients in group HSP (3.3%) could not tolerate their position during the intervention due to discomfort and pain at the knee or hip. These eleven patients were excluded from the study and general anesthesia was induced. The procedure was well - tolerated by all the patients in group TSP. The data from remaining 349 patients were available for the intention-to-treat analysis. Fig. 4 shows the flow diagram of participants through each stage of the study. Patient recruitment happened between May 2, 2019 and December 23, 2019 and patients were followed-up for 3-5 days after surgery. The trial ended after the pre-planned number of patients who concluded the intended follow-up. The demographic data were comparable across the three study groups (Table 1).

Primary outcome measures

The overall success rate of CSEA was 93.3% in the remaining 349 patients. When the success rates were compared between study groups, it was found that the success rate was the highest in group TSP and the lowest in group SP, but this difference was not statistically significant (93.3% vs. 92.2% vs. 92.0%; $p = 1.000$), (Table 2).

The success rates *''at First Try''* (NBC = 0), *äfter Needle Redirection''* (NBC = 1 or 2), and *''at the Second Level''* (NBC = 3-5) were also similar between the three groups ($p = 1.00$, Table 2). Needle – through - needle technique CSEA failed in 26 patients (7.45%). The rate of *''Failed CSEA for the Position''* (NBC = 6) was statistically similar between the TSP, HSP, and SP groups (6.7% vs. 7.8% vs. 8%, respectively; $p = 1.00$). Spinal anesthesia was successful in three patients of group TSP, in two patients of group HSP, and in three patients of group SP. The remaining eighteen patients received general anesthesia.

Secondary outcome measures

Interspinous space identification was identified easy in 59.0%, difficult in 33.0%, and impossible in 8.0% of all patients. The grades of interspinous space identification were not statistically different among the three groups ($p = 0.990$). There was a correlation between the grade of interspinous space identification and success rates of the intervention ($p < 0.001$). The success rate at first try was significantly higher in patients whose interspinous space was considered easy to identify than in patients whose interspinous space was considered difficult or impossible to identify (73.3% > 16.5% > 0.0%; respectively, $p < 0.001$). The rate of failed CSEA also increased as the identification of interspinous space became more challenging (easy (1.0%) < difficult (10.4%) < impossible (42.9); $p < 0.001$). It was found that the rate of ''easy'' interspinous space identification significantly decreased as the body mass index increased (100% > 97.3% > 51% > 15.0%; $p < 0.001$). The grade of interspinous space identification was impossible in 26.1% of obese patients versus 0% in non-obese patients. On the other hand, the first try success rate (NBC = 0) was the highest in patients with a normal body mass index but the lowest in obese patients ($p < 0.001$). However, the logistic regression analysis revealed that the sitting positions and body mass index were insignificant factors in the success of the CSEA. In contrast, the ease of interpinous space identification was a significant factor ($p < 0.001$) (Table 3).

A total of 24 (6.87%) complications were observed and treated throughout the study period. Eight adverse events occurred in each group ($p = 1.000$). For the TSP, HSP, and SP groups, the adverse events were back pain (3, 2, and 2 cases, respectively), hypotension (4, 5, and 4 cases, respectively), bradycardia (1, 0, and 1 case, respectively), and unintentional dural puncture (0, 1, and 1 case, respectively); ($p = 1.000$).

Discussion

The results of the study demonstrated that the success rate of CSEA and the number of needle - bone contact events were not different between the traditional sitting position and modified positions, including the hamstring stretch and squatting positions. The ease of the interspinous space identification was also similar across the positions. Based on the data in the present study, it can be stated that hamstring stretch and squatting position can be used as alternative positions to the traditional sitting position in patients undergoing knee or hip arthroplasty under combined spinal-epidural anesthesia. This statement is consistent with the results of few studies comparing modified sitting positions with the traditional sitting position for epidural or spinal anesthesia.[6–8] In an earlier study, the number of needle – bone contact events and failure rates were found to be similar between the HSP and TSP positions and it was stated that the HSP increased lumbar flexion but also created tension in the supraspinous ligament which led to interspinous depression.[5]

In another study, the traditional sitting position was compared with the squatting position in patients undergoing lower abdominal or extremity surgery under spinal anesthesia. The number of needle-bone contact events was lower in the squatting group although the ease of interspinous space identification and success rates were similar. It was concluded that this difference favoring the squatting position may be due to the induced tension in the supraspinous ligament.[7] In another study, there was not a significant difference in the number of needle – bone contact events, grades of interspinous space identification or success rates among patients who were positioned in the TSP, HSP and SP for spinal anesthesia.[8] However, the overall success rates in those studies ranged between 98.3% and 99.0%, which was higher than that in our study (92.0%-93.3%). This discrepancy may be explained by the differences between our study and other studies in the literature:

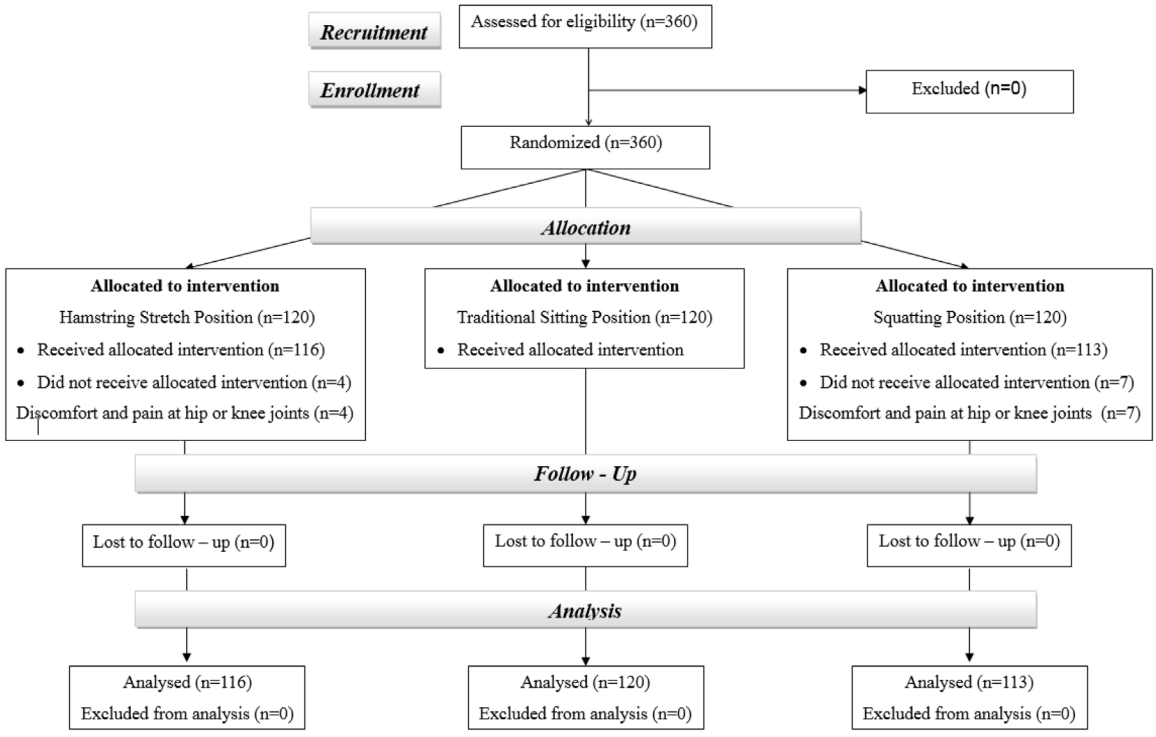

Figure 4 Diagram showing the flow of participants through each stage of the trial.

Table 1 Patient baseline characteristics and features of surgical procedures performed according to treatment group.

Baseline characteristics		Group TSP (n = 120)	Group HSP (n = 116)	Group SP (n = 113)	*p*
Age (years)[a]		68.3 (7.5)	67.9 (7.3)	68.4 (7.5)	0.815
Gender (n)	Female/Male	68 / 52	63 / 53	64 / 49	0.917
Body Mass	Underweight	9 (7.5%)	11 (9.5%)	10 (8.8%)	1.000
Index Class[b]	Normal	39 (32.5%)	37 (31.9%)	36 (31.9%)	
($kg.m^{-2}$)	Overweight	35 (29.2%)	33 (28.4%)	32 (28.3%)	
	Obesity class I	22 (18.3%)	20 (17.2%)	21 (18.6%)	
	Obesity class II	11 (9.2%)	12 (10.3%)	10 (8.8%)	
	Obesity class III	4 (3.3%)	3 (2.6%)	4 (3.5%)	
ASA status (n)	I / II / III	51 / 56 / 13	49 / 55 / 12	50 / 50 / 13	0.992
Arthroplasty (n)	Hip / Knee	79 / 41	79 / 37	68 / 45	0.434

TSP, traditional sitting position; HSP, hamstring stretch position; SP, squatting position; ASA, American Society of Anesthesiologists physical status classification.
$p < 0.05$ was considered as statistically significant.
[a] Data presented as mean (standard deviation).
[b] Data presented as absolute number (%).

a) The patients in this current study groups were older (68.29 ± 7.40 years) than those included in other studies (between 40.4 ± 0.8 years and 48.8 ± .8.6 years.[6–8] It is well known that degenerative spine conditions are common in older patients and cause a gradual loss of a normal spine structure and function over time. General symptoms include spinal deformity, limited motion and chronic pain with movement, which may make the neuraxial procedure more difficult to perform.
b) Obese patients were included in our study. In other studies, patients with a body mass index higher than 32, 35 and 40 $kg\,m^{-2}$ were excluded.[6–8] The body mass index was between 35 and 39.9 $kg\,m^{-2}$ in 33 (9.2%) patients and was higher than 40 $kg\,m^{-2}$ in 11 (3.1%) patients in the current study. When the success rates and number of needle-bone contact events were compared between different body mass index classes, it was found that the success rate was lower and the number of needle-bone contact events was higher in patients with higher body mass index. Additionally, interspinous space identification was also considered difficult in overweight patients and impossible in obese patients which increased the failure rate. It was reported that patient's age greater than 65 years and BMI > 30 $kg\,m^{-2}$ are associated with

Table 2 Comparison of study groups regarding number of needle bone contact, success of the intervention and ease of intervertebral space identification.

Variable		Group TSP (n = 120)	Group HSP (n = 116)	Group SP (n = 113)	*p*
Needle Bone Contact[a]	0	59 (49.2%)	56 (48.3%)	55 (48.7%)	0.997
	1	26 (21.7%)	25 (21.6%)	25 (22.1%)	
	2	2 (1.7%)	1 (0.9%)	1 (0.9%)	
	3	21 (17.5%)	19 (16.4%)	19 (16.8%)	
	4	4 (3.3%)	5 (4.3%)	4 (3.5%)	
	5	0 (0.0%)	1 (0.9%)	0 (0.0%)	
	6	8 (6.6%)	9 (7.8%)	9 (8.0%)	
Success[a]	at First Try	59 (49.2%)	56(48.3%)	55 (48.6%)	
	After Needle Redirection	28 (23.3%)	26 (22.4%)	26 (23.0%)	1.000
	at Second Intervertebral Space	25 (20.8%)	25 (21.5%)	23 (20.4%)	
	Overall	112 (93.3%)	107 (92.2%)	104 (92.0%)	
	Failed CSEA	8 (6.7%)	9 (7.8%)	9 (8.0%)	
Ease of Inter-Vertebral Space Identification[a]	Easy (n = 206)	69 (57.5 %)	70 (60.3%)	67 (59.3 %)	0.995
	Difficult (n = 115)	41 (34.2 %)	37 (31.9%)	37 (32.7 %)	
	Impossible (n = 28)	10 (8.3%)	9 (7.8%)	9 (8.0%)	

TSP, traditional sitting position; HSP, hamstring stretch position; SP, squatting position; NBC, needle bone contact; CSEA, combined spinal epidural anesthesia.
$p < 0.05$ was considered as statistically significant.
[a] Data presented as absolute number (%).

Table 3 Relationship of body mass index and ease of interspinous space identification to the success rate of the intervention, multivariate logistic regression model.

Variables	Regression coefficient	Standard error	Wald's χ^2 value[a]	95% CI of OR			p
				OR	Lower	Upper	
Body Mass Index							
Normal weight	Reference	–	0.40	–	–	–	0.940
Under weight	-17.196	-16.913	0.00	0.000	0.000	–	0.998
Overweight	-18.451	-16.411	0.00	0.000	0.000	–	0.998
Obese	-19.605	-16.192	0.00	0.000	0.000	–	0.998
Ease of Intervertebral Space Identification							
Easy	Reference	–	15.640	–	–	–	< 0.001
Difficult	-2.475	-2.740	6.165	0.065	0.007	0.562	0.013
Impossible	-4.337	-4.23	14.866	0.009	0.001	0.098	< 0.001

CI, confidence interval, OR, odds ratio.
$p < 0.05$ was considered statistically significant.
[a] The variables with a Wald's $\chi 2$ value > 0.25 were included in the multivariate model.

poor positioning which result in having difficulty in adequately flexing the lumbar spine.[1] The findings in the current study are consistent with those in reports that revealed that a higher body mass index is associated with the difficulty in performing the neuraxial intervention due to an increased lumbar epidural depth and poor visibility of the landmarks used for interspinous space identification.[5,7,8,16,17] However, it should be noted that BMI was not found as a significant factor in the success rate of the intervention according to logistic regression analysis.

c) A combined spinal – epidural anesthesia technique was used in our study. Although failures might be caused by similar issues in separate level - separate needle CSEA technique and spinal or epidural anesthesia, the needle - through - needle combined spinal - epidural anesthesia technique has specific mechanisms as the failure to penetrate dura mater due to the inadequate advancement of a short spinal needle that is too short, failure to stabilize the fine spinal needle, and deviation of from the midline during local anesthetic administration.[9]

It was observed that four patients in group HSP and another seven patients in group SP could not tolerate their position due to pain during the procedure whereas no patient in group TSP. The pain might be unbearable

with maximum extension or flexion of the knees in patients with degenerated joints, as the positions stretch the muscles. It has been reported that muscle impairments and pain in patients with osteoarthritis are not only limited to the quadriceps but also involve the hamstring and hip muscles.[18,19]

This study has several limitations: a) the block performers could not be blinded to the positioning b) they did not have sufficient experience to perform CSEA in the squatting position, and c) the grading of interspinous space identification was subjective.

Ultrasonography has gained popularity in recent years as a useful tool for clinical examinations when performing central neuraxial blocks. It provides objective information including the depth of the epidural space, and the location of the midline and interspinous spaces.[20,21]

It is concluded that both the squatting and hamstring stretch positions may be used as alternative positions to the traditional sitting position for combined spinal – epidural anesthesia in patients undergoing hip or knee arthroplasty because of the similar success rates, number of needle – bone contact events, and grades of interspinous space identification. However, it should be noted that patients with degenerated knee or hip joints may have intolerance to modified sitting positions due to pain. The body mass index and the grade of intervertebral space identification may be important determinants of combined spinal – epidural anesthesia success. Additional studies using radiologic imaging or ultrasound are required to identify more objective measurements that predict difficulty of performing combined spinal – epidural anesthesia.

Registration

The trial was registered prior to patient enrollment at ClinicalTrials.gov (http://clinicaltrials.gov), (NCT03541798, principal investigator: Ceyda Ozhan Caparlar, date of registration: May 1, 2019).

Conflict of interest

The authors declare no conflicts of interest.

Author's contributions

MÖÖ conducted the study, collected the data and contributed the writing of the manuscript. CÖÇ and MBE analyzed the study results and contributed the revision of manuscript. MAS and BA assisted in analysis data and contributed the writing of the manuscript. MÖÖ designed, directed the study and reviewed the study results.

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