Original Article

DOI: 10.4274/haseki.galenos.2024.9851
Med Bull Haseki 2024;62:57-64

Effect of Spinal Needles used by Anesthesia Residents on Procedural Success and the Perception of Click Sensation: A Randomized Prospective Trial

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Abstract

Aim: The type and diameter of the needle used in spinal anesthesia (SA) affect the procedure's success and the sensation of clicking during a dura puncture. This study aimed to compare the effects of Quincke and pencil-point needles of the same thickness, when used by anesthesia residents new to SA application, on procedural success and the number of trials required to perceive click sensation.

Methods: This prospective randomized study included 213 adult patients undergoing elective surgery under SA, divided into six groups based on needle type and diameter: Group I: Quincke (Q)-25 Gauge (G), Group II: Q-26G, Group III: Q-27G, Group IV: Pencil-point (P)-25G, Group V: P-26G, and Group VI: P-27G. The number of interventions for SA (1-3), the attempt (1, 2, or ≥3) during which the stylet was removed and cerebrospinal fluid (CSF) flow occurred, considering that the click sensation was felt during the procedure, and the time taken for CSF appearance (<1.9 s or ≥2 seconds) were recorded.

Results: No difference was found between the groups in terms of demographic data, the American Society of Anesthesiologists risk, puncture site, number of click sensation trials, time for CSF appearance, and feasibility of the procedure ($p>0.05$). The SA success rate in the first trial ($p<0.001$) was higher when pencil-point needles were used.

Conclusion: Although the effects of spinal needles with different tip designs and diameters on the number of trials required to perceive click sensation are similar, due to the high rate of SA success in the first trial, the use of pencil-point needles is recommended for anesthesia residents new to SA application.

Keywords: Spinal needle type, spinal needle diameter, click sensation, success rate, anesthesia residents

Introduction

Spinal anesthesia (SA) is a simple, low-cost, and reliable local anesthesia method with a high success rate and is frequently used by anesthesiologists in lower abdominal and extremity surgeries (1). Based on their tip designs, we classify spinal needles as either atraumatic or conventional. Conventional needles (Quincke=Q) are most frequently used, have sharp tips, and allow injection from the tip. Atraumatic needles (pencil-point=P), on the other hand, have blunt tips and a side port that allow injection (2,3). A previous mortality study demonstrated that conventional needles cause irregular tissue resections and lead to an increase in cerebrospinal fluid (CSF) leakage, whereas atraumatic needles separate the dura tendons from each other and do not cause irregular resections (4). Therefore, atraumatic needles can reduce postdural-puncture headache (PDPH) incidence by limiting CSF leakage after lumbar puncture (5). Spinal anesthesias performed with needles having the same thickness but different tip designs have demonstrated different amounts of CSF escaping outside the dura (6,7). In general, as the diameter of the needle decreases, the SA success rate and PDPH incidence also decrease (8-10). It has been reported that the click sensation felt in dural punctures performed

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Received: 13.03.2024 **Accepted:** 26.04.2024

with spinal needles of different thicknesses and types may be an indicator of the success of the spinal puncture (11).

The present study aimed to compare the effects of Quincke and Pencil-Point needles of the same thickness, used by anesthesia residents new to SA application, on the success rate of the procedure and the number of trials required to perceive the click sensation.

Methods

Compliance with Ethical Standards

After obtaining permission from the local ethics committee (decision no.: 2018/20, clinicalTrials.gov identifier: NCT05704816; principal investigator: G.K., and date of registration: March 10, 2022), this prospective randomized observational study was conducted at Zonguldak Bulent Ecevit University Hospital in Turkey during November 2018-2019. Figure 1 presents the flow diagram of the study according to the Consolidated Standards of Reporting Trials 2010 (12).

Participants

The inclusion criteria of this study were as follows: patients should be between 18 and 45 years of age; they should be scheduled to undergo elective lower abdomen/extremity surgery; they should fall in the American Society of Anesthesiologists (ASA) I-II risk group; they should not have bleeding diathesis; and they should provide written consent to participate in the study. Patients for whom SA was contraindicated and those who were morbidly obese, pregnant, allergic to drugs used in this study, and had undergone previous spinal surgery and SA were excluded.

Patient Management and Data Collection

Vascular access in patients who were not premedicated was established before surgery using an 18-gauge (G) catheter, and a 10 mL/kg saline infusion was administered for 30 minutes (min). The patients were then taken to the operating room and provided with routine hemodynamic monitoring. They received 3-5 lt. min. of oxygen through a nasal cannula. The patients' demographic data (age, gender, height, and weight) and ASA I-II risk were recorded.

Spinal Anesthesia Application

The patient was asked to remain in a seated position, stretch his or her legs down the table, and keep his or her head in flexion, shoulders down, and tummy in. A straight line was drawn between the iliac crests. This line passes through the fourth lumbar vertebra's (L4) spinous process. After determining this space, the intervertebral spaces where the procedure was to be performed were located, and the physician performing the intervention evaluated the procedure's feasibility as easy, medium, or difficult. The lumbar vertebral space (L2-L3 or L3-L4) that could best be palpated was identified, and local anesthesia was subcutaneously administered by injecting 1 mL of 2% animal. Patients were randomized using a sealed envelope method into 6 groups: Group I: Q-25G, Group II: Q-26G, Group III: Q-27G, Group IV: P-25G, Group V: P-26G, and Group VI: P-27G, based on the needle type and diameter, using a sealed envelope. All spinal needles were used with a 21-G guide needle. The tip of the spinal needle was then moved parallel to the dura tendons, and the guide needle was placed along the midline of the determined intervertebral space. When the dural puncture click was perceived, the needle probe was pulled back, and free CSF flow was observed. Assuming that the click sensation due to the dural puncture was perceived, the needle probe was pulled out, and the trial number during which the CSF returned was recorded (1, 2, and ≥3). The duration from the perception of click sensation due to dural puncture and removal of the needle probe to the observation of CSF (<1.9 or ≥2 sec) was recorded using a chronometer. When the return of clear CSF was observed, the open end of the needle was turned toward the head. Spinal anesthesia was performed by injecting 2-3 mL of 0.5% hyperbaric bupivacaine into the spinal space. A successful lumbar puncture was confirmed by the observation of free CSF flow.

After the procedure, the needle was removed from the skin, and the area was closed with a sterile sponge. Following the procedure, the patient was immediately placed in the supine position. The number of interventions applied for SA (1/2/3) and the presence of paresthesia during the procedure were recorded. The "electric shock" that occurred in the leg while the spinal needle was advanced during SA was evaluated as a feeling of paresthesia. For the application, a maximum of three interventions were allowed at one location. The same cannula was used for repetitive punctures in the same patient. When the procedure was unsuccessful after three interventions, the patient was excluded from the study, and the procedure was repeated by a senior physician. If hemodynamic changes related to vagal reflexes (such as decreasing blood pressure, passing out, and having a seizure) were noted in the patient during the procedure, he/she was excluded from the study. All interventions were performed by three different anesthesia assistants who were new to SA practice but had at least 20 SA experience with spinal needles of different diameters and tip designs before the study. A physician who was experienced in SA but did not know the study asked whether the patients had headaches and backaches within the first 24 hours postoperatively and recorded them.

Approach to Postspinal Headache and Back Pain

It was ensured that the patients remained in bed for at least 4 hours (h) in the postoperative period.

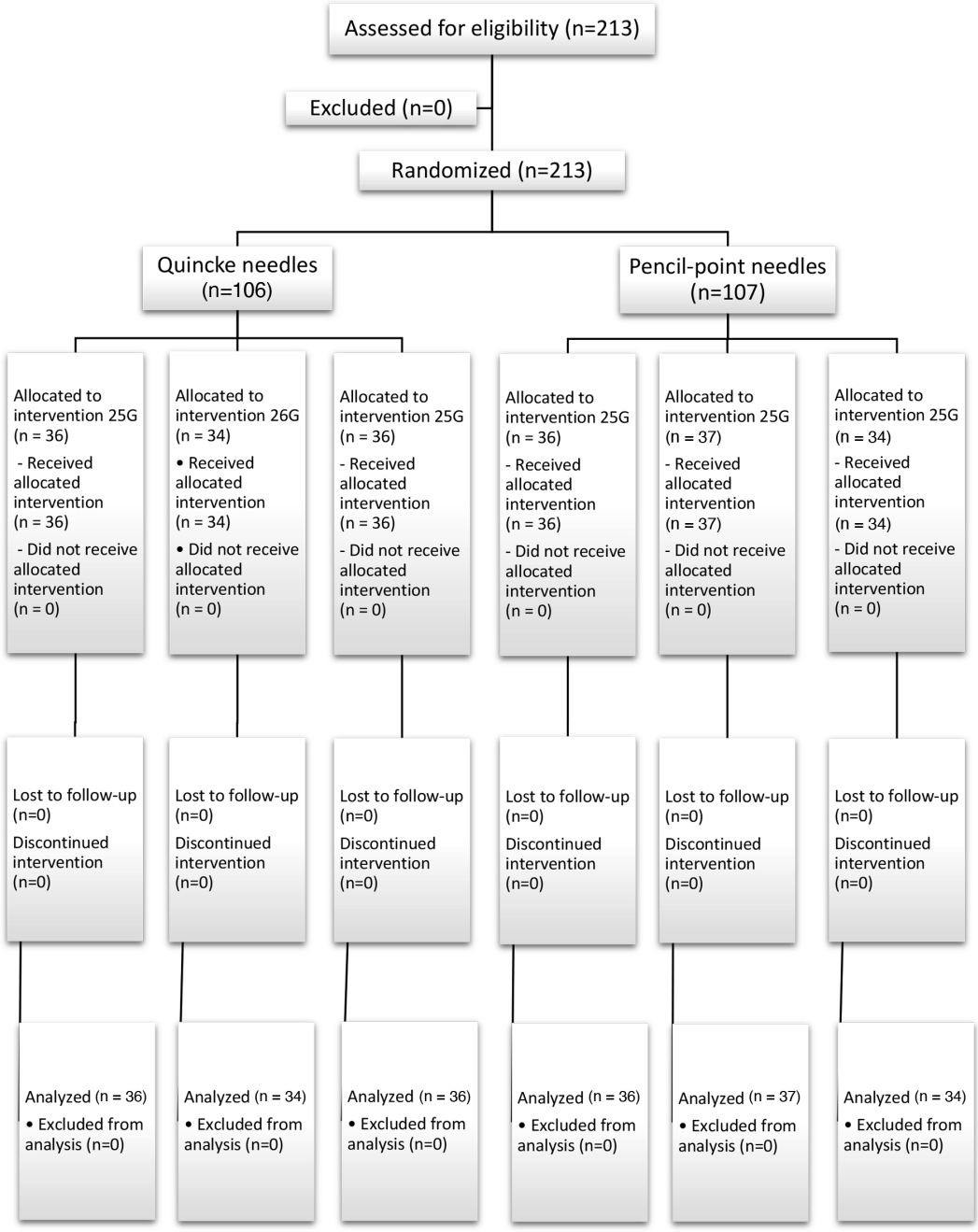

Figure 1. CONSORT flow diagram of the study

The physician investigated whether the patients had PDPH and postspinal back pain (PSBP) 24 hours after the procedure. The onset of these pains following SA and their increase with movement were accepted as sufficient. In the case of pain development, patients were recommended bed rest and an increase in fluid intake (oral and/or 2,500 mL/day IV fluid intake). Geralgine-K® tablets were administered depending on the severity of pain (light, moderate, or heavy). An epidural blood patch was administered in severe PDPH cases that did not respond to treatment.

Sample Size Calculation

In the study, in which 185 cases should be included with 95% confidence (1-α), 80% test power (1-β), and w = 0.264 impact size, 31 cases were included in each group for two different types of needles and for three different diameters (11).

Statistical Analysis

The study data were analyzed using Statistical Package for the Social Sciences Version 23.0 (IBM SPSS Inc., Chicago, IL, USA). The normal distribution of the data was checked with the Kolmogorov-Smirnov test. In the comparison of categorical variables according to needle type, the chi-square test was used. In the comparison of normally distributed data according to needle type, a one-way ANOVA was employed. For the comparison of the data without normal distribution according to needle type, the Kruskal-Wallis test was used, and multiple comparisons were analyzed with the Dunn test. The analysis results are presented as mean ± standard deviation for quantitative data. The statistical significance level was set at $p<0.05$.

Results

Demographic and Clinical Characteristics of the Participants

The study involved 213 patients. The mean age of the patients was determined to be 35.4±9.3 years. Spinal anesthesia was successfully performed on all patients, and no patients were excluded from the study. The groups were found to be similar in terms of demographic data and ASA risk (Table 1).

No difference was observed between the groups in puncture site, number of trials for click sensation, CSF observation time, or feasibility of the procedure (Table 2). It was observed that 60% of SA interventions were successful in the first trial, and the rest were successful in the second trial. Compared with Quinke needles, the first-try success rate was higher with pencil-point needles, and the highest success rate was obtained with 25G pencil-point needles ($p<0.001$). Paresthesia development was found to be more frequent with pencil-point needles during the procedure ($p=0.004$), with a rate of development of 5.6% for 27G Quincke needles and 13.5% for 26G pencil-point needles. No paresthesia was observed when using the other needle types. A total of 7 patients (n=1Q/n=6P) reported PDPH, but there was no statistically significant difference between the groups in terms of headache. PSBP developed in only 4 patients on whom a 26G pencil-point needle was used ($p=0.004$) (Table 2). Two of the four patients with moderate backaches also experienced headaches, and they were administered Geralgine-k®. Other patients

Table 1. Comparison of demographic data and ASA risk [number (n) or mean ± SD]

	Quincke			Pencil-point			
	25G (n=36)	**26G (n=34)**	**27G (n=36)**	**25G (n=36)**	**26G (n=37)**	**27G (n=34)**	**p-value**
Female/Male (n)	8/28	13/21	11/25	10/26	12/25	10/24	0.801
Age (years)	36.5±8.2	38.1±8.6	32.4±10	35.1±9.5	36.4±9.5	33.9±9.5	0.128
Height (cm)	172.2±8.5	170.4±9.7	171.9±7.5	172.1±8.8	171.3±7.4	170.4±9.6	0.910
Weight (kg)	78.4±15.8	79.1±12.2	74.6±13.2	79.1±13.8	79.1±13.5	76.9±13.4	0.678
ASA I/II (n)	19/17	12/22	18 /18	14/22	8/29	10/24	0.053

Kruskal-Wallis test statistic, Analysis of variance test statistic
SD: Standard deviation, ASA: The American Society of Anesthesiologists

Table 2. Comparison of categorical variables by needle type and diameter

	Quincke			Pencil-point			
	25G (n=36)	**26G (n=34)**	**27G (n=36)**	**25G (n=36)**	**26G (n=37)**	**27G (n=34)**	**p-value**
Procedure success 1/2	17a/19	18ab/16	15a/21	32c/4	26b/11	20ab/14	<0.001
The number of trials required to perceive click sensation 1/2/≥3	15/12/9	15/10/9	14/18/4	13/14/9	16/16/5	17/11/6	0.660
CSF flow time (sec) <1.9/≥2	14/22	11/23	8/28	17/19	8/29	8/26	0.101
Procedure's feasibility Easy/Medium/Difficult	25/7/4	22/11/1	24/12/0	24/10/2	26/10/1	22/12/0	0.401
Presence of paresthesia Yes/No	0^a/36	0^a/34	2^{ab}/34	0^a/36	5^b/32	0^a/34	**0.004**
Postspinal back pain	0	0	0	0	4a	0	**0.004**

Chi-square test statistic,
[a-c]: There is no difference between times with the same letter in a group
CSF: Cerebrospinal fluid

with headaches did not require any analgesics, and their issues were resolved on their own.

Discussion

In this study, we compared the effects of Quincke and pencil-point needles of the same thickness used by anesthesia residents new to SA application on the success of the procedure and the number of trials required to perceive click sensation. It was determined that the success rate in the first trial was higher for the 25G pencil-point needles. Patients experienced backaches more frequently when 26G pencil-point needles were used, and there was no statistically significant difference between the groups in terms of click sensation.

Opinions about the success rate in the first trial according to the type and diameter of spinal needles vary (6-10,13-16). In a meta-analysis study comparing atraumatic and conventional spinal needles, it was reported that the success rate at the first attempt was similar (13). Westbrook et al. (6) reported that puncturing the dura with pencil-point needles was more difficult and less successful than that with Quincke needles. They explained that this was because it was technically difficult to use the needle, the sensation of the needle puncturing the dura was minimal, and local anesthetic injection was challenging. Another study reported that Quincke needles can easily penetrate skin and ligaments, whereas pencil-point needles make it easier to recognize the dura mater (16). Another study demonstrated that trial number in SA depended on the experience of the practitioner (13,17,18). Krommendjik et al. (18) reported that they achieved a success rate of 81.8% in the first attempt with pencil-point needles, but the SA reported that 69% of the applications were made by assistants with different experience periods. Performance characteristics, such as failure rate, first-try success rate, and average number of attempts, have been reported to show similar efficacy when using atraumatic and conventional needles (13). In this study, the majority of SAs were completed in the first trial, and the remaining SAs were completed in the second trial. The success rate in the first trial was higher (60%) when using pencil-point needles. For 25G pencil-point needles, the success rate in the first trial was 88.9%. However, the success rate was found to be lower for 26G (70.3%) and 27G (58.8%) needles, suggesting that the SA success rate decreased with a decrease in needle diameter. We concluded that because all interventions were performed using a guide needle, it was not difficult to use pencil-point needles. Therefore, it would be appropriate for anesthesia residents new to SA applications to use pencil-point needles, as this would increase the chances of procedural success.

Opinions on perceiving click sensation based on the type and diameter of spinal needles also vary (11,18,19). Krommendijk et al. (18) reported that in SA performed with 25G Pencan needles, click sensation was perceived in 78.4% of the patients; the perception of click sensation while performing SA is an important indicator of the success of the procedure. Shutt et al. (19) reported that they perceived spinal click sensation, albeit not explicitly, in all cases performed using a 25-G pencil-point needle, and they explicitly perceived the click sensation in only a few of the cases performed using a 26-G Quincke needle. According to the results of the present study, click sensation was perceived, independent of the groups, in 42.3% (n=90) of all patients who participated in the study in the first trial, 38% (n=81) in the second trial, and 19.7% (n=42) in the third and subsequent trials. The frequent perception of click sensation in the first trial explains the success of the SA procedure. Although there was no difference between needle type and diameter in terms of perceiving click sensation, practitioners stated that they were able to perceive click sensation more clearly, smoothly, and easily when using pencil-point needles. Various studies have investigated the relationship between PSBP and needle type, diameter, and number of attempts (13,17,19,20). A meta-analysis study compared atraumatic and conventional needles and found similar backache incidences (13). Pittoni et al. (17) observed a higher rate of backache incidence among patients when using a 22G pencil-point needle (14.5%) compared with a 25G pencil-point needle (5.9%), and they stated that the reason for this was not related to the needle diameter, not the number of trials. Shutt et al. (19) could not identify a relationship between backache incidence and trial number of needles. Krommendijk et al. (18) reported a PSBP rate of 7.8%. Only 4 of the 213 patients included in this study developed backache, which shows that the rate was quite low (1.8%). We believe that the development of backache with 26G pencil-point needles is coincidental, and because of the good response of the patients to oral analgesics, they did not encounter severe backache. We believe that because the number of trials did not make a difference in backache development, the pain could be related to the use of a guide needle, and the practitioner's experience is not a factor in the development of pain. More studies that cover a larger number of patients on this issue are needed.

PDPH incidence is affected by many factors, such as needle diameter, tip design, patient position, prophylactic intravenous fluid use, bed rest, and clinician experience (3,7-10,13-25). Among the mechanisms recommended for preventing PDPH, needle tip design has been the most prominent. Studies conducted with Quincke and pencil-point needles with equal external diameters have reported less CSF loss with pencil-point needles. This was attributed to the design of the needle tip, not the needle diameter. The design of the needle has a significant

effect on PDPH (6,8,9,18,21-23). In a study comparing pencil-point needles and smaller-diameter Quincke needles, it was reported that pen-tipped needles cause headaches at a lower rate (9). Shaikh et al.'s (21) study on obstetric patients, SA performed using 25G Q, 27G Q, and 27G Whitacre point needles showed PDPH rates of 8.3%, 3.7%, and 2%, respectively. They recommended the use of a 27-G Whitacre point spinal needle during the procedure. As the diameter of the spinal needle increases, the incidence of PDPH increases; however, as the thickness of the spinal needle decreases, the difficulty of the procedure increases, which subsequently decreases the chance of success (8-10). In this study, we determined the headache incidence to be 3.2%, regardless of the age group. The higher incidence of headache development during the 24-hour postoperative period when pencil-point needles were used was surprising and contrary to what was stated in the literature. However, headaches that develop in the 24-hour postoperative period may not be evaluated as PDPH. Instead, it would be considered a headache that lasts for a short time and resolves without any intervention. From the interviews of the patients, we found that they frequently complained about headaches. In addition, due to the young age of our patients, we cannot provide clear information about whether they were mobilized in the early postoperative period and to what degree they complied with the doctor's recommendations. Because there is no difference in the number of attempts for SA, we believe that headaches are not dependent on the number of attempts or the experience of the practitioner.

Past studies have emphasized that having the same size needle is not sufficient to provide the same CSF flow, and the inner diameter is more important than the outer diameter (7,10,24,26). A recent study reported that a pencil-point needle is easy to use and does not have a low flow rate, while the flow rate of two different spinal needles with the same diameter is similar (2). It has been suggested that CSF collection takes an unreasonably long time with a needle diameter of less than 22 g (0.7 mm) (23). Krommendijk et al. (18) reported that in SA performed using Pencan needles, CSF was observed within 2 s after the procedure in 95.9% of the patients. Although the inner diameters and tip designs of the needles used in our study were different, we observed that the CSF exposure times were similar (less than 2 seconds in 30.9% of our patients).

Krommendijk et al. (18) studied the evaluations made by doctors regarding the ease of performing SA using 25G Pencan needles. They reported that 85.2% of the doctors found the procedure to be easy, 6.2% found the ease of use to be medium, 6.7% found it difficult, and 1.9% found it impossibly difficult. In this study, doctors evaluated the feasibility of the procedure. The results demonstrated that 33.3% of the doctors found the procedure easy when using pencil-point and sharp-point needles, 14% found the procedure to be feasible with the Quincke needle medium, and 2.3% found it difficult. In the case of pencil-point needles, 15% of doctors rated procedural feasibility as medium and 1.4% as difficult. We believe that needle tip design and diameter do not change the practicability of the procedure.

Paresthesia is an abnormal sensation that occurs during a spinal, epidural, or combined spinal epidural (CSE) injection or the placement of a permanent spinal needle. The reason for developing paresthesia during SA performed using pencil-point needles is the distance from the tip of the needle to the orifice. Before the orifice enters the subarachnoid space, the tip of the needle should pass through the subarachnoid space by at least 0.5 mm. It has been assumed that paresthesia caused by the needle can be produced by contact of the tip of the needle with a spinal nerve stem in the epidural space or a spinal nerve in the intervertebral foramen. The development of paresthesia is affected by various factors, such as needle tip design, use of CSE kits with long spinal needles, and the puncture technique (25-30). In theory, Sprotte needles have a higher incidence of paresthesia than Quincke needles because the interaction between the needle and tissue during lumbar puncture increases the incidence of paresthesia by causing a deviation of the needle tip. The use of guide needles has been recommended to decrease this incidence (25). In the single-shot subarachnoid technique, the removal of the probe when the needle tip is still in the interspinal ligament and its continuous forward movement until CSF is observed can decrease the incidence of paresthesia. A study that compared paresthesia development during the use of pencil-point and sharp-pointed needles reported that paresthesia was observed in 20 out of 300 (6.6%) patients, although the difference was not statistically significant (n=13 and 7, respectively) (28). In this study, paresthesia was observed when using 26G pencil-point (n=5) and 27G Quincke (n=2) needles. Paresthesia occurred in 7 of 213 (3.3%) patients; all cases of paresthesia were transient, and no neurologic complications were observed. Although all interventions were performed with accompanying guide needles, we conclude that the puncture technique may have affected paresthesia development.

Study Limitations

Our study has certain limitations. The SA procedure is standardized for at least 20 procedures, regardless of needle type and diameter, for beginners. The effect of similar or additional interventions using different diameters and types of needles on outcomes has not been evaluated.

It should also be noted that needle diameter, type, and some other factors related to the patient may also have an impact on the time it takes for CSF to appear. In addition, the results might have been different if residents of different seniority levels were involved in this study, instead of only residents who were new to SA. Another limitation is that this study was a single-center trial with a small sample size. Finally, it would be appropriate to evaluate the complications of postoperative headaches and backaches at a later time. As the strength of our study, we would like to point out that the SA procedure performed using different needle tips will be very useful for assistants who are new to SA application in terms of feeling the layers of the spinal area and gaining needle practice.

Conclusion

Although the effects of spinal needles with different tip designs and diameters on the number of trials required to perceive click sensation are similar, due to the high rate of SA success in the first trial, the use of pencil-point needles is recommended for anesthesia residents new to SA application. However, they should also be careful regarding the development of paresthesia and back pain.

Ethics

Ethics Committee Approval: The ethical approval was obtained from The Institutional Review Board of Zonguldak Bulent Ecevit University (decision no.: 2018/20, clinicalTrials.gov identifier: NCT05704816; principal investigator: G.K., and date of registration: March 10, 2022).

Informed Consent: Written informed consent was obtained from patients.

Authorship Contributions

Concept: G.K., T.O., C.B., H.A., Design: G.K., B.G.K., T.O., R.D.O., H.A., Data Collection or Processing: G.K., B.G.K., T.O., K.B., C.B., R.D.O., O.P., Analysis or Interpretation: G.K., B.G.K., C.B., O.P., H.A., Literature Search: G.K., K.B., R.D.O., O.P., Writing: G.K., B.G.K., H.A.

Conflict of Interest: No conflicts of interest were declared by the authors.

Financial Disclosure: This study received no financial support.

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