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DUAL DRAINAGE SYSTEM IN THE MANAGEMENT OF CEREBROSPINAL FLUID LEAKAGE FOLLOWING SPINAL SURGERY

SPİNAL CERRAHI SONRASI GELİŞEN SEREBROSPİNAL SIVI KAÇAĞININ YÖNETİMİNDE ÇİFT DRENAJ SİSTEMİ

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ABSTRACT

Introduction: The objective of this prospective cohort study was to compare the outcomes of a standardized dual range with a prolonged time of drainage to single drain system in the management of intra operative dural tears.

Methods: Between 2018 and 2023, 116 patients (16.1%) with intraoperative dural tears were identified from 720 spinal surgeries performed at Eskisehir City Hospital. Patients underwent standardized surgical procedures for spinal stenosis, disc herniation, spondylolisthesis, spinal fractures, tethered cord, and intradural tumors. Following a protocol change in 2020, thirty patients were assigned to Group A (single subfascial drain, 2018-2020) and eighty-six patients to Group B (dual drainage system with subfascial and subcutaneous drains, 2020-2023).

Results: The CSF leakage rate was significantly lower in Group B (2.33%) compared to Group A (16.67%) (p=0.042). Success rates, defined as complete resolution without surgical intervention, were higher in Group B (97.67%) versus Group A (83.33%) (p=0.038). The infection rate was 2.33% in Group B and 6.67% in Group A (p=0.452). Mean drainage duration was 7 days in Group A versus 14 days in Group B (p<0.001), with Group B patients achieving earlier hospital discharge (median 3 days, range 2-5) compared to Group A (median 7 days, range 6-9). Both groups were followed for a minimum of 60 days post-surgery.

Conclusion: A standardized dual drain system with prolonged drainage time demonstrated superior outcomes compared to single drain system in managing dural tears after spinal surgery, achieving lower CSF leakage rates and higher success rates.

Keywords: spinal surgery;, dural tear;, cerebrospinal fluid leakage;, dual drainage system;, extended drainage duration

ÖZET

Giriş: Bu prospektif kohort çalışmasının amacı, intraoperatif dural yırtıkların tedavisinde uzun süreli drenaj ile standardize edilmiş çift aralıklı drenaj sisteminin sonuçlarını tek dren sistemi ile karşılaştırmaktır.

Yöntemler: 2018-2023 yılları arasında Eskişehir Şehir Hastanesi'nde gerçekleştirilen 720 omurga ameliyatından intraoperatif dural yırtığı olan 116 hasta (%16,1) tespit edildi. Hastalara spinal stenoz, disk hernisi, spondilolistezis, spinal kırıklar, gergin kord ve intradural tümörler için standardize cerrahi prosedürler uygulandı. 2020'deki protokol değişikliğinin ardından, otuz hasta Grup A'ya (tek subfasiyal dren, 2018-2020) ve seksen altı hasta Grup B'ye (subfasiyal ve subkutan drenlerle ikili drenaj sistemi, 2020-2023) atandı.

Bulgular: BOS kaçağı oranı Grup B'de (%2,33) Grup A'ya (%16,67) kıyasla anlamlı derecede düşüktü (p=0,042). Cerrahi müdahale olmaksızın tam rezolüsyon olarak tanımlanan başarı oranları Grup B'de (%97.67) Grup A'ya (%83.33) göre daha yüksekti (p=0.038). Enfeksiyon oranı Grup B'de %2,33 iken Grup A'da %6,67 idi (p=0,452). Ortalama drenaj süresi Grup A'da 7 gün iken Grup B'de 14 gündü (p<0.001) ve Grup B hastaları Grup A'ya (medyan 7 gün, aralık 6-9) kıyasla hastaneden daha erken taburcu oldu (medyan 3 gün, aralık 2-5). Her iki grup da ameliyat sonrası en az 60 gün boyunca takip edilmiştir.

Sonuç: Uzatılmış drenaj süresine sahip standardize ikili dren sistemi, spinal cerrahi sonrası dural yırtıkların yönetiminde tek dren sistemine kıyasla daha üstün sonuçlar göstermiş, daha düşük BOS sızıntı oranları ve daha yüksek başarı oranları elde etmiştir.

Anahtar Kelimeler: spinal cerrahi;, dura yırtığı;, beyin omurilik sıvısı kaçağı;, ikili drenaj sistemi;, uzatılmış drenaj süresi

INTRODUCTION

Dural tears are one of the most important and common complications of spine surgery. The incidence of dural tears in lumbar spine surgery varies between 1.8% and 17.4%. [1,2] This complication complicates postoperative patient care and negatively affects the healing process. [3] Risk factors for the development of dural tear include the age of the patient, the nature of the surgery, ligament ossification, and the severity of spinal cord degeneration, as described in previous studies. [3]

Serious complications such as cerebrospinal fluid (CSF) fistula, infection, arachnoiditis, meningitis, headache due to intracranial hypotension, diplopia, vomiting or, rarely, intracranial hemorrhage may occur due to the development

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of dura tear. [4,5] These complications significantly reduce the quality of life of patients and may lead to prolonged hospitalization.[6]

The most commonly used methods for repairing dural tears include primary suturing, patching with fat, fascia, or synthetic grafts in large tears, using fibrin glue, and waterproof suturing of the fascia. [7] [8] Prolonged immobilization, application of compression bandages and oral acetazolamide treatment during postoperative follow-up are among the preventive methods applied postoperatively.[9]

Despite all these preventive measures, long-lasting and persistent CSF fistulas are still one of the most challenging complications in spine surgery practice.

The main research question of this study is: "Is a dual drain system and extended drainage time more effective than a single drain system in the treatment of dural tears after spinal surgery?" In this context, the primary hypothesis of our study is that the use of a dual drain system (subfascial and subcutaneous) is more effective than a single drain system in the healing of CSF fistula after dural tear. Our secondary hypothesis is that prolonged drainage time will reduce complication rates.

In the current literature, there is no consensus on drainage management after dural tear. Specifically, the effect of drain type and drainage duration on CSF fistula healing has not been adequately investigated. [10,11] Furthermore, an optimal approach for early mobilization of patients and shortening their hospital stay has not yet been established.[12]

The aim of this study was to evaluate the efficacy of a dual drain system and prolonged drainage time in the treatment of dural tears after spinal surgery. We also aim to examine the effects of this approach on complication rates, length of hospital stay and patient comfort.

METHODS

A retrospective study was conducted from 2018 to 2023, analyzing 116 patients (16.1%) with intraoperative dural tears from a total of 720 spinal surgeries. The study was conducted at Eskisehir City Hospital. by a team of four fellowship-trained spine surgeons using standardized surgical techniques.

For study inclusion, patients needed to meet specific criteria: age ≥18 years, intraoperative dural tear during spinal surgery (posterior thoracal and lumbar decompression with or without instrümentation, intradural spinal tumors,tethered cord) minimum follow-up period of 60 days, and complete clinical and radiological documentation. Exclusion criteria were clearly defined: microdiscectomy procedures, active systemic infection, immunosuppressive therapy, incomplete medical records, and loss to follow-up before 60 days.

Patient characteristics were comprehensively documented, including demographics (age, gender, BMI), comorbidities (diabetes, smoking status, osteoporosis), previous spine surgeries, primary pathology requiring surgery, and ASA physical status classification.

The participants were divided into two groups based on standardized institutional protocols that changed over time. Group A (n=30, 2018-2020) received single subfascial drainage, while Group B (n=86, 2020-2023) received dual drainage (subfascial and subcutaneous). This temporal division was based on a departmental protocol change rather than individual surgeon preference, minimizing selection bias.

In terms of surgical technique standardization, dural tears were classified into three types: Type 1 (linear, <1 cm), Type 2 (linear, >1 cm), and Type 3 (complex or irregular). The standardized repair protocol included primary closure using 4-0 non-absorbable sutures in continuous fashion. Patch graft application criteria were established: required for Type 2 and 3 tears, with autologous fat graft for tears >1 cm and synthetic dural substitute for complex tears. Fibrin sealant (Tisseel™) was applied in all cases, followed by water-tight fascial closure using 0 Vicryl sutures, subcutaneous layer closure with 2-0 Vicryl, and skin closure with 3-0 Prolene.

Regarding drain management, 14-gauge Hemovac drains were used in all cases, with Group A receiving a single subfascial drain and Group B receiving both subfascial and subcutaneous drains. In both groups, free drainage without suction was applied immediately postoperatively instead of using incisional dressings. Every six hours for half an hour, drains in both groups were opened and drainage was performed.

The post-operative care protocol was standardized across both groups. Mobilization began with bed rest and 30° head elevation on day 1, followed by progressive mobilization as tolerated on days 2-3. Medication included prophylactic 3rd generation cephalosporin during drainage and oral acetazolamide post-drain removal for 7 days. Monitoring consisted of hourly neurological checks for the first 24 hours, daily CRP and WBC monitoring, and wound inspection every 8 hours. The follow-up protocol included daily assessment during hospital stay, weekly visits for the first month post-discharge, and subsequent visits at months 2, 3, and 6. CRP and WBC monitoring was performed at each visit, along with patient satisfaction assessment using VAS score.

Data analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Categorical variables were analyzed using Fisher's exact test or chi-square test, whereas continuous variables were analyzed using Student's t-test or Mann-Whitney U test. $P < 0.05$ denoted statistical significance.

The study adhered to the ethical standards of the Declaration of Helsinki of 1964. The protocol for this study had approval from [Eskişehir City Hospital Scientific Research Ethics Committee] (Ethics Committee Approval Number: ESH/BAEK 2024/60). Written informed consent was obtained from all participants or their guardians.

Table 1: Demographic Characteristics and Surgical Details

Characteristic	Group A (n=30)	Group B (n=86)	P-value
Gender			0.823
Female, n (%)	18 (60%)	54 (63%)	
Male, n (%)	12 (40%)	32 (37%)	
BMI (kg/m²), mean ± SD	27.4 ± 4.2	26.9 ± 3.8	0.534
ASA Classification			0.876
ASA I	4 (13.3%)	12 (14.0%)	
ASA II	18 (60.0%)	50 (58.1%)	
ASA III	8 (26.7%)	24 (27.9%)	
Comorbidities			
Diabetes	6 (20.0%)	16 (18.6%)	0.865
Smoking	8 (26.7%)	22 (25.6%)	0.908
Osteoporosis	5 (16.7%)	15 (17.4%)	0.922
Patient Satisfaction (VAS)			
Excellent (8-10)	20 (66.7%)	62 (72.1%)	0.568
Good (6-7)	8 (26.7%)	20 (23.3%)	
Fair (4-5)	2 (6.6%)	4 (4.6%)	
Surgical Procedure			0.892
Laminectomy	12 (40%)	33 (38.4%)	
Instrumentation/Fusion	10 (33.3%)	28 (32.6%)	
Tumor Excision	5 (16.7%)	13 (15.1%)	
Tethered Cord Release	3 (10%)	12 (13.9%)	
Primary Surgery	26 (86.7%)	74 (86%)	0.932
Revision Surgery	4 (13.3%)	12 (14%)	

Notes: Values are presented as n (%) for categorical variables and mean ± SD for continuous variables. *P-values* are derived using Chi-square tests for categorical variables and independent t-tests for continuous variables.

RESULTS

Among 720 patients who underwent spinal surgery between 2018 and 2023, 116 patients (16.1%) with intraoperative dural tear were included in the study. Patient allocation was determined based on standardized criteria: Group A (n=30) consisted of patients who received a single subfascial drain according to the surgeon's initial protocol from 2018-2020, while Group B (n=86) included patients who received the dual drain system (subfascial and subcutaneous) after protocol modification in 2020-2023. The study included major spinal procedures: laminectomy (n=45), instrumentation and fusion surgeries (n=38), tumor excision (n=18), and tethered cord release (n=15). Microdiscectomies were excluded due to different risk profiles and management protocols. (Table 1)

When analyzing baseline characteristics, no significant differences were observed between groups in terms of demographic and clinical parameters. Gender distribution was similar (Group A: 60% female, Group B: 63% female; p=0.823), with 18 female and 12 male patients in Group A, and 54 female and 32 male patients in Group B. Mean BMI was comparable between groups (Group A: 27.4 ± 4.2 kg/m², Group B: 26.9 ± 3.8 kg/m²; p=0.534). ASA classification showed a similar distribution, with most patients being ASA II (Group A: 60.0%, Group B: 58.1%; p=0.876). Comorbidity rates were also similar between groups, including diabetes (Group A: 20.0%, Group B: 18.6%; p=0.865), smoking (Group A: 26.7%, Group B: 25.6%; p=0.908), and osteoporosis (Group A: 16.7%, Group B: 17.4%; p=0.922). Patient satisfaction measured by VAS scores was comparable between groups, with the majority reporting excellent outcomes (Group A: 66.7%, Group B: 72.1%; p=0.568). The use of grafts was also comparable between groups, with 10 patients (33.3%) in Group A and 40 patients (46.5%) in Group B receiving grafts during surgery (p=0.561). (Table 1, Table 2)

Table 2: Graft Utilization by Gender

Graft Status	Group A (n=30)	Group B (n=86)	P-value
With Graft	Total: 10 (33.3%)	Total: 40 (46.5%)	0.561
Female with Graft	6 (20%)	27 (31.4%)	
Male with Graft	4 (13.3%)	13 (15.1%)	
Without Graft	Total: 20 (66.7%)	Total: 46 (53.5%)	
Female without Graft	12 (40%)	27 (31.4%)	
Male without Graft	8 (26.7%)	19 (22.1%)	

Age distribution analysis showed comparable demographics between groups. The mean age was 57.33 ± 13.10 years in Group A and 58.98 ± 11.14 years in Group B, with no statistically significant difference (p>0.05). The overall age range was 28-78 years in both groups, with similar median values (Group A: 60 years, Group B: 59 years). (Table 3)

Table 3: Age Distribution Analysis

Parameter	Group A (n=30)	Group B (n=86)	P-value
Mean ± SD (years)	57.33 ± 13.10	58.98 ± 11.14	>0.05
Median (years)	60	59	
Range (years)	28-78	28-78	
Age Distribution			
<40 years, n (%)	4 (13.3%)	10 (11.6%)	
40-60 years, n (%)	14 (46.7%)	41 (47.7%)	
>60 years, n (%)	12 (40%)	35 (40.7%)	

Post-operative CSF leak management and outcomes showed significant differences between protocols. The CSF leakage rate was significantly lower in Group B (2/86, 2.33%) compared to Group A (5/30, 16.67%) (p=0.042). Of the five patients who developed CSF leaks in Group A, three required surgical revision, while two responded to extended drainage. In Group B, both patients with CSF leaks were successfully managed with prolonged drainage without requiring surgical intervention. Success rates, defined as complete resolution without surgical intervention, were significantly higher in Group B (97.67%) compared to Group A (83.33%) (p=0.038). (Table 4)

Table 4: Clinical Outcomes by Drainage Type

Outcome Measure	Group A (n=30)	Group B (n=86)	P-value
CSF Leak Rate	5 (16.67%)	2 (2.33%)	0.042
Management of CSF Leaks			
- Conservative Success	2/5 (40%)	2/2 (100%)	
- Surgical Revision	3/5 (60%)	0/2 (0%)	
Overall Success Rate	25 (83.33%)	84 (97.67%)	0.038

Infection surveillance showed lower rates in Group B (2/86, 2.33%) compared to Group A (2/30, 6.67%), though not statistically significant (p=0.452). The mean drainage duration was significantly longer in Group B (14 days) compared to Group A (7 days) (p<0.001). Complication rates were lower in Group B (2.33%) compared to Group A (13.33%), though this difference did not reach statistical significance (p=0.127). (Table 5)

Table 5: Complications and Drainage Characteristics

Parameter	Group A (n=30)	Group B (n=86)	P-value
Infection Rate	2 (6.67%)	2 (2.33%)	0.452
Complication Rate	4 (13.33%)	2 (2.33%)	0.127
Mean Drainage Duration	7 days	14 days	<0.001
Hospital Stay (median)	7 days	3 days	<0.001
Range of Stay	6-9 days	2-5 days	

The standardized discharge protocol resulted in different hospital stay durations between groups. Group A patients remained hospitalized until drain removal (median 7 days, range 6-9 days). Five patients in this group developed discharge from the incision site within 2-3 days after drain removal, requiring one-day rehospitalization for subcutaneous drain placement under local anesthesia. Group B patients were discharged earlier (median 3 days, range 2-5 days) following a strict protocol that included stable neurological status, adequate pain control, demonstrated drain management competency, and reliable social support.

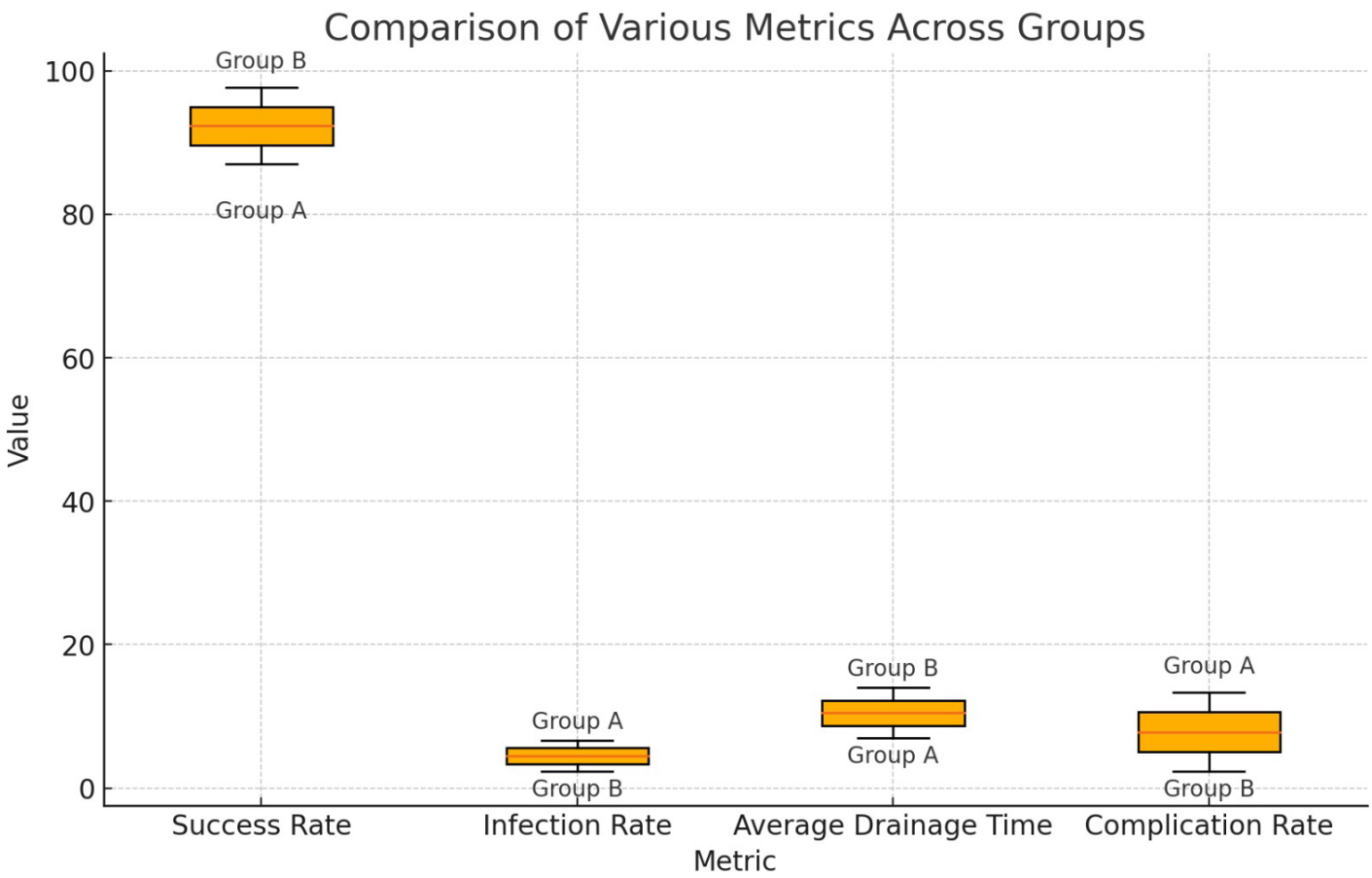
Post-discharge monitoring included daily telephone follow-up for the first week and scheduled clinic visits at days 7, 14, and 30. CRP and WBC monitoring at each visit showed elevated levels in three Group A patients and seven Group B patients, all successfully treated with oral third-generation cephalosporins. The mean follow-up period was 60 days (range 45-75 days), during which only one Group B patient showed incision discharge after suture removal, responding well to conservative management.

DISCUSSION

The objective of this study was to evaluate the effect of a dual drain system and prolonged drainage time on dural tears following spine surgery. Furthermore, we wanted to investigate the effects it has on patient comfort, hospital stay, and the frequency of complications. According to the results of our research, the use of a dual drain system and longer duration for postoperative drainage was more effective than single drain systems. The rate of CSF leakage was 2.33% in Group B (dual drain system), while it reached 16.67% in Group A (single drain system) (p=0.042). At the same time, success rates were 97.67% and 83.33% for Groups B and A, respectively (p=0.038). Moreover, infection and complication rates were lower for the dual drainage group even though such a difference did not reach statistical significance (p>0.05). These results indicate that the double drainage technique combined with an extended period of drainage is a promising modality in treating cerebrospinal fluid fistulas subsequent to dural tears. Dural tears, as well as CSF fistulas, are some of the challenging complications in spinal surgery. Even when intraoperative CSF leaks are not detected, a thinned, onion peel-like dura membrane or poorly circumferential lacerations without adherence sutures may result in postoperative increased pressure causing such leakages. This emphasizes both the difficulty of surgery as well as the need for observing the patient after the surgery closely. Management of dural tears and CSF fistulas is one of the most challenging complications of spinal surgery. Even if CSF leakage is not observed intraoperatively, a thinned dura membrane like an onion peel and non-uniformly circumscribed tears may cause CSF leakage even through the sutures with increased pressure in the postoperative period. This emphasizes the difficulty of surgical repair and the importance of close postoperative follow-up. On the whole, these findings have relatively similar conclusions to the findings of other research done by others as found in the literature. In a study by Lieberson et al., it was shown that the use of drains after dural tear repair decreased the risk of CSF fistulas.[13]

In our investigation the single drain and double drain were shown to be superior by the double drain system which confirms the findings by Schmidt et al. They also mentioned that extended time of drainage contributed positively to fistula repairs.[14] Our results support this finding and emphasize the effectiveness of a mean drainage time of 14 days. On the other hand, Doumouras et al. reported that the use of drains may increase the risk of infection.[15] However, in our study, infection rates were lower in the group using a double drain system, although this difference was not statistically significant. This difference may be related to early mobilization and careful wound care, as suggested by Liang et al.[16] The potential benefits of the dual drain system can be appreciated better from the findings of our study. This reduces the risk of complications through faster healing of CSF leaks. Qiu et al. noted that dead spaces created as a result of dura repair pose a threat to CSF build-up.[17] The double drainage system works in this way by draining accumulated fluids well for both subfascial and subcutaneous spaces. Hijazi et al. highlighted how fluid between fascia and subcutaneous tissue hampers the wound healing process.[18] We have solved this problem, hence allowing for quicker restoration of tissue integrity. Additionally, the dual drain system minimizes the chance of

Figure 1: Comparison of Various Metrics Across Groups



intracranial hypotension due to improved intracranial pressure control, as reported in Chen et al.'s research.[19] Consequently, early patient mobilization is possible, and the entire recovery process becomes more comfortable. Lastly, an efficient drainage system, according to You et al., leads to quicker wound healing through a reduced risk of infection.[20]

Our study, for instance, established that the effects of extended drainage time are one of the key findings. For example, Group B had an average drainage duration of 14 days, which ensured CSF fistula healing was better. A similar finding has already been established by Jung et al., who found that persistent drainage occurred before dural repair.[21] In addition, AbdelFatah reported that prolonged time is effective in maintaining intracranial pressure within normal limits and reducing the chance of CSF leakage.[22] Nevertheless, we must note that there are dangers associated with prolonged drainage. According to Lee et al., a prolonged period might increase the risk of infection.[23] However, in our study, only low rates of infection were recorded because of the use of a dual drain system and close monitoring of patients after surgery. The use of early mobilization and home follow-up for patients reduces possible drawbacks linked to long-term drains, as stated by Jeon et al.[24] Our study also underscores the significance of early discharge and home follow-up. Patients in Group B could leave the hospital within an average period of 3 days thanks to the dual drain system. This approach has considerable benefits regarding patient comfort and hospital costs. Meanwhile, hospital-acquired infections can be avoided through early discharge, and it improves patient satisfaction as reported by Lieberson et al.[13] However, there may be some problems associated with managing drains at home. Educating patients and caregivers is an important point highlighted by Schmidt et al.[14] In our study patients and caregivers were well informed, which in turn assisted in decreasing complication rates. According to Doumouras et al., regular telephone follow-up, along with clinic visits when needed, would make home follow-up safer for patients.[15] Additionally, as stated by Liang et al., the healing process at home can have a positive impact on the mental state of patients, thereby enhancing overall recovery rates.[16] Therefore, implementing early discharge coupled with home follow-up is not only safe but also effective in treating CSF fistulas if it is done through correct selection of patients, sufficient teaching, and close monitoring of such cases.

Firstly, our study has limitations. This was a retrospective study and randomization was not done. This might lead to selection bias. In Group A (n=30), the sample size was quite small in comparison to the rest. It may reduce statistical power for some subgroup analyses as well. Additionally it should pose the limitations related to the fact that the study

was carried out in a single center, thus and generalization becomes difficult. The follow-up duration averaged 60 days; a longer period of follow-up would have given us a better insight into late complications and the recovery course. There is no systematic evaluation of patient satisfaction or quality of life as measured by patient-oriented outcomes. Lastly, we did not undertake any cost analysis; we therefore could not assess if implementing these two drains simultaneously is cost-effective or not. These limitations can be addressed in future studies by increasing sample size, conducting randomized control trials, involving multiple centers, and following up patients for a longer period than 60 days on average. In addition, consideration of patient-centered outcomes and economic evaluation will help to determine its relevance in clinical practice better.

CONCLUSION

This study has shown that evidence has been established that the application of a double drain system and a prolonged drainage period after surgery for spinal dural tears is effective. This technique was able to prevent more CSF leaks, had a better success and lower complications rates than employing only one drain. The dual drain system quickly drains both subcutaneous tissues and subfascial areas, facilitating wound healing while minimizing Cerebrospinal Fluid (CSF) fistula formation. By extending the time for draining, enough time can be allowed to optimize healing to occur after dura repair within a reasonable period. Following this, patients can then be discharged early for home-based care, thus improving patient comfort and reducing hospital costs. However, our study has limitations; hence, larger scale randomized controlled trials should be conducted to validate these results. Besides, further studies could consider those regarding the effectiveness, patient satisfaction, long term effects, cost-effectiveness, etc. In this instance to manage the status of dural tear after the spine surgery by physicians these findings put forward another aspect which would also assist in enhancing treatment plans.

Ethics Committee Approval: The protocol for this study had approval from [Eskişehir City Hospital Scientific Research Ethics Committee] (Ethics Committee Approval Number: ESH/BAEK 2024/60).

Informed Consent: Written informed consent was obtained from all participants or their guardians.

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