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Drains and Drainage Capabilities: Quantitative Analysis of Drain Efficiencies

Andaç Aykan[1], Serbülent Güzey[2], İsmail Şahin[1], Fahrettin Güven Oysul[3], Serdar Öztürk[1], Arşen Akın[1]

[1]Department of Plastic, Reconstructive, and Aesthetic Surgery, Gülhane Military Medical Academy, Ankara, Turkey
[2]Department of Plastic Surgery, Kasımpaşa Military Hospital, İstanbul, Turkey
[3]Department of Public Health, Gülhane Military Medical Academy, Ankara, Turkey

Abstract

Objective: In this study, it was aimed to compare the efficiency of the same type of but different-sized silicone drains at different surgical procedures.

Material and Methods: Twenty-four patients, who had different diagnoses and were operated between 2011 and 2013, were included. In all patients, 7- and 10-mm silicone-ended, Jackson–Pratt drains were used. Drains that were under 30 cc/day removed. The connection tube and perforated silicone end were examined due to the clot content. All drain efficiencies were calculated, and the results were statistically analyzed.

Results: Seven of the 24 patients (29.2%) were males and 17 (70.8%) were females; the mean age was 39.0±11.4 years. Totally, 49 drains were used, of which 25 (51%) were 7 mm and 24 (49%) were 10 mm in size. Median removal time was the 5th day (2–12) for the 7-mm drains and the 6th day (3–14) for the 10-mm drains. There was no statistically significant difference between the groups for drain removal time (p=0.268). Further, there was no difference at the connection tube and silicone end for clot content between the 7- and 10-mm drains (p=0.58). For the drainage volume and efficiency, no difference was observed between the groups (p=0.146).

Conclusion: In this study it was observed that there is no difference in the drainage volume and efficiency between different-sized Jackson–Pratt drains.

Keywords: Drain, drainage, Jackson-Pratt, efficiency, silicone drain, quantitative

INTRODUCTION

Drains are the primary tools among those frequently preferred for reducing the complications associated with surgical procedures. The real aim in using these systems, which can be either open or closed depending on the drainage methods and active or passive depending on the pressure applied, is to prevent the possible accumulation of fluids and to shrink the pouch using negative pressure.[1,2]

Although using drains provide significant benefits in the postoperative period, they also introduce some problems for both the patient and the physician. For the patient, the major concerns are extended hospitalization, fear and anxiety about the drain removal procedure, and possibility of permanent scars on the drain sites in later periods.[3] For the physician, the major concerns are the efficiency of the drain, the timing of its removal, and possible infections that could be caused by the drain.

Preventing the accumulation of fluids, particularly hematoma, is the main purpose of using drains. However, in a number of studies conducted on a range of operations, such as breast reduction surgery, it has been argued that closed and negative pressure drainage, contrary to the common conviction, did not reduce hematoma formation and further extended hospitalization and the use of antibiotics.[4-6] Despite these findings, a majority of the surgeons use drains.[7] This situation is being associated with the habitual practices of the surgeons and a psychological feeling of safety. Because study results have found the utilization of drains to be an ineffective method in each

Correspondence Author: Serbülent Güzey, MD
E-mail: drserbulent@yahoo.com

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and every case and further the possibility of complications, the issue of which drain should be used for which patient has become more complicated.[8,9]

In using drains, the major issue encountered once a case is identified to be suitable is the drain type to be chosen and how efficient that system would be in the postoperative period. Currently, a wide range of drain types are available that can be used by different branches and chosen according to the planned operative procedure. Currently, however, drains with flat silicone ends are widely used in the current surgical procedures. The flat silicone drain system is a drainage mechanism that consists of a drainage tube, a connecting tube, and a reservoir. The efficacy of this system is associated with the width and structure of the drain tube and clot accumulation. Occlusion and angle formations in the connecting tube of the drain, the amount of fluid accumulating in the reservoir, and the extent to which negative pressure can be supplied by the reservoir constitute the important aspects in the drainage that the system can provide. Although different approaches such as milking and washing the drain and applying negative pressure with a syringe are frequently preferred in clinical practices for enhancing the efficiency of the drain, the benefits such approaches provide are not known.

Drain systems can be prone to efficiency variations caused by a range of agents; however, there are no studies available in the literature about the factors affecting their drainage capabilities. This study aimed at showing the efficacy level of Jackson–Pratt-type drains as applied in their routine use and demonstrating the impact which the width of the silicone tube and the clotting density in the drain have on drainage capability.

MATERIAL AND METHODS

Patient Group

A descriptive research model was used in the study, which included 24 patients that were operated on for different diagnoses in our clinic between 2011 and 2013. Patients with systemic comorbidities (diabetes mellitus, diabetes insipidus, hypertension, collagen tissue diseases, and vascular diseases) and smokers were not included in the study. None of the patients were identified to have bleeding and clotting disorders. None of the female patients were operated on during their menstruation periods. All operation procedures were performed by the same surgical team.

Follow-up

Jackson–Pratt-type 7-mm or 10-mm wide and 12-cm long 4/4 perforated drains with white silicone tubes and 80-cm connecting tubes were used for all cases (Fortune Medical Instrument Corp., New Taipei City, Taiwan). All drain reservoirs were of 150 cc (Figure 1) and were emptied twice a day at 7.00 a.m. and 7.00 p.m. Between the emptying times, the two walls of the reservoirs were aligned to touch at one point to provide continuous negative pressure. Reservoirs were drained and re-pressurized during the day when 50 mL or more accumulated in the bulb. No extra procedures such as activating or milking using a syringe were applied to any of the drains. Care was taken to avoid any folding or angling in the connecting tubes of the drains. All drains that were found to achieve a level of less than 30 mL in the daily follow-up were removed. Before removing the drain, the negative pressure was first released and then drained under neutral pressure. The amount collected until the removal of the drain and the removal date were recorded.

Evaluation

a) Macroscopy

The connecting tubes and the perforated silicone tubes of the drain systems were separately examined for clotting content. The reservoir was macroscopically examined for any possible impairment that could have caused air leaks or pressure losses. The amount of fluid collected in the connecting tubes was graded on a scale of *mild, moderate, and severe* (*Mild:* clot accumulation in less than 25% of the connecting tube, *Moderate:* clot accumulation in 25%–75% of the connecting tube, *Severe:* clot accumulation in more than 75% of the connecting tube). The silicone tube was evaluated on a scale of four grades, namely, *clean, mild, moderate*, *and severe* (*Clean:* no clotting observed in the silicone tube, *Mild:* clot accumulation observed in less than 25% of the silicone tube, *Moderate: clot accumulation observed in* 25%–75% of the silicone tube, *Severe:* clot accumulation observed in more than 75% of the silicone tube) (Figure 2).

b) Function

The drainage capabilities of the drain systems were examined for functional evaluation. Following the evaluation of clot densities in the silicone tubes and the connecting tubes, the reservoirs were re-pressurized with negative pressure and the drain systems were submerged in basins filled with water to measure the water intake for 30 s. The collected data were divided into the data obtained for the amounts of water drained by two new drains, 7 mm and 10 mm, in 30 s (standard amount of drainage) to calculate the "drain efficiency" values (Equation 1).

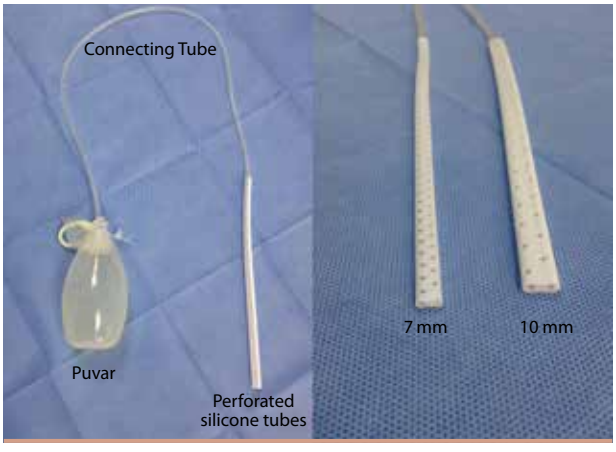

Figure 1. View of the drainage system parts and size differences in 7-mm and 10-mm drains

Figure 2. Clot formation in the tube at 50% in a 7-mm drain with a silicone tube

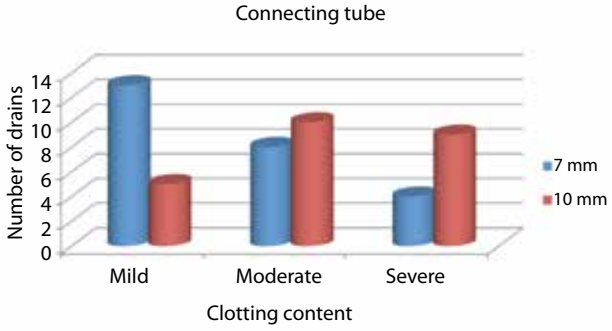

Figure 3. Number of drains with different-sized silicone tubes by clotting content in the connecting tubes

Equation 1. Calculation of drain efficiency

$$\text{Drain efficiency} = \frac{\text{Identified Amount of Drainage}}{\text{Standard Amount of Drainage}} \times 100$$

The standard drainage amount for each of the two new drains (7 mm and 10 mm) was found to be 75 cc/30 s in the drain efficiency calculation.

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 15 for Windows. Correspondence of the variables to the distribution was assessed using the Shapiro–Wilk test. In the descriptive statistics, discrete variates were shown in numbers (percentage), and continuous variates that corresponded to the normal distribution were shown in average±standard deviation values, whereas variables that did not correspond to the normal distribution were shown in median (smallest-largest) values. To determine the differences among the groups, chi-square test was conducted to compare the discrete variates, t-test to compare the continuous variates that corresponded to the normal distribution, and Mann–Whitney U test to compare those that did not correspond to the normal distribution. Values in which the p value was less than 0.05 were accepted as significant.

RESULTS

Of the 24 patients included in the study, 7 were male (29.2%) and 17 were female (70.8%), and the average age was 39.0±11.4 years. Of the patients in which 7-mm drains were used, 2 were male (18.2%) and 9 were female (81.8%), and their average age was 40.7±9.2 years. Of the patients in which 10-mm drains were used, 5 were male (38.5%) and 8 were female (61.5%), and their average age was 37.5±13.2 years. No statistically significant differences were identified between the study groups with respect to gender and age (p>0.05). Although a total of 49 drains were used in the study, 25 of these drains were of 7-mm width (51.0%), and 24 were of 10-mm width (49.0%). The median removal time was 5 days after the operation (earliest 2 days and latest 12 days) for the 7-mm drains and 6 days after the operation (earliest 3 days and latest 14 days) for the 10-mm drains. No statistically significant differences were found between the study groups with respect to the number of days the patients had the drain in place (p=0.268). No complications were encountered in any of the patients during or after the removal of the drain.

Reservoir

Reservoir assessments were conducted after the drains were removed, and no defects that could have caused a loss of pressure were identified in any of the bulbs.

Connecting Tube

Clotting at different levels were observed in all of the connecting tubes that were used in both (7 mm and 10 mm) drain groups. In the assessment of the connecting tubes, of the total 49 drains used, clot formations were identified to be mild in 18 drains (36.7%), moderate in 18 drains (36.7%), and severe in 13 drains (26.5%). Of the 25 drains in the 7-mm drain group, clot formations were identified to be mild in 13 drains (52.0%), moderate in 8 drains (32.0%), and severe in 4 drains (16.0%). Of the 24 drains in the 10-mm drain group, clot formations were identified to be mild in 5 drains (20.8%), moderate in 10 drains (41.7%), and severe in 9 drains (37.5%). Although clot accumulation was found to be denser in the 10-mm connecting tubes (79.0% moderate-severe), it was found to be less dense in the connecting tubes of the 7-mm drains (48.0% moderate-severe) (Table II, Figure 3). No statistically significant differences were found between the 7-mm and 10-mm drain groups with respect to the amount of clotting in the connecting tube (p=0.58).

Silicone Tube

In the assessment of the silicone tubes, of the total 49 drains used, clot formations were identified to be clean in 8 drains (16.3%), mild in 13 drains (26.5%), moderate in 19 drains (38.8%), and severe in 9 drains (18.4%). Of the 25 drains in the 7-mm drain group, clot formations were identified to be clean in 3 drains (12.0%), mild in 6 drains (24.0%), moderate in 10 drains (40.0%), and severe in 6 drains (24.0%). Of the 24 drains in the 10-mm drain group, clot formations were identified to be clean in 5 drains (20.8%), mild in 7 drains (29.2%), moderate in 9 drains (37.5%), and severe in 3 drains (12.5%). Although clot accumulation was observed to be denser in the silicone tubes of the 7-mm drains (64.0% moderate-severe), it was found to be less dense in the silicone tubes of the 10-mm drains (50.0% moderate-severe) (Table III, Figure 4). No statistically significant differences were found between the 7-mm and 10-mm drain groups with respect to the amount of clotting in the silicone tube (p=0.657).

Table I. Socio-demographic characteristics of patients, the type of surgery performed, drain size, and number of drains used in surgical procedures

Patient no	Gender	Age (years)	Diagnosis	Surgical procedure	Size of drain used	Number of drains used
1	Female	45	Gigantomastia	Breast reduction surgery	7 mm	2
2	Female	46	Gigantomastia	Breast reduction surgery	7 mm	2
3	Female	33	Gigantomastia	Breast reduction surgery	7 mm	2
4	Female	36	Gigantomastia	Breast reduction surgery	7 mm	2
5	Female	34	Hypoplastic Breast	Breast augmentation with implant	7 mm	2
6	Female	56	Breast CA--mastectomy	Reconstruction with breast implant	7 mm	4
7	Female	42	Breast CA--mastectomy	Reconstruction with breast implant	7 mm	4
8	Male	45	Decubitus ulcer	Reconstruction with local flap	7 mm	1
9	Female	43	Abdominal dystrophy	Abdominoplasty	7 mm	2
10	Female	47	Abdominal dystrophy	Abdominoplasty	7 mm	2
11	Male	21	Heel defect	Rectus muscle flap	7 mm	2
12	Female	42	Gigantomastia	Breast reduction surgery	10 mm	2
13	Female	41	Gigantomastia	Breast reduction surgery	10 mm	2
14	Male	22	Gynaecomastia	Gynaecomastia correction (excision)	10 mm	2
15	Female	35	Breast CA--mastectomy	Reconstruction with TRAM flap	10 mm	3
16	Female	52	Abdominal dystrophy	Abdominoplasty	10 mm	2
17	Female	41	Abdominal dystrophy	Abdominoplasty	10 mm	2
18	Female	63	Gigantomastia	Breast reduction surgery	10 mm	2
19	Female	43	Gigantomastia	Breast reduction surgery	10 mm	2
20	Male	48	Decubitus ulcer	Reconstruction with local flap	10 mm	1
21	Female	38	Gigantomastia	Breast reduction surgery	10 mm	2
22	Male	21	Maxillary defect	Rectus muscle flap	10 mm	2
23	Male	21	Lower extremity defect	Reconstruction with latissimus dorsi flap	10 mm	1
24	Male	21	Upper extremity defect	Reconstruction with latissimus dorsi flap	10 mm	1

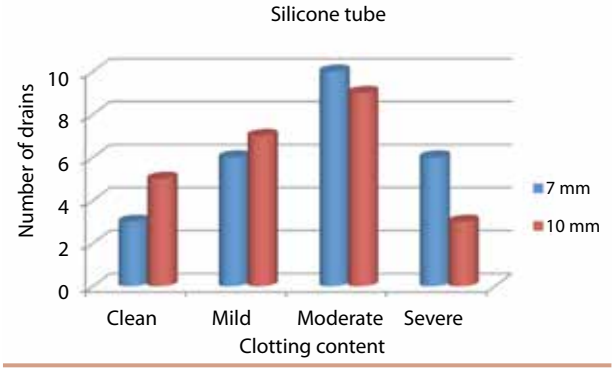

Figure 4. Drains with different-sized silicone tubes by clotting content in the connecting tubes

Amount of Drainage and Performance of Drains

The average drainage amount in 30 s was found to be 35.7±13.6 cc for the 49 drains used in the study. The average drainage amounts were calculated to be 38.5±12.5 cc/30 s for the 7-mm drains and 32.8±14.3 cc/30 s for the 10-mm drains. No statistically significant differences were found between the groups in terms of drainage amounts with respect to their drain widths (p=0.146) (Table IV).

Although the average performance of all drains was found to be 47.6±18.1%, the average performance of the 7-mm drains was 51.3±16.7% and that of the 10-mm drains was 47.5±19.1%. No statistically significant differences were found between the groups in terms of drain efficiency with respect to their drain widths (p=0.146) (Table IV).

In the analyses conducted based on the clotting contents in the silicone tubes and the connecting tubes, a decrease in line with the clotting content was identified in the drainage amount in cases when clotting was higher in both sections (Figures 5 and 6).

DISCUSSION

The leading purpose for using drains is either dissection of tissues or shrinking of large cavities caused by excision and preventing any possible hematoma and fluid accumulation in these cavities.[1,2] However, drains may not always lead to

the results that are intended in line with their purpose of utilization. Comparative studies are available that have been conducted for demonstrating the efficacy of drains in plastic surgery practices.[10,11] The data obtained in these studies have led to a review of the treatment and the follow-up approaches in certain surgical procedures. Identification of a 0.2%–8.1% hematoma risk for cases in which drains are used during facelift surgery has introduced the use of tissue adhesives.[10] In the studies conducted by Marchac and Sandor,[11] although the risk of major hematoma was found to be 9% for cases in which drains were used in facelift surgery, this risk was found to be 2% for the group in which tissue adhesives were used. Additionally, a significant decrease was observed in ecchymosis and edema formation. Also, in a retrospective study conducted by Zoumalan and Rizk[10] on 605 facelift patients, tissue adhesives were found to provide a significant reduction in hematoma formation compared with drains. In breast reduction surgeries, on the other hand, the positive effects of drain usage on hematoma and wound healing could not be demonstrated in the numerous retrospective studies conducted since the mid-nineties.[12-14] Similarly, a prospective study conducted by Collis et al.[4] on 150 patients was unsuccessful in demonstrating the positive effects of drain usage on hematoma and wound healing, and the authors, referring to Halsted's words from 1893, remarked that "[it is] better not to apply drainage at all than to apply unknowingly." On the other hand, recommending the utilization of drains in selected breast reduction procedures, Ngan et al.[15] have defined these cases as young patients and cases in which less than 500 g is resected. In another study conducted by Borile et al.[16] on abdominal dermolipectomy patients, no statistically significant differences were found with respect to hematoma or seroma formation between the two groups in which drains and abdominal corsets were used. Other than in plastic surgery, the utilization of drains has also been demonstrated to not provide any additional benefits in a range of surgical procedures, including thyroidectomy, hip arthroplasty, and hepatic surgery.[17-20]

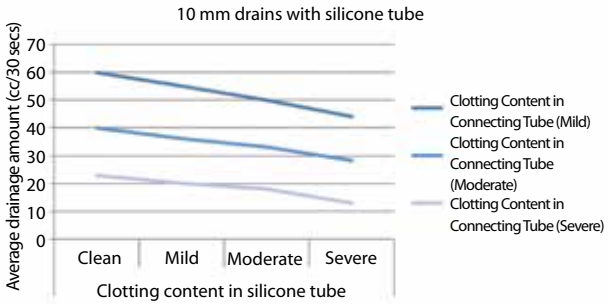

Figure 5. Variations in drainage capability based on clotting content in the silicone tube and the connecting tube of 10-mm drains

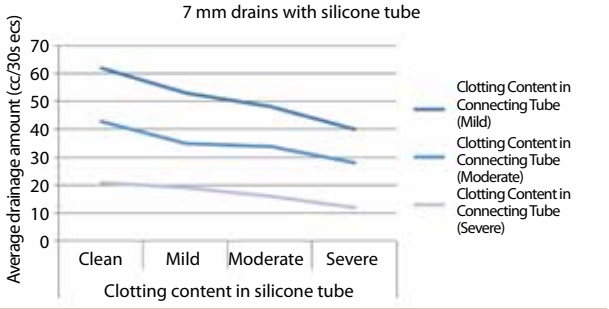

Figure 6. Variations in drainage capability based on clotting content in the silicone tube and the connecting tube of 7-mm drains

Table II. Clotting amounts in the connecting tubes compared by groups

		Connecting tube				
		Mild	Moderate	Severe	Total	p*
		Number (%)	Number (%)	Number (%)	Number (%)	
Drain size	7 mm**	13 (52.0)	8 (32.0)	4 (16.0)	25 (100.0)	0.58
(diameter)	10 mm**	5 (20.8)	10 (41.7)	9 (37.5)	24 (100.0)	
Total**		18 (36.7)	18 (36.7)	13 (26.5)	49 (100.0)	

*Chi-square test. **Percent to total

Numerous publications are available in the literature that compare the efficacy of drainage systems by the types of procedure.[4,10-20] Moreover, how efficient drains function in the postoperative period, regardless of the surgical procedure type, is another topic that is yet to be studied. No studies are available in the literature about the impact of the type and the size of the drain on its efficacy. This study aimed at investigating the efficacies of drains of the same type but of different sizes used after different types of surgical procedures.

Currently, there are many different types of drains available that can be used in surgical procedures. Drains with flat silicone ends, however, are rather commonly used both in plastic

Table III. Amount of clotting in the silicone tube of the drains compared by groups

		Silicone tube					
		Clean	Mild	Moderate	Severe	Total	
		Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	p*
Drain size	7 mm**	3 (12.0)	6 (24.0)	10 (40.0)	6 (24.0)	25 (100.0)	0.657
(diameter)	10 mm**	5 (20.8)	7 (29.2)	9 (37.5)	3 (12.5)	24 (100.0)	
Total**		8 (16.3)	13 (26.5)	19 (38.8)	9 (18.4)	49 (100.0)	

*Chi-square test **Percent to total

Table IV. Collected fluid amount and performance in groups compared by drain widths

	Drainage amount (cc/30 secs)	p*	Drainage efficiency (%)	p*
7 mm	38.5±12.5		51.3±16.7	
10 mm	32.8±14.3	0.146	43.7±19.1	0.146
All drains	35.7±13.6		47.6±18.1	

*T-test in independent groups

surgery procedures and in other surgical sciences. Therefore, patient groups in which Jackson–Pratt-type drains with 7-mm and 10-mm flat silicone ends were used have been chosen in our study. The fact that no statistically significant differences were identified between the groups with respect to gender and age in the patient groups indicates that the efficacy of the drains was assessed in a homogeneous patient group. In previously conducted studies, drain efficacy was assessed in patient groups that had undergone a specific surgical procedure such as facelift, breast reduction or abdominoplasty.[10-20] In this study, the efficacy of a selected type of drain was assessed in patient groups that have been operated on by the same surgical team for diverse surgical procedures.

The flat silicone drain system is a closed and mechanical drainage mechanism that consists of a drain end, a connecting tube, and a reservoir. The efficacy of this drainage system is disrupted by mechanical occlusion. Clot formation in the drain and folding of the connecting tube to obstruct liquid flow are situations that are frequently encountered in clinical applications. Therefore, in our study, to evaluate the efficacy of the drainage, the clotting content in the silicone tube and the connecting tube was first macroscopically examined once the drain was removed. In the examination of the connecting tube, clotting at different levels was identified in all of the cases. There were also cases in which no clotting was identified in the silicone section of the tube. Therefore, although the clotting in the connecting tube was assessed by three grades (*mild*, *moderate*, and *severe*), the silicone tube was assessed by four grades, namely, *clean*, *mild*, *moderate*, and *severe*. This gives rise to the thought that in cases where the silicone tube was found clean, the clotting in the silicone tube was drawn inside of the connecting tube with the impact of the negative pressure created by the reservoir of the closed system. Although no statistically significant differences were identified between the two study groups in terms of the clotting amounts in the connecting tube and the silicon tube, it was observed that in 10-mm and 7-mm drains with silicon tubes, occlusion had, in a large part, formed in the connecting tube and in the silicone tube, respectively. This variation may be explained by the fact that although the widths of the tube ends are different, the diameter of the connecting tubes in both types ise the same. The occlusion, which was observed to be more severe in the connecting tubes of the 10-mm drains, was related to the displacement of the large clot that had formed in the tube end towards the connecting tube under the negative pressure created by the drain. The observed occlusion in the connecting tubes of the 7-mm drains was related to the smaller size of the clots, which allowed them to leave the silicone section and freely pass through the connecting tube. In our study, no statistically significant differences were identified based on drain widths between the two drain groups with respect to drainage amounts and drainage efficiency. However, in drains with no clot accumulation found in the silicone tube, a decrease was observed in drainage amounts in line with the increase in the clotting amount found in the connecting tube. In clinical applications, this decrease may cause the system to drain the collection in the pouch in a longer period of time. In our study, 10-mm drains with silicone tubes were identified to remain in place longer; however, no statistically significant differences based on drain widths were found between the groups with respect to the time for which the drains remained in place.

In practice, various different application styles are frequently used to enhance drain efficacy. Mechanically cleaning the connecting tube of the drain (washing and applying extra pressure) is the primarily used method. This method, which is also phrased as "drain activation," is widely thought to increase the drainage. However, there are no studies available in the literature on the extent to which the clot inside the drain can impact the drainage, the necessity of the drain activation procedure, or when the drain should be activated. Moreover, although some studies report that drain occlusion is a rare complication (1%), its occurrence can be a significant source of mortality and morbidity.[21] In addition, in areas such as plastic surgery where perfusion dynamics stands in the forefront, a hematoma or fluid accumulation that can form in the surgically created pouch can quickly render the entire operation process unsuccessful. Further, a prolonged drainage period causes new clot formations distal to the clotted section of the drain and inside the tissue as a result of congestion. In our study, a significant decrease was identified in the drainage capability of the system in cases where more than 25% clotting was found in the connecting tube of the drain. Therefore, we find it beneficial to clean the drain regardless of the drain tube width in cases when clotting at this level is seen in the connecting tube. Additionally, in the light of the obtained data, it can be stated that the connecting tube of a wider-ended drain should be cleaned more frequently than that of a narrow-ended drain to ensure effective drainage.

There are no exact criteria with respect to the size of the drains to be used in the postoperative period. The general approach is to prefer wider-ended drains in cases where the surgical pouch is wider or postoperative bleeding is deemed likely, otherwise to prefer narrow-ended drains as much as possible. In our study, no significant differences were identified between the drainage amounts and efficiencies of the 7-mm and 10-mm drains with silicone tubes. Moreover, because less clotting had formed in the silicone end inside the tissue, wider-ended drains can be more suitable after surgical procedures that involve larger cavities.

The material of a drain system is another factor that plays a significant role in drainage. Drains can be made of various types of material, which give them different surface features

and different adhesion rates. A study conducted by Ernst *et al*.[22] has shown that drains made of plastic or of a mix of plastic and latex will function with 20% efficiency after 7 days because of fibrin- and clot-based occlusions, whereas silicone offers a more beneficial and suitable structure than the former. Given that all of the drains used in our study were of silicone content and yet clot formations that could affect the drainage were identified, materials offering different surface properties could be used for this purpose.

CONCLUSION

Our study demonstrated that there are no differences between the drainage amount and efficiency provided by the Jackson–Pratt-type drains with different-sized silicone tubes. Given that occlusions mostly occur inside the tissue in narrow-ended drains and considering the difficulty to intervene in this region during drainage, we believe that wider-ended drains will be more suitable in cases in which long-term drain utilization or intensive fluid drainage is expected.

Ethics Committee Approval: Ethics committee approval was not received for this study. Because in this study we tried to evaluate of a routine procedure that is independent from the patient (drains were evaluated following pull out).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - İ.Ş., S.G., A.A.; Design - İ.Ş., S.G., A.A.; Supervision - S.Ö., İ.Ş.; Resources - A.A., S.G.; Materials - Ar.A.; Data Collection and/or Processing - A.A., Ar.A., S.G..; Analysis and/or Interpretation - S.G., İ.Ş., A.A.; Literature Search - S.G., A.A.; Writing Manuscript - S.G., A.A.; Critical Review - İ.Ş., S.Ö.; Other - F.G.Ö., Ar.A.

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