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Do Current Scoring Systems Predict the Length of Hospital Stay in Cases of Fournier's Gangrene?

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ABSTRACT

Objective: The aim of this study was to investigate the reliability of scoring systems to predict the length of hospital stay in cases of Fournier's gangrene (FG), and to contribute to the potential development of new scoring systems to more accurately predict the length of hospital stay of FG patients.

Materials and Methods: This retrospective study examined the data of FG patients treated between January 2016 and April 2021. The length of hospital stay was evaluated using demographic characteristics, laboratory values, vital signs, and Fournier's Gangrene Severity Index (FGSI), Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC), and Combined Urology and Plastics Index (CUPI) scores.

Results: A total of 28 patients were treated for FG during the study period. The mean length of hospital stay was 13.7±5.4 days. The median FGSI, LRINEC, and CUPI score was 2 (min–max: 0–11), 4 (min–max: 0–10), and 5.5 (min–max: 1–9), respectively. The analysis indicated that the CUPI score had a statistical correlation with the length of hospital stay; the FGSI and LRINEC were not found to have a significant predictive ability of the length of hospitalization.

Conclusion: The findings indicated that the FGSI and LRINEC disease severity scores were not sufficient to predict the length of hospital stay. The CUPI scoring system was more useful but was judged to be a weak model. Improvement or a new scoring instrument based on additional research is needed.

Keywords: Disease severity score, Fournier's gangrene, length of stay, morbidity, necrotizing fasciitis

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INTRODUCTION

Fournier's gangrene (FG) is a form of necrotizing fasciitis that generally affects the perineal area. It can be fatal if not diagnosed quickly and treated early. The primary treatment approach is surgical debridement and administration of broad-spectrum antibiotics (1). Today, the mortality rate has decreased significantly with developments in diagnosis, treatment, and intensive care facilities (2, 3). However, morbidity and a prolonged hospital stay continue to be an important problem because patients are often in the middle-high age group and have comorbidities. Multiple debridements, reconstructive surgeries, diverting stoma procedures, and related complications can be seen in these cases, and hospitalization may extend up to 9 months (4). Therefore, much of the research has focused on determining the risk factors affecting the length of hospital stay, and several scoring systems have been developed to predict the length of hospitalization (5, 6). There are a number of disease severity scoring systems in the literature to predict disease prognosis or mortality in these cases (7–9). However, the reliability of these systems is unclear (5–9). A new and specific scoring system is needed to better anticipate the length of hospital stay. A reliable predictor of hospital stay would facilitate treatment management for FG patients and a more effective use of health resources. However, the literature offers only a limited number of studies on this subject (5). The primary purpose of this study was to determine the risk factors that affect the length of hospital stay by examining the demographic characteristics, laboratory values, and vital signs of FG patients. The secondary aim was to investigate the effectiveness of commonly used disease severity scores in predicting the length of hospital stay. In addition, it is intended that the results of this study will contribute to the improvement of current predictive instruments or the development of new, more accurate scoring systems.

MATERIALS and METHODS

Ethics approval for this retrospective study was granted by the Yozgat Bozok University Clinical Research and Ethics Committee (no: 2017-KAEK-189_2021.04.28_09). Informed consent was obtained from all of the study participants before the surgical procedure. The primary treatment was performed in the Yozgat City Hospital General Surgery Service with guidance as needed from urology, infectious disease, plastic surgery, and reconstructive surgery specialists. Electronic data of patients treated for FG between January 2017 and April 2021 were reviewed and analyzed.

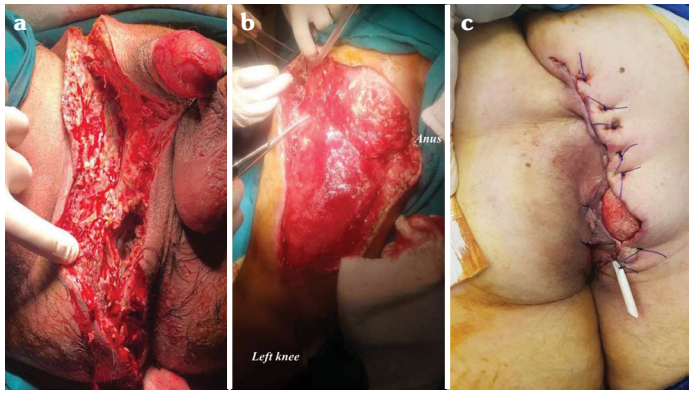

Figure 1. Examples of treatment stage in different patients. (a) A view of Fournier's gangrene before debridement. (b) Preparation before applying vacuum-assisted closure therapy (necrotizing fasciitis extending from the perineum to the back of the left thigh). (c) Closure of defect with cutaneous flap

All patients who were >18 years of age and treated for FG during the study period were included in the research. Data pertaining to patient age, gender, body mass index (BMI), co-morbidities, pre-operative laboratory values, vital signs, diagnostic methods, surgical interventions, length of hospital stay, and mortality status were retrieved and examined. The accepted reference ranges for laboratory data were glucose: 74–106 mg/dL, urea: 17–43 mg/dL, creatinine: 0.51–0.95 mg/dL, hemoglobin: 10.9–14.3 g/dL, hematocrit: 31.2–41.9%, C-reactive protein (CRP): 0–0.8 mg/dL, leukocytes (white blood cell [WBC]): 3.8–11.8x103 µL, albumin: 3.5–5.2 g/dL, sodium (Na): 136–146 mmol/L, potassium (K): 3.5–5.1 mmol/L, bicarbonate (HCO_3): 21–28 mmol/L, calcium (Ca): 8.8–10.6 mg/dL, total bilirubin: 0.3–1 mg/dL, alkaline phosphatase (ALP): 30–120 u/L, international normalized ratio (INR): 0.8–1.2, pulse: 60–100 beats/minute, temperature: 36–38.4°C, and respiratory rate: 12–24/minute.

Fournier's Gangrene Severity Index (FGSI) and Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) scores were used to determine disease severity (7, 8). Patients aged ≥65 were grouped as elderly and patients aged <65 were grouped as non-elderly. Patients with a BMI of 18.5–24.9 kg/m^2 were considered normal weight, those with a BMI of 25–29.9 kg/m^2 were considered overweight, and those with a BMI of >30 kg/m^2 were considered obese. Clinical findings, laboratory data, and radiological imaging methods were used to diagnose the disease. Surgical interventions, such as debridement, partial thickness grafting, closure with a cutaneous flap, vacuum assisted closure (VAC), and diverting ileostomy or colostomy were performed with appropriate antibiotherapy (Fig. 1).

Statistical Analysis

Descriptive and inferential statistical analysis was performed using SPSS Statistics for Windows, Version 22.0 software (IBM Corp., Armonk, NY, USA). Categorical data were presented as numbers (n) and percentages (%), and numerical values were expressed as median (minimum–maximum values) and mean±SD. A chi-squared or the Fisher's exact test was used for categorical data in comparative analyses. Skewness-kurtosis evaluation and the Shapiro-Wilk test were used to assess the normality of numerical data. Normally distributed numerical data were analyzed using Student's t-test, and the Mann-Whitney U test was conducted to analyze data without a normal distribution. The effects of disease severity scoring and hospitalization scoring systems on the length of hospital stay were investigated using simple linear regression. The parameters affecting the length of hospital stay were evaluated with multiple regression analysis. Unimportant variables were removed from the model by applying the backward selection method, and an independent variable was selected. In the multiple linear regression analysis, the significance value accepted for adding a parameter was $p<0.05$ in model building and $p<0.1$ for removal of a parameter. Clinical and literature data were considered in the selection of parameters to be embedded in the model. The results were evaluated with a 95% confidence interval (CI) and the significance value applied was $p<0.05$.

Table 1. Distribution of demographic data, disease severity scores, length of hospital stay, preoperative laboratory data, and preoperative vital signs

	Median (min–max)	Mean±SD
Age (years)	62 (23–85)	60±16.2
Body mass index (kg/m^2)	28.5 (23–37)	27.6±3.6
Fever (C^0)	37.6 (36–39.2)	37.5±0.8
Heart rate (beats/min)	82 (60–105)	85±10.2
Respiratory rate (breaths/min)	24.5 (18–32)	24.3±3.9
FGSI score	2 (0–11)	3.1±2.8
LRINEC score	4 (0–10)	3.9±3.4
CUPI score	5.5 (1–9)	5.3±2.1
Length of hospital stay (days)	10 (5–28)	13.7±5.4
C-reactive protein (mg/dL)	7.8 (0.1–53)	13.8±15.3
White blood cell (x10^3/µL)	11.2 (4.7–23)	12.5±5.2
Blood glucose (mg/dL)	142.5 (90–350)	159±61.5
Hematocrit (%)	40 (28–48)	39.5±5.5
Creatinine (mg/dL)	0.85 (0.4–3.8)	1.1±0.7
Serum sodium (mmol/L)	137 (126–145)	136.9±4.4
Serum potassium (mmol/L)	4.2 (3.5–6.3)	4.3±0.6
Serum bicarbonate (mmol/L)	29 (12–33)	27±5.7
Albumin (g/dL)	3.7 (2.9–5.5)	3.8±0.6
Calcium (mg/dL)	8.4 (7–10.1)	8.5±0.9
Alkaline phosphatase (IU/L)	114 (45–340)	140±80.4
Total bilirubin (mg/dL)	0.9 (0.3–2.6)	1.1±0.8
INR	1.1 (0.6–1.6)	1.2±0.2

Min: Minimum; Max: Maximum; SD: Standard deviation; CUPI: Combined Urology and Plastics Index; FGSI: Fournier's Gangrene Severity Index; INR: International normalized ratio; LRINEC: Laboratory Risk Indicator For Necrotizing Fasciitis; INR: International normalized ratio

RESULTS

A total of 28 patients treated for FG between January 2016 and April 2021 were enrolled in this study. The patients were aged 22–84 years, with a mean age of 60 (Table 1). Five of the patients (17.8%) were women, and 23 (82.1%) were men. The mean BMI was 27.6 kg/m^2 (range: 23–37 kg/m^2); 9 patients (32.1%) were normal weight, 11 (39.3%) were overweight, and 8 (28.6%) were

Table 2. Demographic characteristics of the study patients

Groups	Number of patients (%)	Length of stay (days)	p
Age (years)			0.81#
<65	18 (64.3)	13.8	
≥65	10 (35.7)	13.4	
Gender			0.08#
Female	5 (17.9)	20.2	
Male	23 (82.1)	12.3	
Body mass index			0.1*
Normal	9 (32.1)	12.9	
Overweight	11 (39.2)	11.9	
Obese	8 (28.7)	17	
Diabetes mellitus			**0.001**#
No	15 (53.8)	10.7	
Yes	13 (46.4)	17.1	
Hypertension			**0.001**#
No	9 (32.1)	9	
Yes	19 (67.9)	15.9	
Comorbidity number			**0.005***
0	9 (25)	7.9	
1	10 (27.8)	14.9	
2	13 (36.1)	16.1	
3	4 (11.1)	15.5	

#: Student's t-test; *: Analysis of variance

Table 3. Simple linear regression analysis of disease severity scores and hospitalization time prediction on length of hospitalization

	ß	95% CI		p	R^2
CUPI score	0.39	0.04	1.97	**0.04**	0.28
FGSI score	0.18	-0.41	1.12	0.36	0.12
LRINEC score	0.29	-0.15	1.1	0.13	0.15

ß (Beta): Standardized coefficient; CI: Confidence interval; CUPI: Combined Urology and Plastics Index; FGSI: Fournier's Gangrene Severity Index; INR: International normalized ratio; LRINEC: Laboratory Risk Indicator For Necrotizing Fasciitis

obese. Only 9 of the patients (25%) did not have any comorbidities, while the other 21 (75%) patients had at least 1 comorbid disease. Ten patients (27.8%) had 1 comorbidity, 13 (36.1%) had 2, and 4 (11.1%) had 3 comorbidities (Table 2). Hypertension (HT) was detected in 19 patients (67.9%), diabetes mellitus (DM) in 13 patients (46.4%), coronary artery disease (CAD) in 2 patients (5.5%), and chronic obstructive pulmonary disease (COPD) in 2 patients (5.5%). The average length of hospital stay was 13.7 days (Table 1). Temperature, respiratory rate, pulse values, and median and mean values of laboratory parameters are shown in Table 1. The median FGSI and LRINEC disease severity scores was 2 (min–max: 0–11) and 4 (min–max: 0–10), respectively. The median value of the CUPI score, which was used as the predictive score for the length of hospital stay, was 5.5 (min–max: 1–9) (Table 1). The accuracy of the scoring system scores to anticipate the length of hospital stay was investigated using simple linear regression analysis. The CUPI score was found to be significant (ß=0.35 [95% CI: 0.2, 2.03], p=0,04). The FGSI and LRINEC scores were not significant (ß=0.18 [95% CI: -0.41, 1.12], p=0.36; ß=0.29 [95% CI: -0.15, 1.1], p=0.13, respectively). The R2 value of the CUPI was 0.281. The CUPI score was found to be a weak, but significant test, explaining 28% of hospital stay (Table 3). When the effects of the demographic characteristics of the patients and the increase in comorbidities on the duration of hospitalization were investigated, the duration of hospitalization was found to be significantly longer in the case of DM, HT, and increased comorbidity (p=0.001, p=0.001, and p=0.005, respectively). The length of stay was similar between groups in terms of age (elderly or non-elderly), gender, and BMI (normal weight, overweight, or obese) (p=0.81, p=0.08, and p=0.1, respectively) (Table 2). Temperature, pulse, respiratory rate, and laboratory data were grouped as normal and abnormally distributed according to the reference values. Only respiratory rate and glucose parameters were found to significantly prolong the hospital stay (10.8 vs. 16.6 days, p=0.003 and 10.3 vs. 14.8 days, p=0.04, respectively) (Table 4). Multivariate linear regression analysis was performed using demographic and laboratory values. The results indicated that the presence of HT did not have a significant effect in the created model. In addition to the presence of DM, there was a significant increase in the duration of hospitalization in proportion to increases in glucose level and respiratory rate (ß=0.41 [95% CI: 2.41, 6.26], p<0.001; ß=0.56 [95% CI: 0.03, 0.06], p<0.001; and ß=0.18 [95% CI: 0.01, 0.5], p=0.04, respectively) (Table 5).

Eleven patients (39.3%) were diagnosed with FG according to clinical and laboratory data, and computed tomography (CT) was used in the other 17 patients (60.7%). False negative results were observed in 3 (17.6%) patients who underwent CT. The main radiological findings in the other 14 patients (82.4%) were soft tissue abnormalities, such as abscess, air, inflammation, edema, and necrotizing fasciitis. In 6 (21.4%) patients, the defect was treated with split-thickness grafts or cutaneous flaps once the septic state of the wound had regressed. VAC (Haromed Exsudex, Ghent, Belgium) treatment was applied in 13 (46.4%) cases, with the wound dressing set changed 2 or 3 times a week. In the other 9 patients (32.1%), intermittent debridement and dressings were applied. In cases where a primary skin closure was not possible, wound healing was left to secondary healing. Only 2 (7.1%) patients needed a diverting stoma. One stoma was closed after 3 months and the other was closed after 12 months due to delays caused by the coronavirus 2019 pandemic. No mortality was observed in any patient.

DISCUSSION

In this study, the mean length of hospital stay of the FG patients was 13.7 days, and the maximum was 28 days. The results of the regression analysis revealed that the FGSI and LRINEC scoring systems used in the prediction of disease prognosis and mortality in FG patients were insufficient to accurately determine the length of hospital stay. However, the CUPI scoring system demonstrated a significant ability to predict the length of hospital stay.

Table 4. Distribution of the parameters in the scoring systems used in the current study and the effect on the length of hospital stay

	Reference range	n (%)	LOS (days)	p
Heart rate (beats/min)	+	27 (96.4)	13.9	0.29#
	-	1 (3.6)	8	
Temperature (C^0)	+	24 (85.7)	13.8	0.72#
	-	4 (14.3)	12.7	
Respiratory rate (breaths/min)	+	14 (50)	10.8	**0.003#**
	-	14 (50)	16.6	
Blood glucose (mg/dL)	+	7 (25)	10.3	**0.04#**
	-	21 (75)	14.8	
Hematocrit (%)	+	15 (53.6)	13.5	0.87#
	-	13 (46.4)	13.8	
C-reactive protein (mg/dL)	+	6 (21.4)	12.5	0.56*
	-	22 (78.6)	14	
White blood cell (x10^3/µL)	+	15 (53.6)	14.8	0.44#
	-	13 (46.4)	12.8	
Creatinine (mg/dL)	+	19 (67.9)	13.1	0.43*
	-	9 (32.1)	14.9	
Serum sodium (mmol/L)	+	18 (64.3)	12.3	0.65#
	-	10 (35.7)	16.2	
Serum potassium (mmol/L)	+	26 (92.9)	13.6	0.73#
	-	2 (7.1)	15	
Serum bicarbonate (mmol/L)	+	11 (42.9)	15.7	0.13#
	-	16 (57.1)	12	
Albumin (g/dL)	+	22 (78.6)	12.7	0.74*
	-	6 (21.4)	17.2	
Calcium (mg/dL)	+	15 (53.6)	13	0.49#
	-	13 (46.4)	14.7	
Alkaline phosphatase (IU/L)	+	15 (53.6)	11.9	0.06#
	-	13 (46.4)	15.7	
Total bilirubin (mg/dL)	+	18 (64.3)	13.8	0.89#
	-	10 (35.7)	13.5	
INR	+	22 (78.6)	13.5	0.74#
	-	6 (21.4)	14.3	

#: Student t-test; *: Mann-Whitney U test; (+): Within reference range; (-): Outside of reference range; INR: International normalized ratio; LOS: Length of stay

Table 5. Multiple linear regression analysis evaluation of the parameters

	ß	95% CI		p
Blood glucose (mg/dL)	0.56	0.03	0.06	**<0.001**
Diabetes mellitus	0.41	2.41	6.26	**<0.001**
Hypertension	0.18	-0.27	4.35	0.08
Respiratory rate (breaths/min)	0.18	0.01	0.5	0.04

ß (Beta): Standardized coefficients; CI: Confidence interval

According to the demographic characteristics of the patients, a significant portion (75%) were male (82.1%), which is consistent with previous studies (4, 6, 10–12). In addition to male gender, diabetes, malignancy, immunosuppression, trauma, malnutrition, and alcoholism have been observed to be predisposing factors in FG (4, 13, 14). In this study, 25% of the patients did not have any comorbidities, but the reported average proportion in the literature with comorbidities is 10% (1). HT constituted 51.1% of the existing comorbidities, and DM constituted 46.4%, which is consistent with the literature (3, 14, 15). The FG patients in our study did not have any known risk factors other than gender and DM. Reported FG mortality rates vary between 0% and 42% in the literature (16). While age, female gender, and DM are considered risk factors for mortality, HT and COPD have not been shown to be associated with mortality. (10, 15, 17–19). The data on the relationship between obesity and FG are limited. In a retrospective study comparing normal weight patients with overweight patients (BMI>25 kg/m^2), found that weight did not have a significant effect on mortality (n=91, p=0.6) (19). We observed no mortality during the study period, and BMI demonstrated no effect on hospital stay (p=0.1). Similarly, Furr et al. (3) did not find a significant relationship between obesity and length of hospital stay in their study (p=0.55). The absence of mortality in our study may be explained by the referral of patients with a poor general condition and a high disease severity score to a more advanced medical center. Existing data showing that the mortality rate is lower at in-service hospitals or hospitals with a lower patient volume supports the finding (3).

The FGSI, LRINEC, Uludağ Fournier's gangrene severity index, NUMUNE Fournier score and other disease severity scoring systems have been developed to predict the prognosis and mortality of FG in a differential diagnosis (7–9). Although there is as yet no ideal model, the FGSI and LRINEC are widely used. While parameters such as temperature, pulse, respiratory rate, WBC, hematocrit, Na, K, creatinine, and HCO_3 are used in the FGSI (7), the LRINEC is based on glucose, creatinine, CRP, WBC, hemoglobin, and Na values (8). In this study, the median FGSI and LRINEC score was 2 and 4, respectively. In 1 study, the mean cutoff value of the FGSI score was determined to be 7.5 in mortality cases (10). In another study, the LRINEC score was 9.2 in patients with a mortal course of FG, and 8.4 in patients who survived (20). The disease severity score in our study was generally lower than the data reported by advanced medical centers (9, 10, 12). The data we examined support the reliability of the disease severity score systems used in terms of mortality; however, despite some research suggesting that they could be used to predict the length of hospital stay, our results did not show them to be as effective in this regard (FGSI: ß=0.18 [95% CI: -0.41,1.12], p=0.36; LRINEC: ß=0.29 [95% CI: -0.15, 1.1], p=0.13). The cutoff value and length of stay in these studies were heterogeneous and contradictory (6, 20). Gönüllü et al. (20) used the LRINEC scoring system for patients with necrotizing fasciitis, half of whom had FG. They found that as the LRINEC score increased, the length of hospital stay increased. However, they determined a cutoff value as 6 and did not find a significant difference in the duration of hospitalization between groups (14 days vs. 21 days, p=0.21). Another study found that non-mortal FG patients with an FGSI score of 5.7 and a LRINEC score of 7.4 may have an extended

hospital stay of 52 days (21). Other researchers have observed that the mean hospital stay of FG patients with an FGSI score of 7.5 was 21 days (n=80) (6). As indicated in the published findings, even with a higher disease severity score, the length of hospital stay may only be less than half as long.

In the literature, a reported length of hospital stay ranges from 2 to 276 days (4). The hospitalization period ranged from 5 to 28 days in the current study. We found that age (<65 years vs. >65 years) did not significantly affect the length of hospital stay (13.8 days vs 13.4 days, p=0.81). In a multicenter study, patients over 60 years of age were found to be at risk for prolonged hospitalization, and the length of hospital stay was found to be proportional to an increase in the number of comorbidities. Among the comorbidities examined, only HT and renal failure demonstrated a significant effect on the length of hospital stay (p<0.001 and p=0.01, respectively) (3). Eksi et al. (6) found that age and gender did not affect the length of hospital stay in a study of 80 patients, which is in line with the results of the current study. In the same study, it was also observed that the presence of comorbidities did not have an effect on the length of hospital stay (6). Our study found that the presence of DM and HT and the number of comorbidities prolonged the length of hospital stay (p=0.001, p=0.001, and p=0.005, respectively). However, age, gender, and weight were not found to have an effect on the length of hospitalization (p=0.8, p=0.08, and p=0.1, respectively). All of the parameters used in the disease severity scoring systems and the prediction of hospitalization duration were statistically evaluated in this study, and only the respiratory rate and blood glucose value (p=0.003 and p=0.04, respectively) appeared to alter the length of hospital stay. When the parameters were evaluated using regression analysis, DM, glucose, and respiratory rate were significant in predicting the duration of hospitalization.

Although the CUPI scoring system appears to determine the length of hospital stay more accurately than other systems we analyzed, it nonetheless seems to be a weak model (R^2=0.28, p=0.04). A score of between 0 and 2 is recorded according to the normal or abnormal distribution of parameters such as age, hematocrit, urea, Ca, ALP, HCO_3, albumin, and total bilirubin. The maximum CUPI score is 15. Ghodoussipour et al. (5) determined a CUPI cutoff value of a median of 5 (min–max: 3–11) days. They found that the mean length of a hospital stay for a patient with a score of ≤5 was 23 days, while it was 71 days if the score was >5. They suggested that the CUPI was a more significant predictor of the duration of hospitalization than the FGSI or the LRINEC (ß=11.8 [95% CI: 5.7, 17.9], p=0.001). Although 54 patients were included, the CUPI score could only be calculated in 29 patients due to incomplete data. The R2 value in was found to be 0.38, and although that is higher than the value determined in the current study, it can be considered weak. There may be many factors that can affect the length of hospital stay. Additional examination of these parameters in high-volume and multicenter studies could be valuable to the development of a better hospital stay scoring system. We propose that the results of this study are significant in that they demonstrate the applicability of different scoring systems that affect length of stay in FG patients in a public secondary hospital. Nevertheless, our research is limited due to its single-center, retrospective study design.

CONCLUSION

FG patients typically have a long hospital stay. The results of this study suggest that the current disease severity scores in use are insufficient to accurately predict the length of hospital stay. The CUPI scoring system can be useful in a determination of the length of stay, but needs to be improved based on multicenter and high-volume studies.

Ethics Committee Approval: The Bozok University Clinical Research Ethics Committee granted approval for this study (date: 28.04.2021, number: 2017-KAEK-189_2021.04.28_09).

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

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – SK, EH; Design – SK; Supervision – SK; Data Collection and/or Processing – EH; Analysis and/or Interpretation – SK; Literature Search – SK, EH; Writing – SK; Critical Reviews – SK.

Conflict of Interest: The authors have no conflict of interest to declare.

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