

Supine percutaneous nephrolithotomy in impacted proximal ureteral stones larger than 15 millimeters; Comparison of flexible ureterorenoscopy and retroperitoneal laparoscopic ureterolithotomy

15 milimetreden büyük impakte proksimal üreter taşlarında supin perkütan nefrolitotomi; Fleksible üreterorenoskopi ve retroperitoneal laparoskopik üreterolitotominin karşılaştırılması

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ÖZET

Amaç: Çapı 15 mm'den büyük gömülü proksimal üreter taşlarının tedavisinde sırtüstü mini-perkütan nefrolitotomi (SMPCNL), retroperitoneal laparoskopik üreterolitotomi (RPUL) ve fleksibl üreterorenoskopi (FURS) etkinlik ve güvenliğini karşılaştırmayı amaçladık.

Gereç ve Yöntemler: Ağustos 2015-Eylül 2020 tarihleri arasında kurumumuzda proksimal üreter taşı nedeniyle SMPCNL, RPUL ve FURS uygulanan hastaların verileri gözden geçirildi. Toplanan veriler yaş, cinsiyet, vücut kitle indeksi (VKİ) ve hidronefroz derecesi, taş yoğunluğu, ameliyat süresi, hastanede kalış ve iyileşme süresi, komplikasyon oranları ve ameliyat süresi gibi taşsız ve demografik verileri içeriyordu.

Bulgular: Genel olarak 162 hasta dahil edildi. Bu hastaların 52'si (%32,1) Grup 1 (SMPCNL grubu), 53'ü (%32,7) Grup 2 (RPUL grubu), 57'si (%35,2) Grup 3'te (FURS grubu) idi. Ortalama ameliyat süreleri Grup 1'de 53±8.2 dakika, Grup 2'de 63,2±6,6 dakika ve Grup 3'te 73,7±7,5 dakika idi (p=0,000). Ortalama hastanede kalış süresi Grup 3'te diğer gruplara göre anlamlı olarak daha kısaydı (p=0.000). İlk değerlendirmede taşsızlık oranları RPUL, SMPCNL ve FURS gruplarında %100, %90.3 ve %87.7 idi. Bu oran FURS grubunda diğer gruplara göre anlamlı derecede düşüktü (p=0.02).

Sonuç: SMPCNL ve RPUL prosedürleri, proksimal üreter taşları 15 mm'den büyük hastaların tedavisinde FURS kadar güvenlidir.

Anahtar Kelimeler: supin, perkütan nefrolitotomi, büyük impakte proksimal üreter taşları

Cite As: Kargı T, Ekşi M, Ayten A et al. Supine percutaneous nephrolithotomy in impacted proximal ureteral stones larger than 15 millimeters; Comparison of flexible ureterorenoscopy and retroperitoneal laparoscopic ureterolithotomy. Endourol Bull. 2023;15(1):1-8. doi: 10.54233/endouroloji.1140588


This study was approved by the University of Health Sciences, Dr.Sadi Konuk Training and Research Hospital Ethical Committee (Approval Number: 2021-03-11, Date: 2021-02-01). All research was performed in accordance with relevant guidelines/regulations, and informed consent was obtained from all participants.

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Received: July 4, 2022 **Accepted:** November 29, 2022



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ABSTRACT

Objective: We aimed to compare the efficacy and safety of supine mini-percutaneous nephrolithotomy (SMPCNL), retroperitoneal laparoscopic ureterolithotomy (RPUL), and flexible ureterorenoscopy (FURS) in the treatment of impacted proximal ureteral stones larger than 15 mm in diameter.

Material and Methods: Data of the patients who underwent SMPCNL, RPUL, and FURS in our institution for proximal ureteral stones between August 2015 and September 2020 were reviewed. Collected data included age, gender, body mass index (BMI) and hydronephrosis grade, stone density, duration of surgery, hospital stay and recovery period, stone-free and demographic data such as complication rates and duration of surgery.

Results: Overall, 162 patients were included. Of these patients, 52 (32.1%) were in Group 1 (SMPCNL group), 53 (32.7%) were in Group 2 (RPUL group), and 57 (35.2%) were in Group 3 (FURS group). Mean operative times were 53±8.2 minutes in Group 1, 63.2±6.6 minutes in Group 2, and 73.7±7.5 minutes in Group 3 (p=0.000). The mean hospital stay was significantly shorter in Group 3 compared to the other groups (p=0.000). The stone-free rates at the initial evaluation were 100%, 90.3%, and 87.7% in the RPUL, SMPCNL, and FURS groups. This rate was significantly lower in the FURS group compared to the other groups (p=0.02).

Conclusion: SMPCNL and RPUL procedures are as safe as FURS in treating patients with proximal ureteral stones larger than 15 mm.

Keywords: supine, percutaneous nephrolithotomy, large impacted proximal ureteral stones

INTRODUCTION

The optimal treatment strategy for proximal ureteral stones is a matter of debate. (1, 2, 3, 4). This debate is more prominent in the treatment of impacted proximal ureteral stones greater than 15 mm in diameter. (5). These stones can lead to hydronephrosis, pyonephrosis, pyelonephritis, and functional deterioration of the ipsilateral kidney (5). Therefore, they should be treated immediately for relief of urinary tract obstruction. The European Association of Urology (EAU) guidelines recommend extracorporeal shock wave lithotripsy (ESWL) and ureterorenoscopy (URS) as first-line methods in the treatment of the proximal ureteral stones less than 10mm (6). However, ESWL is not preferred as a first-line treatment in patients with relatively larger proximal ureteral stones, since stone-free rates decrease as stone diameters increase. (1, 7, 8). In addition, rigid or semirigid ureteroscopy performed in patients with proximal ureteral stones is not as successful as those performed in the treatment of distal ureteral stones. (1, 9, 10). The technological developments led to the use of flexible ureterorenoscopy (FURS), which provided relatively higher stone-free rates with lower complication rates (1, 10). However, relatively more invasive surgical methods such as antegrade mini-percutaneous nephrolithotomy (MPCNL) and retroperitoneal laparoscopic ureterolithotomy (RPUL) are still considered as alternatives (2, 3, 4, 11, 12). It was reported that the mean duration of mini-percutaneous nephrolithotomy surgery could be shortened by implementing the supine approach (i.e., SMPCNL), and the complication rates of RPUL could be reduced by increasing experience (3,11, 12). To our knowledge, there is no study evaluating the results of SMPCNL, RPUL and FURS in the literature. Our study aimed to compare these techniques in terms of efficacy and safety in the treatment of impacted proximal ureteral stones larger than 15 mm.

MATERIAL AND METHODS

Patient Selection

This study was approved by the Ethics Evaluation Committee of Istanbul Health Sciences University Bakırköy Dr Sadi Konuk Training and Research Hospital (Approval No: 2021-02-11). All patients gave both verbal and written consent to be included in the study. The target population of this study consisted of patients who underwent surgical treatment for proximal ureteral stones between August 2015 and September 2020 in the Urology Clinic of Istanbul Health Sciences University, Bakırköy Dr Sadi Konuk Training and

Research Hospital. The data of these patients were analyzed retrospectively. Patients with multiple stones, a history of ipsilateral kidney or ureter surgery, bleeding diathesis, systemic comorbidity, and stones ≤ 15 mm were excluded from the study. Patients with incomplete data were also omitted. After consenting, the surgeon gave the final decision regarding the surgical treatment method in collaboration with the patient. All patients underwent a contrast-enhanced imaging method (i.e., computerized tomography or intravenous pyelography) during diagnostic management. Patients were categorized as per the surgical method used: SMPCNL, RPUL, and FURS. All patient data were derived from electronic patient data. The three groups were compared concerning demographic data, including age, gender, body mass index and hydronephrosis grade, duration of surgery, duration of hospital stay and convalescence, stone-free, and complication rates (Table 1). The longest axis of the stone was considered as the stone size. All patients had undergone urine cultures preoperatively, and antibiotherapy was given to those with positive results. All patients had negative urine cultures on the day of surgery. Complications were classified based on the modified Clavien-Dindo classification system (16). Clavien grade I and II complications were considered minor, while Clavien III, IV, and V were considered major complications (Table 2).

Table 1. Preoperative, Demographics, Operative and Postoperative Data

| Parameters (mean \pm SD) | Total (n=162) | Group 1 (n=52) | Group 2 (n=53) | Group 3 (n=57) | p |
|---------------------------------|------------------|--------------------|-----------------|-----------------|---|
| Age (years) | 41,5 \pm 11,5 | 42,4 \pm 12,6 | 40 \pm 10,8 | 42,1 \pm 11,3 | 0,530* |
| Gender (n ; %) | | | | | 0,637" |
| Male | 97 (59,9) | 32 (61,5) | 29 (54,7) | 36 (63,2) | |
| Female | 65 (40,1) | 20 (38,5) | 24 (45,3) | 21 (36,8) | |
| BMI (kg/m ²) | 26,3 \pm 2,1 | 26,6 \pm 1,9 | 25,9 \pm 2,2 | 26,5 \pm 2,1 | 0,158* |
| Stone Size (mm) | 18 \pm 2 | 17,7 \pm 2,2 | 18,6 \pm 2,1 | 17,7 \pm 1,6 | 0,052* |
| Hounsfield Unite (HU) | 1002,8 \pm 188 | 1035,7 \pm 222,3 | 980 \pm 173,5 | 994 \pm 164,8 | 0,288* |
| Surgical time (min) | 63,6 \pm 11,2 | 53 \pm 8,2 | 63,2 \pm 6,6 | 73,7 \pm 7,5 | <0,001* Group 1 vs Group 2-3 |
| Complications (n ; %) | | | | | |
| Minor | 28 (17,2) | 9 (17,3) | 6 (11,3) | 13 (22,8) | 0,282" |
| Major | 5 (3) | 1 (1,1) | 2 (3,7) | 2 (3,5) | 0,821" |
| DJS Placement (n ; %) | 51 (31,4) | 5 (9,61) | 16 (30,1) | 32 (56,1) | <0,001" Group 2 vs Group 1-3 |
| LOS (days) | 2,4 \pm 1,1 | 3,2 \pm 0,6 | 3,1 \pm 0,4 | 1,1 \pm 0,7 | <0,001* Group 3 vs Group 1-2 |
| RDA (days) | 7,3 \pm 1 | 7,2 \pm 0,8 | 7,7 \pm 1,4 | 7 \pm 0,5 | 0,001 ¹ Group 2 vs Group 1-3 |
| Success rate (n ; %) | 150 (92,6) | 47 (90,3) | 53 (100) | 50 (87,7) | 0,02" Group 3 vs Group 1-2 |
| Axillary procedures (ESWL) | 3 (1,8) | 1 (1,9) | 0 (0) | 2 (3,5) | 0,343" |
| Success rate (3. month) (n ; %) | 155 (95,6) | 50 (96,1) | 53 (100) | 52 (91,2) | 0,060" |

BMI: Body Mass Index **Hg:** Hemoglobin **LOS:** Length of stay **RDA:** Return to Daily Activities **RF:** Residual Fragment

* One-way ANOVA " Chi-Square test ! Kruskal Wallis Test

Table 2. Complications according to the Clavien grading system

| (n ; %) | sMPNL (Group 1) | L-RU (Group 2) | F-URS (Group 3) |
|------------------------|--------------------|-------------------|--------------------|
| Grade I | | | |
| Mucosal injury | 2(3,8) | - | 4(7) |
| Ureteral perforation | - | - | 1(1,7) |
| Renal colic | 4(7,6) | 2(3,7) | 5(8,7) |
| Bleeding | 1(1,9) | - | - |
| Ileus | - | 1(1,8) | - |
| Abdominal distention | - | 1(1,8) | - |
| Subcutaneous emphysema | - | 1(1,8) | - |
| Grade II | | | |
| Fever | 2(3,8) | 1(1,8) | 3(5,2) |
| Grade IIIa | | | |
| Urinary leakage | 1(1,9) | 1(1,8) | - |
| Grade IIIb | | | |
| Ureteral stricture | - | 1(1,8) | 1(1,7) |
| Grade IV | | | |
| Sepsis | - | 1(1,8) | 1(1,7) |
| Grade V | | | |
| Minor complications | 9(17,3) | 6(11,3) | 13(22,8) |
| Major complications | 1(1,9) | 2(3,7) | 2(3,5) |
| Total complications | 10(19,2) | 8(15) | 15(26,3) |

Statistical Analysis

Statistical analysis was done with SPSS v20.0. The normal distribution of the data was investigated with the Kolmogorov-Smirnov test and the data were expressed as mean±standard deviation. Chi-square test and Fisher Exact test were used to compare categorical variables, Student's t-test and analysis of variance (ANOVA) were used to compare continuous variables. For data that did not show normal distribution, comparisons between groups were made using the nonparametric Kruskal-Wallis test. The Bonferroni test was applied to determine intergroup differences. $p < 0,05$ was considered to be significant. The G-Power 3.1 program was used for the sample size of the study. According to the power analysis, the total number of patients was determined as 160.

SMPCNL

Modified Galdakao Valdivia position was given, and upper or middle pole access was performed by fluoroscopy or ultrasound guidance either supracostally or subcostally under the posterior axillary line (13). The ureter was catheterized, and calyceal dilatation was achieved by using plastic dilators. A 20F Amplatz sheath was placed, and a 7,6F semirigid ureteroscope (Karl Storz) was advanced through the sheath. The stone was fragmented with a pneumatic lithotripter (ELMED, Vibrolith) and the pieces were extracted with stone forceps. A 14F nephrostomy catheter was placed and advanced toward the renal pelvis before the completion of the procedure. A double J stent was placed according to the surgeon's preference. Nephrostomy catheters were removed 3 days after the operation and stents were removed 21 days after the operation.

RPUL

Patients were given a lateral decubitus position. An incision was made between the 12th rib and spina ischiadica, and a balloon dilator was introduced to develop the retroperitoneal space. Subsequently, 5/10 mm ports were inserted 5 cm superomedially and inferomedially. The ureter was identified on the psoas

muscle. The location of the stone was found by ureteral bulging and confirmed using an atraumatic endo-grasper. The stone was extracted by a stone grasper after opening the adjacent ureter by cold-incision. A double J stent was placed according to the surgeon's preference. The ureteral incision was sutured by 4/0 Vicryl. A drain was inserted into the surgical field. The surgical drain was removed once the daily drainage was below 50 cc/day. The Double J stent was removed at the end of the third postoperative week.

FURS

The patient was given a lithotomy position under general anesthesia. A hydrophilic guidewire was introduced toward the ipsilateral ureter by cystoscopy and semirigid ureteroscopy. A ureteral access sheath (9.5/11.5F or 12/14F) was advanced over the guidewire. Subsequently, the flexible ureteroscope (7.5F Storz Flex-X2) was introduced through the sheath, and the stone was fragmented by dusting technique using 200 μ holmium laser (0,8–1,5 J and 8–12 Hz). All stone fragments were not routinely removed; however, at least one fragment was retrieved by a tiplless nitinol basket for stone analysis. A double J stent was placed according to the surgeon's preference. It was removed after the completion of the third postoperative week.

Postoperative Assessments

All patients underwent imaging within two days after surgery to assess residual stones. Direct urinary system radiography was preferred for opaque stones and non-contrast computed tomography was preferred for non-opaque stones. Patients were considered stone-free if there were no stone fragments or clinically insignificant residual stone fragments (i.e., <4 mm). Those who were not stone-free were re-evaluated three months after surgery by kidney-ureter-bladder graphy or an unenhanced computerized tomography. The same success criteria were used during this assessment.

RESULTS

In total, the data of 468 patients were reviewed. After applying the exclusion criteria, 162 patients were included in this study. Among these patients, 52 (32.1%) were assigned to Group 1 (i.e., SMPCNL group), while 53 (32.7%) were in Group 2 (i.e., RPUL group) and 57 (35.2%) were in Group 3 (i.e., FURS group). Ninety-seven (59.9%) patients were male, while 65 (40.1%) were female. There was no significant difference between the groups regarding age, gender distribution, and body mass index (Table 1). Mean patient age was $42,4 \pm 12,6$ in Group 1, $40 \pm 10,8$ in Group 2, and $42,1 \pm 11,3$ in Group 3. The mean stone size was $17,7 \pm 2,2$ mm in Group 1, $18,6 \pm 2,1$ mm in Group 2, and $17,7 \pm 1,6$ mm in Group 3. Groups were also similar regarding stone densities. However, there was a significant difference between the groups concerning the duration of surgery. Mean surgical times were $53 \pm 8,2$ minutes in Group 1, while they were $63,2 \pm 6,6$ minutes in Group 2 and $73,7 \pm 7,5$ minutes in Group 3 ($p=0,000$). In one case of the RPUL group (i.e., Group 2), the stone migrated to the kidney during surgery. It was grasped by a basket catheter advanced through the flexible ureteroscope introduced into the trocar. There was no significant difference between the groups regarding minor and major complication rates (Table 1). A significant hemoglobin drop (i.e., 2.9 g/L) occurred in one case of the SMPCNL group; however, this patient was treated conservatively without blood transfusion. There was no mortality in the entire cohort. The details regarding complications encountered in all groups are displayed in Table 2. The mean duration of hospital stay was $3,2 \pm 0,6$ days in Group 1, $3,1 \pm 0,4$ days in Group 2, and $1,1 \pm 0,7$ days in Group 3. It was significantly shorter in Group 3 than in the other groups ($p<0,0001$). The convalescence duration was $7,2 \pm 0,8$ days in the SMPCNL group, $7,7 \pm 1,4$ days in the RPUL group, and $7 \pm 0,5$ days in the FURS group. It was significantly longer in the RPUL group than in the others ($p<0,001$). In the initial radiological assessment, stone-free rates were calculated as 100%, 90,3%, and 87,7% in RPUL, SMPCNL, and FURS groups. This rate was significantly lower in the FURS group than in the other groups ($p=0,02$). Five patients in the SMPCNL group and 7 patients in the FURS group were not stone-free in the initial assessment. One of the 5 patients in the SMPCNL group and 2 of the 7 patients in the FURS group underwent extracorporeal shock wave lithotripsy (ESWL) as adjunct treatments. The radiological re-assess-

ments performed 3 months after surgery revealed that 50 (96.1%) patients in Group 1, 53 (100%) patients in Group 2 and 52 (91.2%) patients in Group 3 were stone-free ($p=0,06$).

Complications were classified based on the modified Clavien-Dindo classification system (16). Clavien grade I and II complications were considered minor, while Clavien III, IV, and V were considered major complications. (Table 2)

DISCUSSION

The optimal treatment of large impacted proximal ureteral stones is controversial (1-4). However, it is widely accepted that the ideal treatment method should be non-invasive and effective. Undoubtedly, ESWL is the least invasive method to treat these stones (3). The European Association of Urology (EAU) 2020 guidelines recommended ESWL or ureteroscopy as the first-line treatment method for proximal ureteral stones smaller than 10 mm in diameter (6). However, it was reported that, in patients who underwent ESWL, the stone-free rates decreased with increasing stone sizes. Therefore, the adjunct treatment rates increased in these cases. White et al. reported their 5-year experience with ESWL and noted that the stone-free rates were 69,3% and 59,8% in patients with proximal ureteral stones larger than 1 cm and smaller than 1 cm, respectively (8). Kartal et al. compared the success rates of ESWL, semirigid URS, and FURS in patients with proximal ureteral stones larger than 1 cm (1). These authors reported that ESWL led to stone-free rates of 58,6% and 79% in the 15th day and 3rd-month assessments, and adjunct treatment was needed in 25,9% of these patients. These findings imply that ESWL is not an ideal treatment option in patients with proximal ureteral stones larger than 1 cm.

The retrograde ureteroscopic method is frequently preferred in treating proximal ureteral stones (1,9,10). The use of natural orifices is this method's main advantage. However, its success rate in proximal ureteral stones is not as high as in the treatment of distal ureteral stones (1,9,10). Yencilek and colleagues analyzed the efficacy of semirigid URS in patients with stones in different ureteral locations (9). They concluded that the success rates were 98% and 71% in distal and proximal ureteral stones, respectively. In impacted proximal ureteral stones, stones are usually large, close to the renal pelvis, and associated with hydronephrosis (4). Therefore, there is a relatively high risk of stone fragment migration toward the renal collecting system during ureteroscopic fragmentation. In line with this, residual stone and adjunct treatment rates are also somewhat higher in this patient group. The recent technological developments increased the popularity of FURS which had a relatively low complication and high stone-free rate. Galal et al. compared rigid and flexible URS success rates in patients with proximal ureteral stones (10). They reported that the success rates were 68% and 91% in the initial assessment and 79,5% and 94% after 3-month post-operative follow-up. It was also reported that FURS had a low complication rate and was associated with a short duration of hospital stay (1, 11). Antegrade mini-percutaneous nephrolithotomy (MPCNL) and RPUL are more invasive than FURS, but they are recommended as alternative treatment methods since they have significantly high success rates (2, 3, 4, 11, 12). Topaloglu et al. reported stone-free rates of 100% with antegrade PCNL and RPUL in the treatment of proximal ureteral stones (3). Of note, the surgical times were significantly shortened by the supine approach in mini-percutaneous nephrolithotomy, and the complication rates were reduced with increasing experience in RPUL cases (3,11,12). Therefore, these methods are comparable to each other. The antegrade approach can be performed in both prone and supine positions; however, the surgical time is significantly shorter in the supine approach since there is no need for patient re-positioning (14,15). Several studies reported that antegrade percutaneous nephrolithotomy performed for treating proximal ureteral stones in the prone position was associated with long surgical times (2, 4).

On the other hand, Yi-Zang et al. analyzed the surgical times in treating single large proximal ureteral stones (11). They noted that mean surgical times were 49 and 67 minutes in supine mini-percutaneous nephrolithotomy and FURS procedures, and the former was significantly faster than the latter (11). Finally, Stavros et al. compared the antegrade and retrograde procedures in the treatment of large proximal ureteral stones (2). They denoted that most complications were grade 1, and there was no significant difference between the two groups concerning complication rates ($p=0,745$).

Laparoscopic ureterolithotomy can be performed using transperitoneal and retroperitoneal approaches (12). It was reported that RPUL was associated with relatively less postoperative pain and faster postoperative recovery. Although RPUL has disadvantages such as narrow working space and difficulty in identifying the ureter, preservation of the peritoneum and protection of the peritoneal space from contamination with urine are its advantages (3). Yunyang et al. analyzed the safety and efficacy of URS, MPCNL, and RPUL in treating proximal ureteral stones, and they noted that no major complications were encountered in their cohort (4). These authors concluded that RPUL was an effective and safe treatment method provided that it was performed by urologists with fine laparoscopic skills. Several reports stated that antegrade and laparoscopic approaches were associated with longer hospital stays and convalescence times than the retrograde approaches (11, 12). Our study detected the highest stone-free rate in the RPUL group ($p=0,02$). The stone-free rates were calculated as 96,1%, 100%, and 91,2% in SMPCNL, RPUL, and FURS groups during the 3rd-month assessment. Most of the complications were grade 1. There was no significant difference between the groups regarding minor and major complication rates. The SMPCNL group was associated with the shortest surgical time, while the longest surgical time was detected in the FURS group. The shortest duration of hospital stay was observed in the FURS group. The longest convalescence time was detected in the RPUL group.

This study has some limitations that must be considered while evaluating its findings. First, it is a retrospective, single-center study. Second, the treatment decisions were based on patient preferences. Third, the patient follow-up time was relatively short, and long-term complications could not be assessed. Therefore, our findings should be confirmed by prospective randomized trials with relatively more extended follow-up periods.

Despite these weaknesses, our study is the first to compare SMPCNL, RPUL, and FURS in treating single impacted proximal ureteral stones larger than 15 mm in diameter.

CONCLUSION

Our data showed that FURS was associated with a relatively shorter hospital stay and faster recovery. Since there was no significant difference between the three patient groups regarding minor and major complication rates, we postulate that SMPCNL and RPUL were as safe as FURS in the treatment of the patients with proximal ureteral stones larger than 15 mm in diameter. Reduction in the surgical times of mini-percutaneous nephrolithotomy by supine approach and drop in the complication rates of RPUL by increasing experience made SMPCNL and RPUL as reasonable and more effective alternatives to FURS in the treatment of these patients.

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

Financial Disclosure: The authors declared that this study has received no financial support.

Ethical Approval: The study was approved by the Ethics Committee of University of Health Sciences, Dr.Sadi Konuk Training and Research Hospital (Approval No: 2021/03-11, Date: 2021/02/01). The study protocol conformed to the ethical guidelines of the Helsinki Declaration.

Author Contributions: Conception and design; Ekşi M, Data acquisition; Ayten A, Data analysis and interpretation; Evren İ, Drafting the manuscript; Karadağ S, Critical revision of the manuscript for scientific and factual content; Bitkin A, Şahin S, Taşçı Aİ, Statistical analysis; Ekşi M; Polat H, Supervision; Bitkin A, Şahin S, Kargı T; Karadağ S; Taşçı Aİ.

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