

Research Article

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The middle-term results of proximal fibular osteotomy and percutaneous drilling in the treatment of gonarthrosis

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Abstract

This study aimed to investigate the radiographic and functional results of proximal fibular osteotomy (PFO) and percutaneous drilling techniques performed on patients with medial gonarthrosis. This study included 420 knees of 230 patients who underwent surgery in the orthopaedics and traumatology clinic between January 2019 and January 2022. The demographic data of the patients, including age and body mass index (BMI), were recorded together with the joint range of movement, joint space ratio and femorotibial angles. The patients were evaluated using the VAS for pain, WOMAC, Lysholm Knee Score for functionality, and the Short-Form 12 for quality of life. The patients treated with PFO and subchondral drilling comprised 46% females and 54% males with a mean age of 57.08 years, a mean BMI of 31.5 kg/m², and a mean follow-up period of 24.96±6.05 months. Compared to the preoperative period, there was a statistically significant improvement in postoperative pain, functionality, quality of life, joint range of movement, joint space ratio, and femorotibial angle ($p<0.001$ for all). When the patients were grouped according to BMI, those with a BMI< 31.5 kg/m² demonstrated a greater improvement in VAS scores. Based on the study results, the implementation of PFO as an initial intervention—prior to procedures such as knee prosthesis and high tibial osteotomy (HTO) appeared to yield favorable outcomes for patients with medial gonarthrosis and a moderate degree of varus deformity.

Keywords: genu varus, medial gonarthrosis, proximal fibular osteotomy, subchondral drilling

1. Introduction

Osteoarthritis is a non-inflammatory, chronic, degenerative joint disease characterized by cartilage destruction and erosion that develops as a result of mechanical loading on the joint cartilage, osteophytes at the bone edges, subchondral sclerosis, and biochemical and morphological changes in the synovium and joint capsule¹. Knee osteoarthritis is observed in 30% of the population aged>60 years². Varus deformity, which characteristically shows a narrowed medial joint space on standing anteroposterior radiographs, is observed in 74% of patients with knee osteoarthritis³.

When conservative methods fail to adequately relieve pain and function, surgical treatments are applied⁴. These include arthroscopic debridement, osteotomy, and arthroplasty. The primary surgical methods preferred are total knee prosthesis and unicompartmental knee prosthesis, which aim to reduce pain and increase joint function and movement⁵. For young patients with osteoarthritis in the medial compartment of the knee, high tibial osteotomy (HTO) is the preferred initial surgical method⁶. However, this has the disadvantages of a prolonged postoperative non-weight-bearing period on the affected extremity, as well as potential complications including non-union, peroneal nerve paralysis, and wound site infection⁷.

With the rising number of arthroplasty operations currently performed, there has also been a concomitant increase in

revision surgeries associated with infection or loosening, or for iatrogenic reasons. Therefore, there is a clear need for new techniques such as proximal fibular osteotomy (PFO), which is more physiological, avoids implantation, has a lower complication rate, and is more cost-efficient.

This study aimed to present the middle-term functional and radiological results of proximal fibular osteotomy and percutaneous subchondral drilling in patients with varus deformity and medial gonarthrosis.

2. Materials and Methods

The study initially included 425 knees of 235 patients who presented to our clinic between January 2019 and January 2022 with complaints of knee pain and were diagnosed with knee osteoarthritis according to the knee osteoarthritis classification criteria of the American College of Rheumatology (ACR). Five patients were excluded because they underwent total knee prosthesis following proximal fibular osteotomy. Thus, this study was conducted on 420 knees from 230 patients. Inclusion criteria were: varus deformity, medial gonarthrosis, medial knee pain, absence of comorbidities and anomalies, and age between 40 and 75 years. Approval for the study was granted by the Ethics Committee (Decision No:27, dated:13.09.2024). All the participants provided a signed informed consent form.

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The medial joint space was determined with a vertical line (A) between two horizontal lines drawn from the lowest point of the femoral medial condyle and medial plateau of the tibia on anteroposterior knee radiographs and lower extremity full-length radiographs. Similarly, the lateral joint space was determined with a vertical line (B) between two horizontal lines drawn from the lowest point of the lateral femoral condyle and the lateral plateau of the tibia. The joint space ratio (JSR) was defined as the A/B ratio (medial/lateral) (Fig. 1).

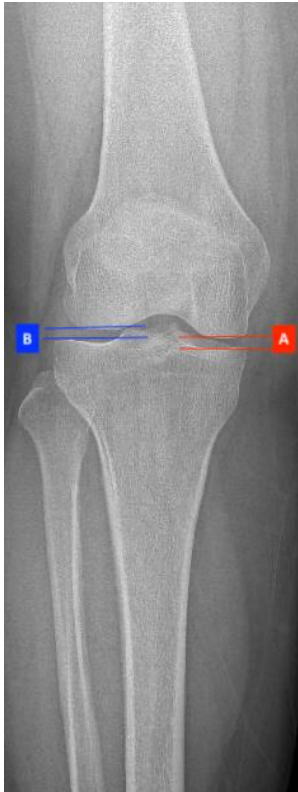


Fig. 1. Determination of the knee joint space ratio as A/B

The length of the osteotomy performed on each patient was recorded in centimeters (cm). Two different surgical teams operated on the patients.

Long-leg radiographs used for radiographic evaluations were obtained using standardized imaging protocols, with radiographs taken at a consistent distance on the same X-ray equipment whenever possible. The femorotibial angles were measured on the standing lower-extremity long radiographs.

Medial and lateral joint spaces were measured on anteroposterior knee radiographs taken in 30° flexion under weight-bearing conditions. All measurements including the femorotibial angle, medial and lateral joint spaces, and fibular proximal segment were performed by a single researcher. Each measurement was repeated three times, and the average value was used for analysis.

Pain was evaluated using the Visual Analog Scale (VAS); functionality was assessed with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Lysholm Knee Scoring Scale; quality of life was measured using the Short Form-12 (SF-12); and radiological assessments

included the femorotibial angle and the Joint Space Ratio (JSR).

All scoring and measurements in the study were performed by a single physician. All patients underwent lower extremity length radiography both preoperatively and postoperatively.

2.1. Surgical Method

Patients were placed in the supine position on the operating table. Under spinal or general anesthesia, a tourniquet was applied to the proximal thigh of the operative extremity, and standard surgical site preparation and draping were performed.

The distance between the fibular head and the lateral malleolus was determined by palpation and measured using a cautery cable. A skin incision of approximately 5–6 cm was then made at a point 6–12 cm distal to the fibular head (Fig. 2).



Fig. 2. The line drawn from the fibula head to the lowest tip of the lateral malleolus to determine the incision line

The bone was accessed by separating the peroneus longus, and the interval was extended longitudinally. After cutting the periosteum with a scalpel, dissection was performed along a 2 cm segment with a dissector, taking care not to create a periosteal defect. Care was taken to remain in the subperiosteal plane due to the close proximity of the peroneal artery, vein, and the deep peroneal nerve. Blunt retractors were placed subperiostally beneath the osteotomy site.

A segment of approximately 2 cm was excised with a motorized cutter, taking care to attach a cutting tip smaller than the fibula diameter (Fig. 3).



Fig. 3. The resected fibula section

The pointed ends of the bones were smoothed using a file. Bone wax was applied to the bone ends to prevent hematoma formation. The tourniquet was then opened, and blood flow was checked. To achieve subchondral decompression, percutaneous drilling was performed using 6-7 K-wires of 1.5 mm. Two wires were directed towards the joint from the medial condyle and the medial of the tibial plateau, while the remaining wires were placed transversely (Fig. 4). Partial mobilization was initiated on postoperative day 1. Patients were scheduled for follow-up visits at 1, 3, 6, and 12 months postoperatively. A degenerative arthritis knee exercise program was prescribed for all patients.

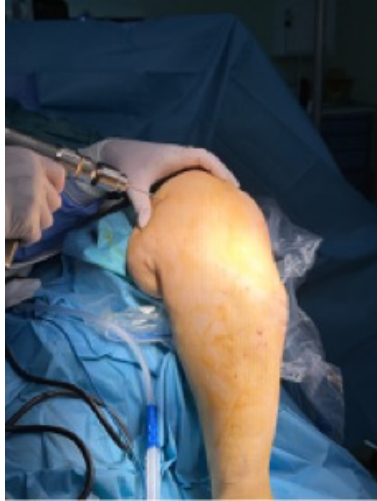


Fig. 4. Percutaneous drilling of the femoral condyle

2.2. Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 20.0. The median difference between groups, stratified by the surgical method performed, was compared using the

Table 1. Preoperative and postoperative evaluation results in patients undergoing PFO and percutaneous subchondral drilling

	Preoperative (n=420)	Postoperative (n=420)	p
VAS	7.90 (7.01-9.02)	2.57 (2.02-3.01)	.001*
WOMAC	57.42(44.30-69.29)	12.62(6.76-17.72)	.001*
Lysholm Knee Score	33 (25-53)	77 (58-93)	.001*
Short-Form 12	43.31(37.82-52.41)	50.91 (45.12)	.003*
Mental Component Physical Component	25.62 (23.24-33.76)	40.82(36.25-51.21)	.001*
Flexion	135(115-135)	135(130-135)	.005*
Extension	0 (0-0)	0 (0-0)	.102
Joint range of movement	135 (113-135)	135 (131-135)	.005*
Joint space ratio	0.29 (0.18-0.48)	0.43 (0.28-0.59)	.001*
Femorotibial Angle	4.71 (2.51-6.92)	3.82 (1.11-5.61)	.001*

VAS: Visual analog score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

*: Significant at the 0.05 level according to Mann-Whitney U analysis

Five patients experienced postoperative loss of dorsiflexion in the great toe and paresthesia in the superficial peroneal nerve dermatome area. Electromyography (EMG) performed at 3 weeks postoperatively revealed complete transection of the deep peroneal nerve in one patient, who was subsequently managed conservatively and followed up for 6 months. Mild nerve damage was observed in the other four patients, who received electrical stimulation along with joint range of movement and strengthening exercises. By the sixth month, dorsiflexion of the great toe had begun to recover in all the

Mann-Whitney U test. The Mann-Whitney U Test was used to compare patients grouped according to specified cutoff values (age, body mass index, proximal fibula length, and osteoarthritis severity). Differences were considered statistically significant at $p < 0.05$.

3. Results

The evaluation included 420 knees of 230 patients, comprising 125 males and 105 females with a mean age of 57.08 years, s mean body mass index (BMI) of 31.5 kg/cm², and s mean follow-up duration of 24.96±6.05 months. According to the Kellgren-Lawrence classification, osteoarthritis grades were distributed as follows: grade 1 in 11.2% of knees, grade 2 in 19.3%, grade 3 in 54.8%, and grade 4 in 14.5%. Significant differences were observed between preoperative and postoperative pain levels, functionality, quality of life, flexion-extension and total joint range of movement angles, joint space ratio, and femorotibial angle values ($p < 0.05$) (Table 1).

The patients were divided into two groups based on the distance of the level of the resected fibula from the fibula head. No significant difference was observed in improvement rates according to the length of the proximal fibula ($p > 0.05$). However, pain levels and quality of life differed significantly according to the BMI of patients who underwent PFO and percutaneous drilling ($p < 0.05$). Additionally, the rate of improvement was statistically significantly different according to age ($p < 0.05$). The patients were also categorized into two groups based on the osteoarthritis severity using the Kellgren-Lawrence classification system, with no significant difference found between the K-L Grade 1-2 group and the K-L Grade 3-4 group ($p > 0.05$) (Table 2). For these analyses, BMI, fibula resection level, and age were based on their median values.

patients, and by the twelfth month, dorsiflexion strength was graded 5/5 with no residual paresthesia.

In four patients, a cut was observed in the perforating branch of the peroneal artery, which was subsequently ligated; no postoperative circulation problems were detected in any patient. Additionally, seven patients reported paresthesia on the lateral aspect of the foot. Symptoms fully resolved by the third month in four patients, while the remaining three showed improvement but persistent symptoms at the twelfth month. One patient developed deep vein thrombosis in the second

postoperative month, which was successfully treated with medical therapy.

Table 2. Evaluation according to the length of the resected fibula, body mass index, age and gonarthrosis stage

	Proximal Fibula Length (<10 cm) (n=250)	Proximal Fibula Length (≥10 cm) (n=170)	p	BMI <31.5 kg/cm ² (n=147)	BMI ≥31.5 kg/cm ² (n=273)	p
VAS	0.73 (0.63-0.78)	0.67(0.5-0.8)	.249	0.75(0.67-0.83)	0.67(0.55-0.75)	.033*
WOMAC	0.8(0.74-0.85)	0.78(0.74-0.86)	.877	0.8(0.77-0.86)	0.77(0.74-0.85)	.464
Lysholm Knee Score	1.12(0.5-1.39)	1.14(0.71-2.28)	.676	0.68(0.26-1.03)	1.22(0.92-1.65)	.017
Short Form-12						
Mental Component	0.09(-0.03-0.39)	0.04(-0.02-0.24)	.653	0.24(0.04-0.48)	0.04(-0.02-0.24)	.356
Physical Component	0.59(0.4-0.79)	0.04(-0.02-0.24)	.314	0.78(0.5-1.03)	0.42(0.37-0.6)	.007*
Joint range of movement	0(0-0.5)	0(0-0.4)	.937	0(0-0.05)	0(0-0.02)	.776
Joint space ratio	0.49(0.23-1.08)	0.29(0.15-0.86)	.077	0.36(0.23-0.93)	0.46(0.16-1.23)	.899
Femorotibial Angle	-0.15(-0.24-0.03)	-0.04(-0.48-0.16)	.221	-0.07(-0.17/-0.02)	-0.15(-0.59-0.12)	.373
	Age <57 years (n=247)	Age ≥57 years (n=173)	p	Kellgren-Lawrence Grade 1 -2 (n=79)	Kellgren-Lawrence Grade 3 -4 (n=341)	p
VAS	0.67(0.63-0.75)	0.75(0.6-0.8)	.186	0.75(0.63-0.78)	0.67(0.62-0.8)	.186
WOMAC	0.8(0.76-0.83)	0.78(0.69-0.86)	.577	0.8(0.74-0.85)	0.79(0.74-0.86)	.577
Lysholm Knee Score	1.22 (1.03-1.72)	0.91 (0.68-0.86)	.193	1.32(0.93-1.97)	1.06(0.68-0.86)	.193
Short Form-12						
Mental Component	0.09(-0.03-0.39)	0.04(0-0.24)	.877	0.24(0.1-0.32)	0.04(-0.03-0.39)	.877
Physical Component	0.57(0.4-1.03)	0.49(0.4-0.69)	.421	0.38(0.35-0.59)	0.57(0.42-0.79)	.421
Joint range of movement	0(0-0.339)	0(0-0)	.016	0(0-0)	0(0-0.16)	.384
Joint space ratio	0.3 (0.08-0.93)	0.47 (0.23-1.57)	.138	0.15(0.01-0.29)	0.49(0.23-1.10)	.138
Femorotibial Angle	-0.07 (-0.21-0.08)	-0.18 (-0.72-0.13)	.293	-0.08 (-0.75-0.13)	-0.12 (-0.24-0.8)	.293

VAS: Visual analog score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

*: Significant at the 0.05 level according to Mann-Whitney U analysis

Radiographic evaluation demonstrated correction of the femorotibial angle and an increase in the joint space ratio. Fig. 5 illustrates an example of medial joint space widening.



Fig. 5. Radiographic image showing widening of the medial joint space

4. Discussion

Existing studies have focused mainly on PF with follow-up periods⁹. Wang et al. determined a significant change in the proximal inclination of the fibula in knees with medial compartment osteoarthritis, and showed that this change was associated with age and the collapse of the medial tibial plateau¹⁰.

PFO was first described by Zhang et al. as a surgical technique that significantly improves joint functions and decreases pain in knee osteoarthritis. In addition to its

functional benefits, radiological evaluations have demonstrated that the technique increases the medial joint space. Compared to other methods, PFO is a less invasive and more cost-effective intervention. It also corrects lower extremity alignment, especially in patients with severe varus knees, while carrying a lower risk of complications. Thus, PFO represents a more reliable and economical alternative to total knee prosthesis and HTO¹¹.

The percutaneous subchondral drilling technique applied in this study was performed using an extra-articular approach in the form of medial condyle decompression, as described by Yang et al.¹². This technique has been utilized in only a limited number of studies. Gopinath et al. reported that, since no fracture occurred in the chondral layer, early weight-bearing on the extremities did not present any issues¹³.

Symptom relief following PFO is attributed to the redistribution of load across the knee joint. Although several theories have been proposed to explain the mechanism of pain reduction such as the no single-tip placement concept, shift phenomenon, multiple cortices theory, muscle competition theory, and dynamic fibular distalization none have been definitively proven¹³.

In 2014, Yazdi et al. first proposed the concept of fibulectomy while examining joint reaction strength in cadaver knees for indications such as fibular or tibial non-union and fibular tumor resection. It was suggested that fibulectomy, when combined with periarticular knee osteotomy, could help

reduce intra-articular pressure in the knee¹⁴.

Baldini et al. conducted a biomechanical cadaver study to investigate the effects of PFO on the knee joint, ankle joint, and tibial plateau. The findings suggested that PFO reduced medial compartment pressure, potentially alleviating pain and improving knee function in medial compartment osteoarthritis⁶. However, as PFO remains a relatively novel

Table 3. The results obtained from various studies in the literature of PFO performed on patients with medial gonarthrosis are presented

Authors	No of patients	Mean age (years)	BMI	Follow-up	Results	Complications
Wang et al.(8)	47	63	-	12 months	VAS values decreased Medial joint space increased	Not reported (-)
Quin et al.(14)	52 (67 knees)	62	27	36 months	Knee functions improved, symptoms decreased	Damage to the superficial peroneal nerve in 8 patients (recovered in 1 month)
Zou et al.(20)	40:PFO 52:HTO	62.3	-	25 months	In the PFO group there was less bleeding and weight-bearing was obtained in a shorter time. *compared to the HTO group, the VAS results were significantly reduced in the PFO group *the complication rate was lower in the PFO group.	PFO group fracture :1 recurrent deformity: 1 HTO group Infection : 1 DVT: 2 Non-union : 2
Liu et al. (15)	84 (111 knees)	59.4	-	12 months	Tibial plateau placement value and HKA angles improved	-
Yang et al. (10)	156	59.2	-	49 months	Medial joint space increased. VAS values significantly decreased.	Deep peroneal damage: 2 Superficial peroneal damage: 2 (recovered within 10 months)

PFO: Proximal fibula osteotomy, HTO:High tibial osteotomy, VAS: Visual analog score, HKA:Hip knee ankle, DVT:Deep vein thrombosis

Several factors, including obesity, age, and the severity of knee osteoarthritis, have been reported to affect the functional results of patients with medial knee osteoarthritis when treated with PFO. Qui et al. reported a negative association between BMI and postoperative recovery outcomes ($p<0.05$, regression coefficient=0.675)¹⁶. High body weight increases the pressure on the medial compartment of the knee, and after osteotomy, the muscles attached to the proximal fibula will have to produce greater traction against knee varus deformity due to weight-bearing. In the current study, patients with a BMI <31.5 kg/m² showed a greater improvement in pain scores. Additionally, those with a BMI <31.5 kg/m² reported a higher quality of life compared to patients with a BMI >31.5 kg/m² ($p<0.005$).

Lui et al. showed that the functional results were affected by the parameter of age in patients who underwent PFO¹⁷. The current study divided patients into two groups based on age: younger and older than 57 years. Patients aged under 57 showed greater improvement in total joint movement ($p<0.005$).

In a 2019 study, Jaheer et al. reported performing the fibula osteotomy at a mean distance of 7 cm below the fibular head but continued to use the term “proximal fibula ostotomy”. They

technique in the literature, the number of studies on its efficacy and outcomes is still limited¹⁵.

Three patients in the current study showed a minimal increase in varus deformity. Table 3 presents the results from various studies in the literature on PFO performed in patients with medial gonarthrosis.

also noted that only a 1 cm bone resection was performed, which did not carry a risk of early union and did not prevent varus deformity correction¹⁸. In the current study, cases of union occurred because the resected fibula segment was smaller than 1 cm.

The current study has the greatest number of cases in the literature to date regarding the determination of indications for the PFO technique and patient selection. The findings suggest that surgical outcomes could be better in patients close to middle age and with a BMI <31.5 , as age-related factors such as quality of life and joint range of movement decline with advancing age. Although HTO should be preferred for younger patients, this study observed better results with PFO in older patients.

The severity of knee osteoarthritis plays a crucial role in determining the indications for PFO. However, a review of the literature indicates that PFO is most commonly performed on patients with Kellgren-Lawrence Grade 3 and 4 osteoarthritis¹⁹. When patients in the current study were divided into two groups based on knee osteoarthritis severity (K-L Grades 1-2 and 3-4), no significant differences were observed in radiographic or functional results. These findings suggest that PFO yields promising results in patients with both

early and late-stage knee osteoarthritis.

Numerous studies in the literature have reported that cartilage repair is often unsuccessful when the natural joint mechanics are not restored, leading to impaired cartilage regeneration and poor recovery outcomes²⁰. In a 2020 review, Kraeutler et al. compared microfracture and drilling techniques for treating cartilage damage. The review reported that the drilling method yielded more favorable outcomes than microfracture in promoting regeneration of knee joint articular cartilage. Specifically, drilling causes less damage to the subchondral bone, thereby allowing greater access to bone marrow stroma and facilitating the formation of a larger volume of repair tissue. Furthermore, multiple studies have demonstrated that deep drilling (6 mm depth) yields better results compared to superficial microfracture (2 mm depth)²¹.

The indications and contraindications for PFO closely resemble those for HTO. One of the few comparative studies was conducted by Zou et al., who evaluated outcomes in 40 patients treated with PFO and 52 patients who underwent HTO for varus knees and osteoarthritis. They found that the PFO group experienced significantly shorter operating times and less intraoperative bleeding. Additionally, the time to full weight-bearing was significantly reduced in the PFO group. Change in pain scores and decreases in the femorotibial angle were less in the PFO group compared to the HTO group. Furthermore, complication rates including neurovascular injury, deep infection, deep vein thrombosis, fracture, delayed union, and recurrent deformity were lower in the PFO group.

PFO has increasingly been reported in the literature as an alternative treatment for medial compartment osteoarthritis, alongside HTO and unicompartmental arthroplasty. Its advantages include being minimally invasive, enabling a faster rehabilitation process, and allowing for an earlier return to work. Moreover, PFO does not require implant use, offering a significant economic advantage²². Although this study does not include a direct comparison with HTO, the results suggest that the outcomes of PFO may be comparable to those reported for HTO in the literature.

Only one study in the literature addressed foot-ankle involvement. In a study involving 53 knees of 49 patients with a 12-month follow-up period, Guo et al. reported that PFO had no impact on foot-ankle alignment or functionality²³. One limitation of the current study is the lack of clinical or radiographic evaluation of foot-ankle effects following correction of lower extremity alignment. Additionally, the absence of a control group represents another limitation.

Compared to unicompartmental knee arthroplasty or total knee arthroplasty, PFO represents a more biological and physiological surgical alternative and is particularly preferred for younger patients due to its favourable functional outcomes. In the current study, patients who underwent PFO combined with percutaneous subchondral drilling demonstrated

promising results, including increased medial knee joint space, reduced pain, and improved knee joint functionality and overall mobility. These findings suggest that PFO techniques aimed at promoting cartilage regeneration can significantly reduce knee pain in varus osteoarthritis, enhance radiographic joint appearance, delay the need for total knee arthroplasty, and facilitate postoperative rehabilitation. Although the underlying mechanisms of pain in most patients were unclear, pain levels decreased rapidly, and by the final follow-up, some patients were completely pain-free. Overall, the results indicate that PFO can serve as an effective preliminary intervention before considering options such as knee prostheses and HTO.

Conflict of interest

The authors declared no conflict of interest.

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Authors' contributions

Concept: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B., Design: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B., Data Collection or Processing: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B., Analysis or Interpretation: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B., Literature Search: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B., Writing: S.E.K., A.B., R.D., T.A., Y.B.B., V.K., M.L.B.

Ethical Statement

Ethics committee approval was received for this study from the Ethics Committee of Suleyman Demirel University, School of Medicine (13.09.2024-27)

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