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Research

Preoperative Radiographic Instability does not Always Require Syndesmotic Screw Fixation in Isolated Lateral Malleolus Fractures

Preoperatif Radyografik İnstabilite, İzole Lateral Malleol Kırıklarında Her Zaman Sindezmoz Vidası ile Tespiti Gerektirmez

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ABSTRACT

Objective: To compare pain, functional outcomes, and complication rates in patients with isolated lateral malleolus fractures who were considered to have syndesmotic instability on preoperative radiographic evaluation but were treated with or without syndesmotic screw fixation according to intraoperative assessment after fibular fixation.

Methods: This retrospective cohort study included 43 adult patients who underwent surgical treatment for isolated lateral malleolus fractures and had preoperative radiographic findings suggestive of syndesmotic instability. After open reduction and internal fixation of the fibula, syndesmotic stability was reassessed intraoperatively under fluoroscopy using the Cotton test, with additional external rotation stress testing when needed. Patients were divided into a stable group who did not require syndesmotic fixation (n=23) and an unstable group who underwent syndesmotic screw fixation (n=20). Pain was assessed using the visual analogue scale (VAS) at 1 year postoperatively, and functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score at 2 years postoperatively.

Results: The median age was 28 years [interquartile range (IQR), 22-45], and the median follow-up was 30 months (IQR, 26-44). Baseline demographic characteristics and follow-up duration were comparable between groups. Median VAS scores were 1 (IQR, 1-2) in the stable group and 1 (IQR, 1-2.75) in the unstable group (p=0.633). Median AOFAS scores were 91 (IQR, 88-93) and 90.5 (IQR, 82.25-93.50), respectively (p=0.750). Complication rates were 4.3% and 15.0%, respectively; the difference was not statistically significant (p=0.395).

Conclusion: Selective syndesmotic fixation based on intraoperative assessment after fibular fixation may be a reasonable strategy for radiographically unstable, isolated lateral malleolus fractures.

Keywords: Isolated lateral malleolus fracture, syndesmotic instability, syndesmotic screw fixation, Cotton test, intraoperative assessment, ankle fracture

ÖZ

Amaç: Bu çalışmada, preoperatif radyografik değerlendirmede sindezmotik instabil olduğu düşünülen izole lateral malleol kırıklı hastalarda, fibula tespiti sonrası yapılan intraoperatif değerlendirmeye göre sindezmoz vidası uygulanan ve uygulanmayan olguların ağrı, fonksiyonel sonuçlar ve komplikasyon oranları açısından karşılaştırılması amaçlandı.

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ÖZ

Gereç ve Yöntem: Bu retrospektif kohort çalışmasına, preoperatif radyografilerinde sindezmotik instabilite düşündüren bulgular saptanan ve izole lateral malleol kırığı nedeniyle cerrahi tedavi uygulanan 43 erişkin hasta dahil edildi. Fibulanın açık redüksiyon ve internal tespitinin ardından sindezmotik stabilite, floroskopi eşliğinde Cotton testi ile yeniden değerlendirildi; gerekli görülen olgularda ek olarak dış rotasyon stres testi uygulandı. Hastalar, intraoperatif değerlendirme sonucuna göre sindezmoz tespiti gerekmeyen stabil grup (n=23) ve sindezmoz vidası uygulanan instabil grup (n=20) olarak iki gruba ayrıldı. Ağrı düzeyi postoperatif 1. yılda görsel analog skala (VAS) ile, fonksiyonel sonuçlar ise postoperatif 2. yılda Amerikan Ortopedik Ayak ve Ayak Bileği Derneği Ayak Bileği (AOFAS) Arka Ayak Skoru ile değerlendirildi.

Bulgular: Ortanca yaş 28 [çeyrekler arası aralık (ÇAA), 22-45] yıl, ortanca takip süresi ise 30 (ÇAA, 26-44) ay idi. Gruplar arasında başlangıç demografik özellikleri ve takip süreleri açısından anlamlı fark saptanmadı. Ortanca VAS skoru stabil grupta 1 (ÇAA, 1-2), instabil grupta 1 (ÇAA, 1-2,75) idi (p=0,633). Ortanca AOFAS skoru sırasıyla 91 (ÇAA, 88-93) ve 90,5 (ÇAA, 82,25-93,50) olarak bulundu (p=0,750). Komplikasyon oranları sırasıyla %4,3 ve %15,0 olup, gruplar arasında istatistiksel olarak anlamlı fark yoktu (p=0,395).

Sonuç: Fibula tespiti sonrası yapılan intraoperatif değerlendirmeye dayalı seçici sindezmoz tespiti, radyografik olarak instabil görünen izole lateral malleol kırıklarında uygun bir tedavi stratejisi olabilir.

Anahtar Kelimeler: İzole lateral malleol kırığı, sindezmotik instabilite, sindezmoz vidası, Cotton testi, intraoperatif değerlendirme, ayak bileği kırığı

INTRODUCTION

Ankle fractures are among the most common injuries in orthopedic trauma practice, accounting for approximately 9-10% of all lower extremity fractures (1). Restoration of anatomical congruity and joint stability is essential for successful treatment, and the integrity of the distal tibiofibular syndesmosis plays a central role in ankle stability, load transmission, and long-term functional outcome. The distal tibiofibular syndesmosis is a complex ligamentous structure that stabilizes the distal tibia and fibula and comprises the anterior and posterior inferior tibiofibular ligaments, the interosseous ligament, and the interosseous membrane. These structures contribute differently but synergistically to syndesmotic stability. Previous studies have shown that the interosseous ligament contributes 22% to overall stability, the anterior inferior tibiofibular ligament contributes 35%, the superficial posterior inferior tibiofibular ligament contributes 9%, and the deep posterior inferior tibiofibular ligament contributes 33%. The anterior inferior tibiofibular ligament is the primary restraint to fibular external rotation, whereas the posterior inferior tibiofibular ligament primarily resists posterior translation (2,3).

Failure to recognize syndesmotic injury may result in chronic instability, persistent pain, functional impairment, and early degenerative change. Clinical and intraoperative stress tests, including the Cotton test, fibular translation test, squeeze test, and external rotation stress test, are commonly used to evaluate syndesmotic integrity by detecting abnormal motion or pain provocation relative to the contralateral side (4-6). Preoperative radiographic parameters, such as medial clear space (MCS) widening and decreased tibiofibular overlap (TFO), are widely used to identify syndesmotic instability. However, because these measurements are based on static imaging, they may not always reflect true mechanical stability. Previous studies have shown that some fractures meeting radiographic criteria for instability may appear stable during intraoperative assessment (7). This discrepancy continues to complicate indications for syndesmotic fixation. Unnecessary fixation may increase implant-related complications, reoperation rates, and cost, whereas failure to stabilize true instability may adversely affect long-term outcomes (8,9).

Although preoperative radiographic findings may suggest syndesmotic instability in isolated lateral malleolus fractures, it remains unclear whether all such patients require syndesmotic screw fixation after definitive fibular reduction and fixation. Because restoration of fibular length, alignment, and rotation may re-establish syndesmotic stability in a subset of cases, intraoperative dynamic assessment may provide additional guidance for surgical decision-making. Nevertheless, the adequacy of commonly used intraoperative stress tests, such as the Cotton test and external rotation stress test, remains controversial. The purpose of this study was to compare clinical outcomes in patients with isolated lateral malleolus fractures who were deemed radiographically unstable preoperatively and were treated, with or without syndesmotic screw fixation, based on intraoperative findings following fibular fixation. We hypothesized that omission of syndesmotic screw fixation in patients without residual instability on intraoperative assessment would not result in worse pain or functional outcomes compared with patients who underwent syndesmotic fixation.

METHODS

This retrospective cohort study evaluated patients who underwent surgical treatment for isolated lateral malleolus fractures at a single tertiary referral center. The study protocol was approved by the Acıbadem Mehmet Ali Aydınlar

University Medical Research Evaluation Board (approval no: 2026-03/27, date: 05.02.2026), and all procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki.

Patients who underwent operative treatment for an isolated lateral malleolus fracture were screened for eligibility. Patients aged 18 years or older were considered for inclusion. Only patients with preoperative radiographic findings suggestive of syndesmotic instability who underwent intraoperative syndesmotic assessment after fibular fixation were included in the study. Exclusion criteria were: open fractures; associated bimalleolar or trimalleolar fractures; pilon fractures; previous surgery on the ipsilateral ankle; syndesmotic fixation performed by methods other than screw fixation; and insufficient clinical follow-up. After applying the inclusion and exclusion criteria, 43 patients were included in the final analysis. Standard preoperative ankle radiographs, including anteroposterior, lateral, and mortise views, were reviewed for all patients. Syndesmotic instability was assessed using established radiographic parameters, specifically the MCS and the TFO. Radiographic measurements were performed independently by two experienced orthopaedic surgeons. In cases of disagreement, the final decision was reached by consensus. Only patients who were considered radiographically unstable based on these preoperative measurements constituted the study population. All patients underwent open reduction and internal fixation of the fibular fracture through a standard lateral approach. After restoration of fibular length, alignment, and rotation, fracture fixation was performed using plate-and-screw osteosynthesis according to standard operative principles. Because all included patients had preoperative radiographic findings suggestive of syndesmotic instability, syndesmotic stability was reassessed intraoperatively after definitive fibular fixation. Under fluoroscopic guidance, dynamic syndesmotic evaluation was performed using the Cotton test, and an additional external rotation stress assessment was performed at the operating surgeon's discretion when further confirmation was required. The purpose of this intraoperative reassessment was to determine whether instability persisted after anatomic reduction and stabilization of the fibula, as fixation alone may restore apparent syndesmotic stability in a subset of patients. Because restoration of fibular length and rotation may re-establish apparent syndesmotic stability in some fractures, intraoperative dynamic assessment was used to determine whether syndesmotic fixation remained necessary after definitive fibular fixation. If no pathologic widening or residual instability of the distal tibiofibular joint was observed during intraoperative testing, no additional syndesmotic fixation was performed. If persistent instability was demonstrated, syndesmotic fixation was performed using a trans-syndesmotic screw under fluoroscopic control. In patients treated with syndesmotic screw fixation, implant removal was routinely planned between postoperative weeks 8 and 12 according to institutional practice.

Patients were categorized based on the results of the intraoperative Cotton test performed after fibular fixation. Patients with no residual syndesmotic instability, and therefore no need for syndesmotic fixation, were assigned to the stable group (Cotton test-negative, n=23). Patients with persistent intraoperative instability requiring syndesmotic screw fixation were assigned to the unstable group (Cotton test-positive, n=20). This grouping strategy allowed the comparison of outcomes between patients who were considered unstable on preoperative radiographic assessment but who were managed differently based on intraoperative syndesmotic evaluation after fracture fixation.

Patients were followed weekly until the third postoperative week, then every 3 months during the first postoperative year, and annually thereafter. During follow-up, wound problems, infection, and other surgery-related adverse events were recorded. In the syndesmotic fixation group, implant-related complications, including loosening, pull-out, breakage, or migration of the syndesmotic screw, were also documented. Pain and functional outcomes were assessed using validated clinical measures. Pain severity was evaluated using the visual analogue scale (VAS) at 1 year postoperatively. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score at 2 years postoperatively. The primary outcomes of the study were to compare postoperative pain and functional outcomes between patients with preoperatively suspected syndesmotic instability who did or did not require syndesmotic screw fixation, based on intraoperative assessment after fibular fixation. Secondary outcomes included a comparison of complication rates between the two groups.

Statistical Analysis

Normality of continuous variables was assessed using both the Kolmogorov-Smirnov and Shapiro-Wilk tests. Because age, follow-up duration, postoperative first-year VAS scores, and postoperative second-year AOFAS scores were not normally distributed, continuous variables were presented as medians and interquartile ranges (IQRs). Categorical variables were expressed as numbers and percentages. Comparisons between the stable and unstable groups were performed using the Mann-Whitney U test for continuous

variables and the chi-square or Fisher's exact test, as appropriate, for categorical variables. All statistical tests were two-sided, and a p-value of <0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics, version 30.0 (IBM Corp., Armonk, NY, USA). Given the retrospective design of the study, no a priori sample size calculation was performed. A post-hoc sensitivity (power) analysis based on the final sample size of 43 patients (23 in the stable group and 20 in the unstable group), assuming a two-sided alpha of 0.05 and a power of 80%, indicated that the study was powered to detect a large between-group effect size.

RESULTS

A total of 43 patients met the inclusion criteria and were included in the final analysis. Based on the intraoperative Cotton test performed after fibular fixation, 23 patients were assigned to the stable group (Cotton test-negative) and 20 patients to the unstable group (Cotton test-positive). The overall median age was 28 years (IQR, 22-45). The cohort consisted predominantly of male patients (33/43, 76.7%), and the right ankle was more frequently involved than the left (29/43, 67.4% vs. 14/43, 32.6%). Normality testing demonstrated that age, follow-up duration, postoperative first-year VAS and second-year AOFAS scores were not normally distributed, as shown by both Kolmogorov-Smirnov and Shapiro-Wilk analyses (all p<0.05) (Table 1). Accordingly, continuous variables were expressed as the median and IQR, and non-parametric methods were used for comparisons between groups.

There were no significant between-group differences in baseline demographic characteristics (Table 2). The median age was 31 years (IQR, 24-45) in the stable group and 26 years (IQR, 20.25-42.75) in the unstable group (p=0.150). Sex distribution was also comparable between groups (male: 69.6% vs. 85.0%; p=0.294), as was injury side (right-sided injuries: 73.9% vs. 60.0%; p=0.331). The median follow-up duration for the entire cohort was 30 months. Follow-up duration was similar between the two groups, with a

Table 1. Normality assessment of continuous study variables

	Kolmogorov-Smirnov*	df	Sig.	Shapiro-Wilk	df	Sig.
Age	0.180	43	0.001	0.874	43	<0.001
Follow-up	0.207	43	<0.001	0.874	43	<0.001
VAS 1st year	0.348	43	<0.001	0.793	43	<0.001
AOFAS 2nd year	0.178	43	0.001	0.900	43	0.001

Values are presented as test statistics for normality
*Lilliefors significance correction was applied for the Kolmogorov-Smirnov test
VAS: Visual analogue scale, AOFAS: American Orthopaedic Foot and Ankle Society, Sig.: Significance, df: Degrees of freedom

Table 2. Comparison of baseline characteristics, clinical outcomes, and complications between groups

	Stable group (Cotton-) (n=23)	Unstable group (Cotton+) (n=20)	p*
Age (year)	31 (24-45)	26 (20.25-42.75)	0.150
Gender, n (%)			
Male	16 (69.6)	17 (85)	0.294
Female	7 (30.4)	3 (15)	
Side, n (%)			
Right	17 (73.9)	12 (60)	0.331
Left	6 (26.1)	8 (40)	
Follow-up (months)	34 (26-44)	29.50 (26-42.5)	0.434
VAS (1 year)	1 (1-2)	1 (1-2.75)	0.633
AOFAS (2 years)	91 (88-93)	90.50 (82.25-93.50)	0.750
Complication, n (%)			
None	22 (95.7)	17 (85)	0.395
Revision	0 (0)	1 (5)	
Infection	1 (4.3)	2 (10)	

Continuous variables are presented as median (interquartile range), and categorical variables as number (%)
* p-values were calculated using the Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test, as appropriate, for categorical variables
VAS: Visual analogue scale, AOFAS: American Orthopaedic Foot and Ankle Society

median of 34 months (IQR, 26-44) in the stable group and 29.5 months (IQR, 26-42.5) in the unstable group (p=0.434). Clinical outcomes did not differ significantly between groups. At 1 year postoperatively, the median VAS pain score was 1 (IQR, 1-2) in the stable group and 1 (IQR, 1-2.75) in the unstable group (p=0.633). At 2 years postoperatively, the median AOFAS Ankle-Hindfoot Score was 91 (IQR, 88-93) in the stable group and 90.5 (IQR, 82.25-93.50) in the unstable group (p=0.750) (Table 2).

Complications were infrequent overall. No complications occurred in 39 patients (90.7%); 4 patients (9.3%) experienced at least one complication. One patient (2.3%) required revision surgery because of screw pull-out, and 3 patients (7.0%) developed infections. The overall complication rate was 4.3% (1/23) in the stable group and 15.0% (3/20) in the unstable group; however, this difference did not reach statistical significance (p=0.395) (Table 2). Overall, patients with preoperative radiographic findings suggestive of syndesmotic instability had comparable pain, functional outcomes, and complication rates, regardless of whether syndesmotic screw fixation was required on intraoperative assessment.

DISCUSSION

In this study, patients with isolated lateral malleolus fractures and preoperative radiographic parameters suggestive of syndesmotic instability had similar mid-term pain, functional outcomes, and complication profiles irrespective of whether syndesmotic screw fixation was added after an intraoperative assessment performed following fibular fixation. These results are clinically relevant because they challenge the assumption that radiographic instability detected preoperatively uniformly necessitates syndesmotic fixation. Instead, they support the notion that anatomic restoration of the fibula may, in some cases, sufficiently restore distal tibiofibular stability, making intraoperative dynamic evaluation a potentially useful determinant of the need for additional fixation. Given the persistent debate regarding the sensitivity and specificity of intraoperative stress tests, our findings do not imply that syndesmotic fixation can be safely omitted in all radiographically unstable fractures; rather, they suggest that selective fixation guided by post-fixation intraoperative assessment may achieve satisfactory outcomes without apparent short- to mid-term clinical disadvantage.

Preoperative radiographic parameters are widely used to assess syndesmotic instability in ankle fractures, with increased MCS and decreased TFO generally regarded as key indicators. However, because these measurements are derived from static imaging, they may not accurately reflect the functional severity of mechanical instability (10,11). This limitation has been consistently highlighted in the literature. Gardner et al. (12) reported that standard radiographic measurements lack sufficient sensitivity for evaluating reduction of the distal tibiofibular syndesmosis and suggested that advanced imaging modalities may provide greater diagnostic accuracy. Likewise, Nielson et al. (13) demonstrated that tibiofibular clear space and TFO on conventional radiographs were not significantly associated with magnetic resonance imaging-confirmed syndesmotic injury, further underscoring the diagnostic shortcomings of static radiographic assessment. Radiographic findings suggestive of instability also do not invariably correspond to intraoperative dynamic evaluation. Jenkinson et al. (14) demonstrated that discrepancies may exist between preoperative radiographic indicators and intraoperative stress testing in ankle fractures caused by external rotation mechanisms, emphasizing the importance of intraoperative assessment in guiding fixation decisions. Consistent with these observations, a subset of patients in the present study fulfilled preoperative radiographic criteria for syndesmotic instability but had negative intraoperative Cotton test findings; accordingly, syndesmotic screw fixation was not performed in these cases.

The anatomical and biomechanical characteristics of the distal tibiofibular syndesmosis further underscore the limitations of static radiographic evaluation. Rather than functioning as a rigid articulation, the syndesmotic complex is a dynamic structure that allows a small but physiologically important degree of motion necessary for normal ankle mechanics. Beumer et al. (9) demonstrated that measurable micromotion exists even in an intact syndesmosis, challenging the traditional view of the distal tibiofibular joint as a fixed construct. In agreement with this concept, Hu et al. (15), using three-dimensional kinematic analysis, showed that the fibula undergoes position- and load-dependent translation and rotation relative to the tibia under physiological conditions. These findings indicate that subtle syndesmotic motion may represent normal functional behavior rather than pathological instability. Taken together, these biomechanical insights suggest that static radiographic measurements may inadequately capture the dynamic stability of the syndesmosis. This may partly explain the discrepancy between preoperative radiographic indicators and intraoperative stress testing observed in both the literature and the present study. Reliance on static parameters alone may therefore overestimate instability and lead to unnecessary fixation.

In the present study, the absence of significant differences in pain scores and functional outcomes between the stable and unstable groups suggests that selective syndesmotic fixation, guided by intraoperative stability testing, may be a safe and reasonable strategy. Such an approach may offer important clinical advantages by reducing complications related to unnecessary implant placement. Syndesmotic screw fixation has been associated with a range of adverse events, including screw loosening, breakage, and mechanical irritation at the fixation site (16-21). Huang et al. (18) evaluated radiographic changes after syndesmotic screw removal and found that syndesmotic diastasis occurred predominantly before, rather than as a result of, screw removal; moreover, removal did not significantly alter TFO or clear space measurements. These findings question routine reliance on implant-based stabilization and further emphasize the dynamic nature of the syndesmotic complex. Collectively, the available evidence, together with the findings of the present study, supports a selective fixation strategy based on intraoperative functional assessment. Avoiding routine syndesmotic screw placement in patients without confirmed residual instability may help minimize implant-related morbidity without compromising clinical outcomes. Schepers et al. (22) reported that routine removal of syndesmotic screws was associated with clinically relevant complications, including wound infection, recurrent syndesmotic diastasis, and implant failure. They further noted that early screw removal increased the risk of recurrent diastasis, whereas prolonged retention increased the likelihood of screw breakage. These findings support a selective approach to both fixation and screw removal, with careful consideration of timing and indications. Similarly, Wójtowicz et al. (23) found no significant functional differences between patients with retained and removed syndesmotic screws in their study, but emphasized that removal should be reserved for clearly indicated cases because of procedure-related morbidity and the absence of consistent clinical benefit. This further reinforces the importance of avoiding routine hardware removal unless specific symptoms or indications are present. In addition, a recent systematic review evaluating fixation techniques for Weber B ankle fractures found that syndesmotic screws did not result in superior functional outcomes compared with cases managed without screw fixation, while remaining prone to complications such as loosening and breakage (24). This finding aligns with the present results, which show no statistically significant difference in complication rates between the stable and unstable groups, and further supports the view that the inherent disadvantages of screw fixation may outweigh its benefits in the absence of confirmed instability. Although the complication rate was numerically higher in the unstable group, the difference was not statistically significant, which further supports the potential value of avoiding unnecessary fixation.

To the best of our knowledge, studies specifically focusing on isolated lateral malleolus fractures that meet preoperative radiographic criteria for syndesmotic instability yet demonstrate intraoperative stability remain scarce. Most previous investigations have concentrated on radiographic assessment, fixation techniques, or screw removal outcomes, rather than directly correlating intraoperative stability testing with subsequent pain and functional outcomes in this distinct subgroup. The present study addresses this clinically relevant gap by evaluating outcomes according to intraoperative Cotton test findings and selective syndesmotic fixation. In doing so, it provides additional insight into the role of dynamic intraoperative assessment in surgical decision-making and contributes to the ongoing debate regarding potential overtreatment when fixation decisions rely solely on static radiographic parameters.

Study Limitations

Several limitations of this study should be considered. The retrospective design may introduce selection bias and preclude causal interpretation. The relatively small sample size may have limited the ability to detect subtle but clinically relevant between-group differences. Intraoperative syndesmotic instability was assessed using dynamic stress tests, mainly the Cotton test, with additional external rotation stress testing when required; however, the diagnostic performance of these methods may remain a matter of debate. Moreover, postoperative advanced imaging was not routinely performed; therefore, syndesmotic reduction was not evaluated with computed tomography. The single-center nature of the study may also restrict the generalizability of the findings. Nevertheless, this study has notable strengths. It examined a well-defined, clinically relevant subgroup of isolated lateral malleolus fractures with preoperative radiographic suspicion of syndesmotic instability and addressed a practical surgical question regarding the need for additional syndesmotic fixation after fibular stabilization. The direct comparison of selectively fixed and nonfixed patients provides clinically meaningful evidence that supports an intraoperatively guided treatment strategy in appropriately selected cases.

CONCLUSION

Among patients with isolated lateral malleolus fractures who were considered to have syndesmotic instability on

preoperative radiographic evaluation, a selective treatment strategy based on intraoperative assessment after fibular fixation resulted in similar levels of pain, functional outcomes, and complication rates irrespective of whether syndesmotic screw fixation was performed. Our findings indicate that routine syndesmotic fixation may not be necessary in all radiographically unstable cases, and they support the potential value of intraoperative dynamic evaluation in surgical decision-making. However, these results should be interpreted with caution, and prospective studies with larger cohorts are warranted to validate this approach.

ETHICS

Ethics Committee Approval: The study protocol was approved by the Acıbadem Mehmet Ali Aydınlar University Medical Research Evaluation Board (approval no: 2026-03/27, date: 05.02.2026).

Informed Consent: Retrospective study.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: Y.İ., M.Y.A., D.A., T.K., Concept: Y.İ., M.Y.A., D.A., T.K., Design: Y.İ., M.Y.A., D.A., T.K., Data Collection or Processing: Y.İ., M.Y.A., D.A., T.K., Analysis or Interpretation: Y.İ., M.Y.A., D.A., T.K., Literature Search: Y.İ., M.Y.A., D.A., T.K., Writing: Y.İ., M.Y.A., D.A., T.K.

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