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INTRODUCTION

Appendiceal tumors are extremely rare, accounting for less Penile fracture (PF) is a rare but serious urological emergency characterized by rupture of the tunica albuginea due to sudden blunt trauma to the erect penis, which can lead to severe sexual and psychosocial consequences. The estimated incidence is approximately 1 in 175,000 cases per year, most commonly occurring in sexually active men aged 30–40 years (1,2). Etiology varies geographically and culturally (1,3). While intracorporeal pressure is approximately 100 mmHg during a normal erection, it can rise to 1000–1500 mmHg with forced flexion, which increases susceptibility to rupture (1,4). Clinically, sudden severe pain, immediate detumescence, and deviation are often reported along with a “cracking” sound; physical examination

Long-term erectile function outcomes following penile fracture repair: The critical impact of surgical timing on three-year outcomes

Abstract

Aim: Penile fracture is a urological emergency requiring urgent surgical intervention. While early repair within the first 24-48 hours is considered the gold standard, the impact of surgical timing is not established and long-term outcomes regarding erectile function are poorly understood due to relatively short follow-up and inconsistent use of validated assessment tools. We aimed to evaluate long-term erectile function outcomes after penile fracture surgery and to determine clinical factors associated with erectile dysfunction.

Materials and Methods: This retrospective cohort study included 38 patients who underwent surgery for penile fracture between January 2014 and December 2023. Erectile function was assessed using the International Index of Erectile Function-5 (IIEF-5) questionnaire before surgery, at 6 months, and 1, 2, and 3 years after surgery.

Results: The mean follow-up period was 66.17±40.22 months. The preoperative IIEF-5 score was 22.50±1.99, which decreased to 17.63±3.40 at 6 months and remained at 19.58±2.64 at 3 years, showing a persistent decrease (p=0.001). The fracture-to-surgery time interval was negatively correlated with the change in IIEF-5 score. Postoperative angulation was observed in 21.1% of patients and was significantly associated with mid-shaft fractures (p=0.023). Nodule formation was observed in 21.1% of cases and showed a strong relationship with delayed surgery (median 42 hours vs. 8 hours, p=0.001).

Conclusion: Delay in surgery is the most important modifiable risk factor and longer delays have progressively adverse effects. These findings indicate that urgent surgical intervention is critical in penile fracture.

Keywords: Penis/surgery, tunica albuginea/injuries, sexual dysfunction, physiological, penile erection, time factors, retrospective studies

typically reveals marked ecchymosis and “eggplant deformity.” (5,6). Associated urethral injury occurs in 5–20% of cases and is significant in terms of prognosis when it manifests as hematuria or bleeding from the meatus (7).

The current approach considers surgical repair within the first 24–48 hours as the gold standard and has demonstrated significantly lower rates of erectile dysfunction (ED) compared to conservative treatment (6.6–16.5% vs. 45.5–52.9%) (1,8). However, the quantitative effect of surgical timing on long-term function has not been fully defined. Some studies report that delays longer than 8 hours increase the risk of ED by approximately 3-fold, while delays beyond 24 hours can increase the risk by 4.8–21-fold (9,10). It has been suggested that delay may contribute to chronic ED through cavernous fibrosis, collagen deposition,

and veno-occlusive mechanisms (7). However, the magnitude of this relationship, the possible threshold durations, and its independence from anatomical factors such as lesion localization remain unclear.

Another important limitation in the literature is the lack of long-term follow-up data and the heterogeneity of assessment tools. Most studies report follow-up periods of 6–24 months, with very few studies reporting objective erectile function data beyond the mid-term (6,11). Furthermore, many series rely on subjective patient reports rather than validated scales such as the International Index of Erectile Function-5 (IIEF-5), contributing to a wide range of reported ED rates between 0% and 52.9% (5,8). The impact of lesion characteristics such as fracture location and tear size on erectile outcomes and postoperative angulation/nodule development is limited, with current evidence suggesting that tear length (≥ 2 cm) and complex tear patterns are associated with worse functional outcomes (10,12).

This study aims to address these knowledge gaps by (i) evaluating changes in IIEF-5 scores during at least 3 years of follow-up after penile fracture surgery, (ii) determining the effect of the time interval between injury (fracture) and surgical repair on long-term erectile function, and (iii) investigating possible associations regarding fracture location, postoperative angulation, and nodule development.

MATERIALS AND METHODS

This retrospective cohort study was conducted by analyzing data from patients who underwent surgical treatment for penile fracture at the Turgut Ozal University Malatya Training and Research Hospital Urology Clinic between January 2014 and December 2023. All conduct concerning the study were in line with the principles of the Helsinki Declaration. The study protocol was approved by the Malatya Turgut Özal University Health Sciences Clinical Research Ethics Committee (Decision No: E-30785963-020-341614, Date: 22.10.2025). Due to the retrospective observational design of the study and the use of routine clinical follow-up data, individual patient consent was not obtained.

Study Group

The study included male patients aged 18 years and older with a clinically- or radiologically-confirmed diagnosis of penile fracture who were found to have a tunica albuginea tear, had undergone surgical treatment, and attended follow-up for at least 6 months. At our institution, surgical repair is the standard treatment approach for all confirmed penile fractures, consistent with current guideline recommendations. Surgical intervention was indicated for all patients with clinically or radiologically confirmed tunica albuginea rupture. Conservative management was reserved exclusively for patients with penile hematoma without tunica albuginea tear, who were excluded from this study.

In order for a patient to be included in the analyses, they had to have undergone IIEF-5 measurement before surgery and at least once after surgery. Patients with only superficial or deep dorsal

vein rupture without tunica albuginea rupture ($n=5$), those with known Peyronie's disease ($n=1$), subjects with missing follow-up data, individuals who underwent conservative treatment, and patients under 18 years of age were excluded from the study.

A total of 72 patients presenting with suspected penile trauma were evaluated during the study period. Of these, 24 patients were excluded due to the absence of tunica albuginea rupture (penile hematoma only), leaving 48 patients with confirmed tunica albuginea rupture. Subsequently, 10 patients were excluded: 5 with Buck fascia bleeding without tunica albuginea tear, 1 with known Peyronie's disease, 2 who underwent conservative treatment, 1 with missing follow-up data, and 1 patient under 18 years of age. Consequently, 38 patients were included in the final analysis (Figure 1).

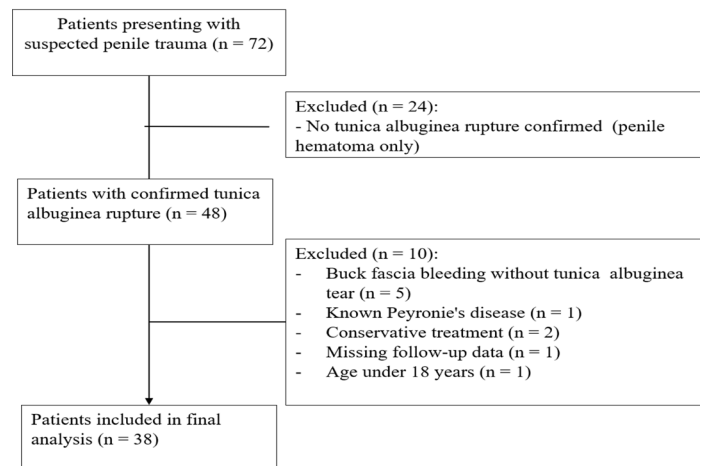


Figure 1. Patient selection flowchart

Data Collection and Measurements

The patients' age, fracture location, direction of penile fracture, size of tunica albuginea tear, presence of urethral injury, time between fracture and surgery, and duration of surgery were retrospectively recorded from patient files. Parameters such as age, time between fracture and surgery, tunica tear size, and urethral injury were included in the analyses as factors that could potentially affect erectile function and complications. Fracture location was categorized as proximal (the region from the penile root to the distal 1/3), mid-shaft (the middle 1/3 of the penile body), and distal (the distal 1/3 region near the penile glans). The direction of penile fracture was classified as right, left, or bilateral.

Erectile function was assessed using the IIEF-5 questionnaire, which is on a scale from 0 to 25 points, with lower scores indicating more severe ED. To reduce information bias, all IIEF-5 questionnaires were administered in a standardized manner. The questionnaire was administered before surgery and at 6 months, 1 year, 2 years, and 3 years postoperatively, and changes in scores were calculated relative to preoperative values. The preoperative IIEF-5 score was obtained retrospectively during the first follow-up visit, where patients were asked to recall their erectile function status prior to the fracture event.

Penile angulation and nodule formation were evaluated in the postoperative period. Penile angulation was defined as the presence of visible curvature in the erect penis, and nodule formation was defined as the presence of palpable hardness in the penile shaft; both were recorded categorically as present or absent. To reduce measurement bias, physical examination findings were evaluated according to objective criteria. The follow-up period was recorded in months as the time elapsed from the date of surgery to the date of the last follow-up.

Surgical Technique and Perioperative Management

To minimize measurement bias, the same surgical technique was applied to all patients, and surgeries were performed by experienced surgeons. All patients underwent a subcoronal circumferential degloving incision under spinal or general anesthesia. This technique allows for complete evaluation of the tunica albuginea, detection of contralateral tears, and visualization of urethral injuries. After hematoma evacuation, the tunica albuginea tear was repaired using interrupted 3-0 absorbable sutures (polyglycolic acid or polydioxanone).

In patients with suspected urethral rupture, the diagnosis was confirmed with retrograde urethrography. In two patients with confirmed urethral rupture, the urethra was repaired using the end-to-end primary anastomosis technique with 5-0 polydioxanone sutures. The watertightness of the tunica repair and the presence of additional tears were confirmed by performing an artificial erection test with saline. A 16F Foley catheter was inserted preoperatively in patients without urethral rupture and removed 24 hours after surgery. In the two patients with urethral rupture, a catheter was inserted after repair and left in place for 7 days.

Elastic penile compression dressing was applied for the first 12 hours after surgery. The loosened bandage was continued for 2-3 more days, depending on the surgeon's preference. All patients were given oral analgesics and prophylactic antibiotics during the postoperative period. Antiandrogens or sedatives were administered for 4 days to 2 weeks to suppress erection. Patients were advised to abstain from sexual activity for 6 weeks after surgery.

Follow-up Protocol

Patients were called for follow-up visits at 6 months, 1 year, 2 years, and 3 years after surgery. At each visit, a physical examination was performed to assess penile angulation and nodule presence, and the IIEF-5 questionnaire was administered. The follow-up period was recorded as the time from the date of surgery to the date of the last follow-up visit

Statistical Analysis

Data collection and analyses were performed on SPSS version 26.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro-Wilk test. Normally distributed data were expressed as mean±standard deviation, while non-normally distributed data were presented as median (25th-75th percentile). Categorical variables were reported as frequencies and percentages. For comparisons

between two independent groups, the Mann-Whitney U test was used for non-normally distributed continuous variables, while the independent samples t-test was applied for normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Correlations between continuous variables were evaluated using Spearman's rank correlation coefficient. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

The mean age of the 38 penile fracture patients was 40.05±11.88 years. Fracture localization was proximal in 60.5% (n=23), mid-shaft in 34.2% (n=13), and distal in 5.3% (n=2) of cases. Right-sided, left-sided, and bilateral fractures were observed in 60.5% (n=23), 31.6% (n=12), and 7.9% (n=3) of patients, respectively. The mean follow-up duration was 66.17±40.22 months.

Urethral injury was present in 5.3% (n=2) of patients. The mean tunica albuginea tear size was 13.66±3.29 mm. The mean fracture-to-surgery interval, which represents the primary variable of interest in this study, was 15.96±16.90 hours. The mean operative time was 71.16±32.74 minutes. Postoperative angulation and nodule formation each occurred in 21.1% (n=8) of patients (Table 1).

Table 1. Age, fracture localization, and surgical characteristics of penile fracture patients	
Variables	Variable
Age (years), Mean±SD	40.05±11.88
Fracture Localization	
Proximal	23 (60.5)
Midshaft	13 (34.2)
Distal	2 (5.3)
Penile Fracture Direction	
Right	23 (60.5)
Left	12 (31.6)
Bilateral	3 (7.9)
Follow-up Duration (months), Mean±SD	66.17±40.22
Urethral Injury	
No	36 (94.7)
Yes	2 (5.3)
Tunica Albuginea Tear Size (mm), Mean±SD	13.66±3.29
Fracture - Surgery Interval (hours), Mean±SD	15.96±16.90
Operative Time (minutes), Mean±SD	71.16±32.74
Angulation	
No	30 (78.9)
Yes	8 (21.1)
Nodule	
No	30 (78.9)
Yes	8 (21.1)
SD: Standard deviation	

The mean preoperative IIEF-5 score was 22.50 ± 1.99 . Postoperative IIEF-5 scores were 17.63 ± 3.40 at 6 months, 18.74 ± 2.79 at 1 year, 19.17 ± 2.77 at 2 years, and 19.58 ± 2.64 at 3 years. Analysis of changes in IIEF-5 scores revealed significant decreases compared to preoperative values: -4.87 ± 3.73 at 6 months ($p=0.001$), -3.86 ± 3.14 at 1 year ($p=0.001$), -3.43 ± 3.02 at 2 years ($p=0.001$), and -3.46 ± 2.84 at 3 years ($p=0.001$) (Table 2).

The correlation between clinical factors and changes in IIEF-5 scores is shown in Table 3. A significant negative correlation was found between the change in IIEF-5 score from preoperative to 6 months and fracture-to-surgery interval ($r=-0.337$, $p=0.039$) (Figure 2). The change in IIEF-5 score from preoperative to 1 year showed a negative correlation with fracture-to-surgery interval ($r=-0.394$, $p=0.019$). A negative correlation was also observed between the change in IIEF-5 score from preoperative to 2 years and fracture-to-surgery interval ($r=-0.440$, $p=0.008$). No significant correlation was found between tear size and change in IIEF-5 score at any time point.

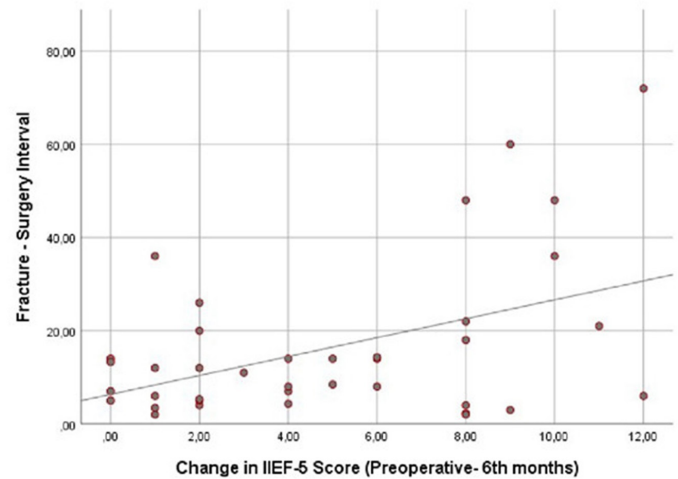


Figure 2. Relationship between change in IIEF-5 score from preoperative to 6 months and fracture-surgery interval. IIEF-5: international index of erectile function-5. scatter plot showing the relationship between fracture-surgery interval (hours) and change in IIEF-5 score from preoperative to 6 months ($r=-0.337$, $p=0.039$)

Table 2. Evaluation of patients' erectile function scores before and after surgery

Variable	Mean $\pm$ SD	Median (Min-Max)	P
Preoperative IIEF-5	22.50 $\pm$ 1.99	23 (17-25)	
Postoperative IIEF-5 (6. months)	17.63 $\pm$ 3.40	18 (12-24)	
Postoperative IIEF-5 (1. year)	18.74 $\pm$ 2.79	18 (14-24)	
Postoperative IIEF-5 (2. year)	19.17 $\pm$ 2.77	18 (14-24)	
Postoperative IIEF-5 (3. Year)	19.58 $\pm$ 2.64	20 (16-24)	
Change in IIEF-5 score			
Preoperative - 6. Months	-4.87 $\pm$ 3.73	-4 (-12-0)	0.001
Preoperative - 1. Year	-3.86 $\pm$ 3.14	-3 (-10-0)	0.001
Preoperative - 2. Year	-3.43 $\pm$ 3.02	-2 (-10-0)	0.001
Preoperative - 3. Year	-3.46 $\pm$ 2.84	-3 (-9-0)	0.001

Negative values indicate a decrease in scores compared to preoperative values; SD: Standard deviation; IIEF-5: International index of erectile function-5

Table 3. Correlation between clinical factors and change in IIEF-5 score

Change in IIEF-5 score		Age (years)	Tear Size (cm)	Fracture - Surgery Interval (hours)
Preoperative - 6. Months	r	-0.025	0.014	-0.337*
	p	0.882	0.934	0.039
Preoperative - 1. Year	r	-0.051	0.071	-0.394*
	p	0.769	0.687	0.019
Preoperative - 2. Year	r	-0.002	-0.009	-0.440*
	p	0.991	0.958	0.008
Preoperative - 3. Year	r	1.000	-0.331	-0.291
	p	-	0.114	0.168

* $p<0.05$; r: Spearman's rho correlation coefficient; Negative r values indicate a decrease compared to preoperative score; IIEF-5: International Index of Erectile Function-5

The change in IIEF-5 score from preoperative to 6 months according to clinical characteristics is shown in Table 4. No significant differences were found between groups in terms of change in IIEF-5 score with respect to fracture localization, penile fracture direction, urethral injury, angulation, or nodule presence ($p=0.328$, $p=0.135$, $p=0.182$, $p=0.930$, and $p=0.428$, respectively).

The comparison of clinical parameters between patients with and without angulation is shown in Table 5. A significant association was found between fracture localization and the presence of angulation ($p=0.023$). The rate of angulation development was higher in mid-shaft fractures (75.0%) compared to proximal (25.0%) and distal fractures (0%). No statistically significant

differences were found between groups with and without angulation in terms of penile fracture direction, urethral injury, age, tear size, and fracture-surgery interval ($p=0.093$, $p=0.302$, $p=0.820$, $p=0.428$, and $p=0.586$, respectively).

The comparison of clinical parameters between patients with and without nodule formation is shown in Table 6. The fracture-surgery interval was significantly longer in the group with nodule formation [42 (17-54) hours vs 8 (4-14) hours, $p=0.001$] (Figure 3). No statistically significant differences were found between groups with and without nodule formation in terms of fracture localization, penile fracture direction, urethral injury, age, and tear size ($p=0.207$, $p=0.354$, $p=0.453$, $p=0.712$, and $p=0.902$, respectively).

Table 4. Comparison of change in IIEF-5 score according to clinical characteristics

Variables	Categories	Change between IIEF 6. months-IIEF preop	P value
Fracture Localization	Proximal	4 (2-8)	0.328
	Midshaft	4 (1-8)	
	Distal	8.5 (8-9)	
Penile Fracture Direction	Right	4 (1-8)	0.135
	Left	5.5 (1.5-9)	
	Bilateral	8 (6-12)	
Urethral Injury	No	4 (1.5-8)	0.182
	Yes	8.5 (8-9)	
Angulation	No	4 (2-8)	0.930
	Yes	5 (0.5-9)	
Nodule	No	4 (2-8)	0.428
	Yes	7 (1.5-9.5)	

IIEF-5: International index of erectile function-5; Data are presented as median 25th-75th percentile)

Table 5. Comparison of clinical parameters with angulation

Variables	Angulation Yes	Angulation No	P value
Fracture Localization			0.023
Proximal	2 (25.0%)	21 (70.0%)	
Midshaft	6 (75.0%)	7 (23.3%)	
Distal	0 (0%)	2 (6.7%)	
Penile Fracture Direction			0.093
Right	3 (37.5%)	20 (66.7%)	
Left	3 (37.5%)	9 (30.0%)	
Bilateral	2 (25.0%)	1 (3.3%)	
Urethral Injury			0.302
No	7 (87.5%)	29 (96.7%)	
Yes	1 (12.5%)	1 (3.3%)	
Age (years)	44 (29-47)	40 (28-50)	0.820
Tunica Albuginea Tear Size (cm)	16 (11-17)	14 (12-15)	0.428
Fracture - Surgery Interval (hours)	9 (5-18)	12 (5-20)	0.586

Categorical data are presented as n (%), continuous data are presented as median (25th-75th percentile)

Table 6. Comparison of clinical parameters with angulation

Variables	Angulation Yes	Angulation No	P value
Fracture Localization			
Proximal	7 (87.5%)	16 (53.3%)	0.207
Midshaft	1 (12.5%)	12 (40.0%)	
Distal	0 (0%)	2 (6.7%)	
Penile Fracture Direction			
Right	4 (50.0%)	19 (63.3%)	0.354
Left	4 (50.0%)	8 (26.7%)	
Bilateral	0 (0%)	3 (10.0%)	
Urethral Injury			
No	8 (100.0%)	28 (93.3%)	0.453
Yes	0 (0%)	2 (6.7%)	
Age (years)	47 (34-49)	40 (28-50)	0.712
Tunica Albuginea Tear Size (cm)	13 (11-16)	14 (12-16)	0.902
Fracture - Surgery Interval (hours)	42 (17-54)	8 (4-14)	0.001
Categorical data are presented as n (%), continuous data are presented as median (25th-75th percentile)			

Categorical data are presented as n (%), continuous data are presented as median (25th-75th percentile)

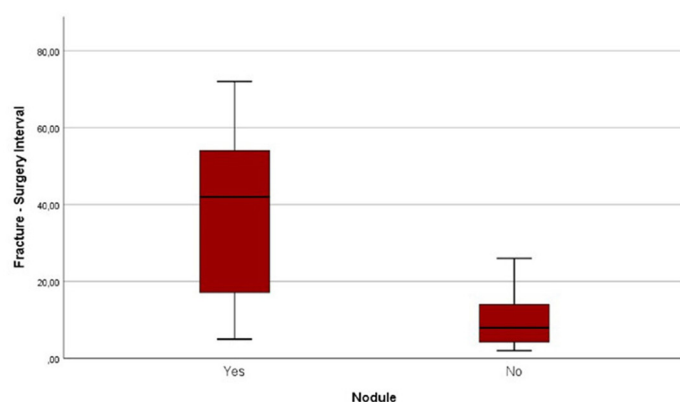


Figure 3. Comparison of Fracture-Surgery Interval According to Nodule Presence. Box plot showing fracture-surgery interval (hours) in patients with and without nodule formation. The fracture-surgery interval was significantly longer in the group with nodule formation ($p=0.001$). Boxes represent median and interquartile range; whiskers represent minimum and maximum values

DISCUSSION

This study presents long-term follow-up results over an average of 66 months in 38 patients with penile fractures. All patients had normal erectile function before surgery, but a mean decrease of 4.87 points in the IIEF-5 was observed at 6 months postoperatively. Erectile function showed gradual improvements over time, but these remained marginal. Even at 3 years, a complete return to preoperative levels was not achieved. The most important factor affecting erectile function was found to be delay in surgery, and a significant negative correlation was found between the time between fracture and surgery and the decrease in IIEF-5 at all postoperative time points except for 3 years. The observed rates of postoperative angulation and nodule formation, along with their respective associations with fracture

localization and surgical timing, underscore the multifactorial nature of complications following penile fracture repair. These findings show the critical importance of early surgical repair in penile fractures in terms of ED and complications.

The complete preservation of erectile function after penile fracture surgery is a controversial topic in the literature, and current data suggest that permanent loss of function is more common than previously thought. We observed a decrease in IIEF-5 scores among 78.9% of patients compared to preoperative levels, which persisted even at the end of the third year, suggesting that “complete preservation” of erectile function after penile fracture surgery may not be a clinically realistic expectation. Beyond statistical significance, the clinical implications of these findings warrant consideration. The mean decrease of 3.46 points in the IIEF-5 score at 3 years represents a shift from the 'no erectile dysfunction' category (22-25 points) to the 'mild erectile dysfunction' category (17-21 points) according to established severity classifications. This categorical transition, although seemingly modest in absolute terms, may have substantial implications for patient sexual satisfaction and quality of life. A decrease of 3-4 points in the IIEF-5 has been considered clinically meaningful in previous erectile dysfunction treatment trials, representing a perceptible change in erectile function from the patient's perspective. Furthermore, in a population of relatively young, sexually active men with previously normal erectile function, even mild erectile dysfunction may cause significant psychological distress and relationship difficulties, particularly when considering the traumatic nature of the initial injury and its potential long-term psychological sequelae. The rates of ED reported in the literature vary considerably. While some series report ED rates limited to 15–20% (13,14), some

long-term cohorts report rates reaching 30–50% (15-17). This wide variation is associated with cohort characteristics and study definitions, as well as ED classification, follow-up periods, and the fact that validated measurement tools are not applied with the same rigor in every study (1,18). The use of a standardized measurement tool such as the IIEF-5 in our study and the follow-up period of up to 3 years allows for the assessment of changes in erectile function in an objective and comparable manner rather than based on subjective patient perception. The most pronounced decline in IIEF-5 scores observed in the first 6 months (mean 4.87 points) appears consistent with the combined effects of tissue edema and inflammation associated with acute trauma, as well as performance anxiety and post-traumatic psychological burden. (19,20). Although a gradual improvement observed in the subsequent 1–3-year period indicates tissue remodeling and vascular adaptation, the failure to achieve a full return to the preoperative level even at the end of the third year suggests that permanent neurovascular damage and structural changes may lead to clinically significant, long-term ED, particularly in patients with specific risk profiles.

One of the most striking findings of this study is that the time between fracture and surgical repair showed a significant and progressively stronger negative correlation with the decrease in IIEF-5 scores at all follow-up points. This linear relationship, obtained by modeling the delay time as a continuous variable in our cohort, is consistent with the finding that even when delay is addressed with categorical thresholds in recent large series, there is a marked increase in risk in terms of erectile function (21). Indeed, in this series reporting 12 years of experience, delayed surgery, large tunical defect, and advanced age were identified as independent risk factors for postoperative ED, and a significant threshold effect was demonstrated for durations exceeding 8.5 hours (21). Similarly, Bıçak et al. emphasized that in cases presenting to the hospital more than 12.5 hours after injury, the risk of ED development or worsening of existing ED is significantly increased, and therefore penile fracture should be treated as a true urological emergency (22). Our data, extending these threshold-based analyses, suggest that the trauma-surgery interval determines erectile outcomes through a continuous dose-response relationship and that binary classifications such as “early-late” do not fully reflect the pathophysiological reality (22). In a meta-analysis providing a higher level of evidence, Yusuf et al. demonstrated that rates of ED, penile curvature, and pain were significantly lower in cases repaired immediately (<24 hours) compared to delayed surgery (23). Haque et al. also reported that early surgery yielded better outcomes in terms of both ED and fibrotic plaque in long-term follow-ups, and that surgical treatment was superior to conservative approaches even in cases presenting beyond 24 hours (24). A more recent systematic review has shown that the incidence of ED after penile fracture surgery ranges from 0% to 52.9%, but that this rate is significantly lower in series where early surgery was performed and that repair within 24–48 hours is associated with optimal functional outcomes (25). Bahçeci et al. and other

recent center series support this pathophysiological framework, reporting that early presentation and emergency surgery reduce complication rates and improve functional outcomes (26). Hardesty et al.'s algorithmic review positions penile fracture as a true “time-sensitive” urological emergency, where each passing hour worsens the neurovascular prognosis (27).

In our study, the postoperative penile angulation rate was determined to be 21.1% (8/38 patients), and it was demonstrated that this deformity was significantly associated with fracture localization. The biomechanical vulnerability of the tunica albuginea plays a critical role in this context: while its thickness is 2 mm during flaccidity, it decreases to 0.25-0.50 mm during erection, with the thinnest region being the ventral side with a single layer; therefore, it is not surprising that 80% of tears occur ventrally and transversely (28). The fact that mid-shaft fractures were observed in 75% of cases with angulation, proximal fractures in 25%, and no distal fractures ($p=0.023$) suggests that mid-shaft fractures carry a significantly higher risk. This rate, when compared to the postoperative curvature frequency reported in series of surgically treated penile fractures (approximately 1–28%), is in the mid-to-high range of the current literature (16,19,29,30). In an East Asian series, the reporting of only 0.8% mild penile curvature with early surgical repair and a relatively short follow-up period indicates that low complication rates in some cohorts may reflect the selected patient profile and limited long-term follow-up (29). In contrast, in a prospective study of 58 cases, Barros et al. found postoperative penile curvature in 13.7% of cases and emphasized that the deformity was a significant source of psychosexual distress in some patients, even though erectile function was largely preserved (19). In a tertiary center series from Turkey, penile deviation was reported in 6.5% of 31 patients operated on within the first 24 hours, and it was demonstrated that the size of the tunica tear and the time elapsed until surgery were the key determinants for late-stage complications (30). In another study focusing on long-term outcomes, curvature was detected in 28% of patients at a median follow-up of 95 months, and it was reported that advanced age and large tunical defects were significantly associated with both curvature and ED (16). Systematic reviews show that early surgical repair generally reduces the penile curvature rate to <5%, while in conservative treatment, curvature rates exceed 10% and are often accompanied by fibrotic plaque formation reaching 25–30%, thus confirming that urgent surgery is also the gold standard in terms of cosmetic results (27,31). In Ouanes et al.'s series of 138 cases, the association of tunical leaks, particularly those located in the proximal shaft of the penis, with a higher risk of ED and curvature supports the anatomical and biomechanical significance of fracture localization (13). Recent complication-focused cohorts have demonstrated that tunica albuginea tear size, bilateral corporal involvement, and complex lesion geometry are independent predictors of postoperative deformity, providing a framework consistent with the greater tendency toward larger tears observed in mid-shaft fractures in our series (11,30). The higher mobility of the mid-shaft region compared

to the proximal and distal segments, and its exposure to greater mechanical stress during erection, may represent a potential biomechanical mechanism explaining the heterogeneous scar contraction and resulting angulation observed during the healing process following asymmetric tunical repair at this level (27).

In our study, the postoperative nodule formation rate was determined to be 21.1% (8/38 patients), and in patients who developed nodules, the median time between fracture and surgery was 42 hours (17–54), while in those without nodule development it was 8 hours (4–14), indicates a significant fibrotic burden close to the upper limit of the spectrum of palpable plaques and nodules defined in the literature among long-term sequelae after penile fracture (1). This rate indicates that nodular complications can increase significantly in cohorts with a high proportion of late-presenting patients, compared to the approximately 0–20% incidence of plaques and nodules reported in series undergoing surgical treatment (25,32). Amer et al.'s meta-analysis emphasizes that the plaque/nodule ratio was approximately 13–14% in cases treated with surgery, while it rose to 19–23% in the conservatively monitored group, thus indicating that early surgery has a significant protective effect on nodular sequelae (1,6,25). Despite meticulous surgical techniques and early repair, palpable scars or nodules were detected in approximately 7–14% of patients in recent prospective and retrospective series. This suggests that although this complication cannot be completely eliminated, it is a biological process that can be reduced, particularly with early intervention (6,32,33). Systematic reviews and current guideline-based summaries comparing early surgery with delayed surgery show that fibrotic complications, including plaque, nodules, and painful erections, are significantly lower with early intervention and emphasize the need to drain hematomas as soon as possible (25,34,35). The approximately fivefold delay difference (42 vs. 8 hours) between groups with and without nodule development in our series was found to be statistically significant at the $p=0.001$ level. When evaluated in conjunction with the literature, this demonstrates that this is a truly 'time-sensitive' urological emergency and that early surgery significantly reduces the long-term burden of fibrotic/nodular complications (34,36,37).

Limitations

Due to its retrospective design, data collection is reliant upon the comprehensiveness and accuracy of medical records. As is the case in many studies in published literature, this is a single-center study that limits generalizability to different surgical experiences and techniques. Nonetheless, since the surgeries in this study were performed using a standardized technique by the same experienced team of surgeons, the single-center design also minimizes the effect of surgical variability on results. Third, the relatively small sample size ($n=38$) limited the statistical power of some subgroup analyses and did not allow for more advanced analyses; however, considering the rarity of penile fracture, this sample size is comparable to many studies in the literature. Fourth, since there was no control group receiving

conservative treatment, the results do not portray the different impacts of surgical and conservative management. Fifth, the assessment of erectile function was based on the self-report IIEF-5 questionnaire, which may be inferior to penile duplex ultrasonography or rigiscan –despite well-established validity. Similarly, the assessment of angulation and nodules was based on clinical examination, and objective angle measurement with a goniometer or confirmation with imaging was not performed. Additionally, the preoperative IIEF-5 scores were obtained retrospectively during follow-up visits rather than at the time of emergency presentation, which introduces potential recall bias. Patients may have difficulty accurately recollecting their baseline erectile function, and this could affect the magnitude of the observed changes in IIEF-5 scores. Finally, important parameters such as psychological factors, sexual satisfaction, and partner satisfaction were not evaluated.

CONCLUSION

This study demonstrates that there is a permanent decrease in erectile function during an average 66-month long-term follow-up after penile fracture surgery, and that delayed surgery is the most important prognostic factor. A strong negative correlation was found between the time between fracture and surgery and ED, and this relationship becomes more pronounced over time. Postoperative angulation is more common in mid-shaft fractures, while nodule formation is strongly associated with delayed surgery. In light of these findings, it is critically important that patients with suspected penile fracture receive surgical treatment as soon as possible. Since every passing hour has a negative effect on erectile function, rapid urology consultation should be provided in emergency departments, and patients should be informed about the importance of urgent referral. Patients with mid-shaft fractures, in particular, should be informed in detail before surgery about the risk of angulation, while patients who present late should be informed about the risk of nodule formation and should be carefully monitored during the postoperative period. Future studies should include larger prospective series, objective erectile function tests, and assessment of psychological factors.

Conflict of Interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

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Ethical Approval

The study protocol received approval from the Malatya Turgut Ozal University Health Sciences Clinical Research Ethics Committee (Decision No: E-30785963-020-341614, Date: 22.10.2025).

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