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Review Article

Surgical Delay of Proximal Hamstring Ruptures Results in Increased Risk of Post-Operative Pain and Stiffness: A Systematic Review

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Abstract

Background: Proximal hamstring repair is a surgical procedure used to repair injuries to the hamstring by reattachment of tendons to the ischial tuberosity. Current literature indicates that early surgical repair yields improved strength, function and return-to-sport relative to delayed intervention. This systematic review seeks to consolidate current data on the optimal surgical window and the impact of surgical delay on patient outcomes and complications.

Methods: PRISMA guidelines, with the MINORS and RoB 2.0 criteria as bias assessment tools, were used and Pubmed, Embase and Web of Science databases were searched for articles on proximal hamstring surgical repair, time of surgery, patient outcomes and complications. This study excluded non-English full-text, systematic reviews and meta-analyses, duplicated studies and any studies without relevance to the topic. Linear regressions were fitted to Patient-Reported Outcome Measures (PROMs) to compare patient outcomes to various surgical delay datapoints. Chi-squared statistics were performed twice for our complications data, defining "delayed" surgery as >6 weeks in the first analysis and >8 weeks from injury in the second.

Results: A total of 37 studies comprising 1,837 patients (weighted mean age 47.4 years) met inclusion criteria. A total of 150 postoperative complications were reported, most commonly neurological symptoms (n = 41), infections (n = 27), re-ruptures (n = 23) and pain or stiffness (n = 23). Pain/stiffness was the only complication with statistically significant associations at both the 6-week and 8-week thresholds (OR = 0.11, 95% CI: 0.02-0.55, p = 0.001). Patient-reported outcomes demonstrated variable associations with time to surgery, with several measures including PHAS, HOS-ADL, LEFS and VAS showing declining trends as surgical delay increased (p = 0.585, 0.00, 0.510, 0.343; R2 = 0.173, 1.00, 0.056, 0.150, respectively), while others such as SF-12 PCS, SF-12 MCS and PHAT displayed improved scores at intermediate surgical intervals (p = 0.103, 0.812, 0.771; R2 = 0.643, 0.022, 0.013, respectively).

Conclusion: Early proximal hamstring repairs (≤ 6 weeks post-injury) were generally associated with superior outcomes and fewer complications. Delayed repair was associated with higher odds of postoperative pain/stiffness, warranting further prospective investigation. Raising awareness on barriers leading to prolonged delays in the field could help prevent other adverse outcomes.

Level of Evidence

Level IV. (Systematic review of levels I-IV studies)

Keywords: Hamstring Repair; Patient-Reported Outcome Measures; Pain; Stiffness

Introduction

Proximal hamstring repair is a surgical procedure used to repair a partial or complete detachment of the hamstring tendon from the ischial tuberosity [1,2]. While hamstring tendon avulsion is a serious injury that can cause substantial loss of strength and functional impairment of the affected limb, operative reattachment tends to yield excellent outcomes, as most patients regain near-normal function and return-to-sport rates can exceed 80% [3,4]. While appropriate nonoperative management of hamstring ruptures may benefit some patients, surgical repair of the avulsed tendons is recommended for active patients, wishing to maintain better outcomes in knee flexion strength [1,4]. Early surgery, often defined as the first 6 weeks post-injury, is associated with superior results, such as higher patient satisfaction, better pain relief, greater strength recovery and higher return-to-sport rates relative to delayed intervention [1,3,4]. In contrast, delayed surgical treatment is often correlated with increased complication risks3, tendon retraction, scarring and reduced postoperative strength [5,6].

Despite evidence that early intervention yields better outcomes, there remain important gaps in our understanding of the impact of surgical delay on patient results. While prior systematic reviews have examined the impact of surgical delay on patient outcomes, these reviews do not reflect the latest literature [1,6]. Furthermore, prior systematic reviews provide limited synthesis regarding unexpected and long-term complications [1,2,6]. As a result, there is no up-to-date consensus on the effect on patient outcomes and specific complications of delayed repair, such as persistent functional deficits and nerve-related complications. This knowledge gap makes it challenging for orthopedic surgeons to counsel patients who present multiple weeks after injury or to determine the optimal window for intervention.

The aim of this systematic review is to evaluate patient outcomes and complications associated with delayed surgical repair of proximal hamstring tendon avulsions. We will synthesize the available evidence to determine how surgical timing influences clinical results and to highlight unexpected outcomes that arise after delayed repair, thereby providing guidance for orthopedic surgeons managing these complex injuries.

Methodology

This systematic review followed the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines [7]. In addition, this review is original as it has not been previously registered in the International Prospective Register of Systematic Reviews (PROSPERO).

Eligibility Criteria

This study included articles on proximal hamstring surgical repair, time of surgery, patient outcomes and complications. The exclusion criteria consisted of articles that were: duplicate studies, systematic reviews and meta-analyses, non-English full-texts, biomechanical or cadaver studies, animal studies and any articles irrelevant to the topic.

Article Search

The article search was conducted in September 2025 on PubMed, Embase and Web of Science. The keywords "proximal hamstring repair" were searched in the title and abstract of these databases. The abstract screening was conducted by two authors based on the inclusion and exclusion criteria (L.N. and A.E.). A third author was present to resolve any conflicts during this process (V.T.). Articles not available in full-text form were omitted along with irrelevant or low-quality studies.

Data Collection

Each full-text was reviewed and extracted in a spreadsheet. The data extracted from each article included but was not limited to: sample size, average age, gender, body mass index, time to surgery, preoperative outcomes, endoscopic versus open, average length of follow-up and postoperative outcomes. Two independent raters (L.N. and A.E.) assessed the bias and methodological quality of non-randomized studies using the Methodological Index for Non-Randomized Studies (MINORS) scale8. An increase in MINORS score denotes less risk of bias and higher quality of articles8. The randomized controlled trials of our study were assessed by the same raters for bias and quality using the Revised Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2.0) criteria, which is scaled on a table of domains with "low risk" in green, "some concerns" in yellow and "high risk" in red9. Any conflicts in assessments were resolved from the objectionable input of additional authors.

Statistical Analysis

Descriptive summaries were used to analyze the study characteristics, including averages and ranges. Complications were reviewed by two authors (L.N. and S.W.) and grouped into seven categories: (1) hematoma/bruising, (2) infection, (3) neurologic symptoms, (4) pain/stiffness, (5) re-rupture, (6) thromboembolic events and (7) other. Cases were stratified by time to surgery. Two thresholds were evaluated: early repair defined as ≤6 weeks from injury versus delayed repair (>6 weeks) and similarly ≤8 weeks versus >8 weeks. Odds ratios, 95% confidence intervals and p-values were calculated using Excel by one author (S.W.). Chi-squared statistics and p-value were calculated using Python 3.14.0 with Polars 1.35.1 by another author (J.L.). To evaluate the relationship between mean time to surgery and each of the reported PROMs, one author (J.L.) fitted linear regressions using SciPy 1.16.3. We also determined the significance of these results by finding a p-value where the null hypothesis is R2=0 using a Wald Test with t-distribution of the test statistic. The review and presentation of the included studies were done in a narrative manner.

Results

Search and Study Characteristics

A total of 286 articles were identified using the search criteria. After abstract screening, 122 full-texts were reviewed for eligibility. Following a full-text review of 59 articles, 37 articles were included in this study. The MINORS and RoB 2.0 scores on risk of bias and data quality for the included studies are found in Fig. 1-3. The level of evidence for the included studies was: level I for 2 Randomized Controlled Trials (RCTs), level II for 3 prospective cohort studies, level III for 9 studies (8 retrospective cohort studies and 1 prospective case series) and level IV for 23 studies (15 retrospective case series, 4 prospective case series and 4 case reports). This systematic review is considered a level IV study as a result. There were 1,837 patients included in this study, reporting a total of 916 females and 830 males (Table 1). The weighted mean age of all reported patients was 47.4 years (range, 14.6-64.2). Prior to the proximal hamstring repair, patients were most frequently diagnosed with a right-sided rupture in 633 cases and left-sided in 589 cases (Table 1). The average time to surgery across studies ranged from 2 weeks to 121.2 weeks. The average length of follow-up ranged from 3.7 months to 102 months across studies.

Complications by Time to Surgery

Complications following proximal hamstring repair were reported in 23 of the 37 included studies (62.2%), while 14 studies reported no complications (37.8%) (Table 2). A total of 150 complications were documented across all studies and categorized into seven groups: neurological symptoms (n=41, 27.3%), infections (n=27, 18.0%), re-rupture (n=23, 15.3%), pain/stiffness (n=23, 15.3%), thromboembolic events (n=15, 10.0%), hematoma/bruising (n=6, 4.0%) and other complications (n=15, 10.0%) (Tables 3-4). Complications were observed across a wide spectrum of surgical timing, occurring in studies with average time to surgery ranging from 2 weeks to 66.73 weeks.

Statistical analysis of complication rates stratified by surgical timing demonstrated that pain/stiffness was the only complication with statistically significant associations at both the 6-week and 8-week thresholds (Table 3,4). At the 6-week cutoff, 2 of 596 patients (0.3%) who underwent repair ≤6 weeks from date of injury experienced pain/stiffness complications compared to 6 of 201 patients (3.0%) who underwent repair >6 weeks from date of injury (OR = 0.11, 95% CI: 0.02-0.55, p = 0.001). The same values were observed at the 8-week threshold (OR = 0.11, 95% CI: 0.02-0.55, p = 0.001). No statistically significant associations were observed for other complication categories, including hematoma/bruising, infection, neurologic symptoms, re-rupture, thromboembolic events or other complications at either threshold.

Postoperative Outcomes Based on Time to Surgery

Multiple patient-reported outcome measures and functional scores were evaluated across studies with varying time to surgery (Fig. 4,5). The outcome scores demonstrated variable patterns in relation to surgical timing. Several outcome measures including the Proximal Hamstring Activity Scale (PHAS), Hip Outcome Score-Sports (HOS-Sports), Lower Extremity Functional Scale (LEFS) and Visual Analog Scale (VAS) showed declining trends with increasing time to surgery (p = 0.585, 0.621, 0.510, 0.343; R2 = 0.173, 0.314, 0.056, 0.150, respectively) Other outcome measures including the Short Form-12 Physical Component Score (SF-12 PCS), Short Form-12 Mental Component Score (SF-12 MCS) and Proximal Hamstring Activity Tool (PHAT) demonstrated higher scores at surgical intervals between 10 and 20 weeks compared to both earlier and later time points (p = 0.103, 0.812, 0.771; R2 = 0.643, 0.022, 0.013, respectively). The Marx Activity Scale (p = 0.148; R2 = 0.947) and Harris Hip Score (p = 0.254; R2 = 0.556) demonstrated no significant trends.

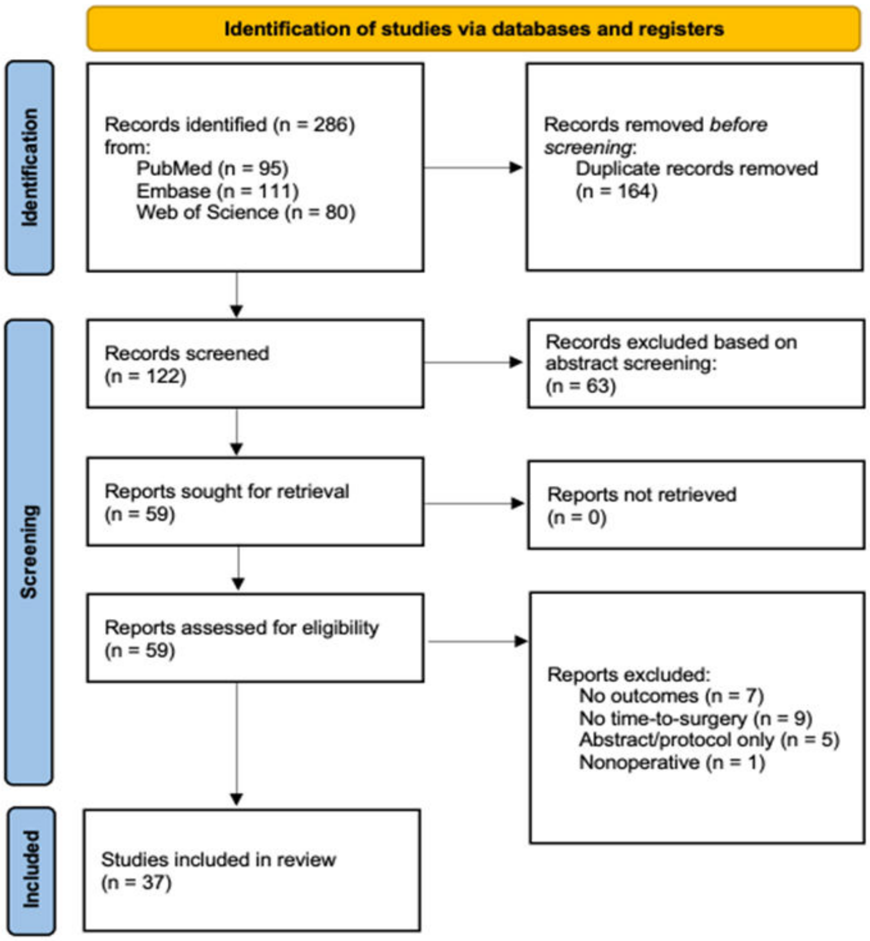

Figure 1: Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram of articles included, after identification and screening, of Proximal Hamstring studies [7].

First author	Publication year	"Comparative" or "Non-comparative" Study	MINORS Score	1: Clearly stated aim	2: Inclusion of consecutive patients	3:Prospective collection of data	4: End points apropriate to study aim	5: Unbiased assessment of study end point	6: Follow-up period appropriate to study aim	7: Less than 5% lost to follow up	8: Prospective calculation of the study size	9: Adaquate control group	10: Contemporary groups	11: Baseline equivalence of groups	12:Adaquate statistical analysis
Chahal	2012	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Fenn	2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Factor	2020	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Sullivan	2023	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Willinger	2020	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Ravich	2025	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Piposar	2017	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Lefèvre	2025	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Kanakamedala	2023	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Lefèvre	2025	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Rothrauff	2025	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Chocholáč	2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Johnson	2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Kaila	2023	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Maldonado	2021	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Lefèvre	2025	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Pihl	2019	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Best	2021	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Bowman	2019	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Lefèvre	2024	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Spoorendonk	2024	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Bajwa	2021	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
van der Made	2022	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Ebert	2019	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Sanderson	2020	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Wilson	2017	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Skaara	2013	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Olowofela	2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Sallay	2008	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Salido	2023	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Kirkland	2008	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Kayani	2020	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Falotico	2025	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Lefevre	2024	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Subbu	2015	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-

Figure 2: Results from the bias and quality assessment of 35 non-randomized studies included in this systematic review, using the Methodological Index for Non-Randomized Studies (MINORS) criteria [8].

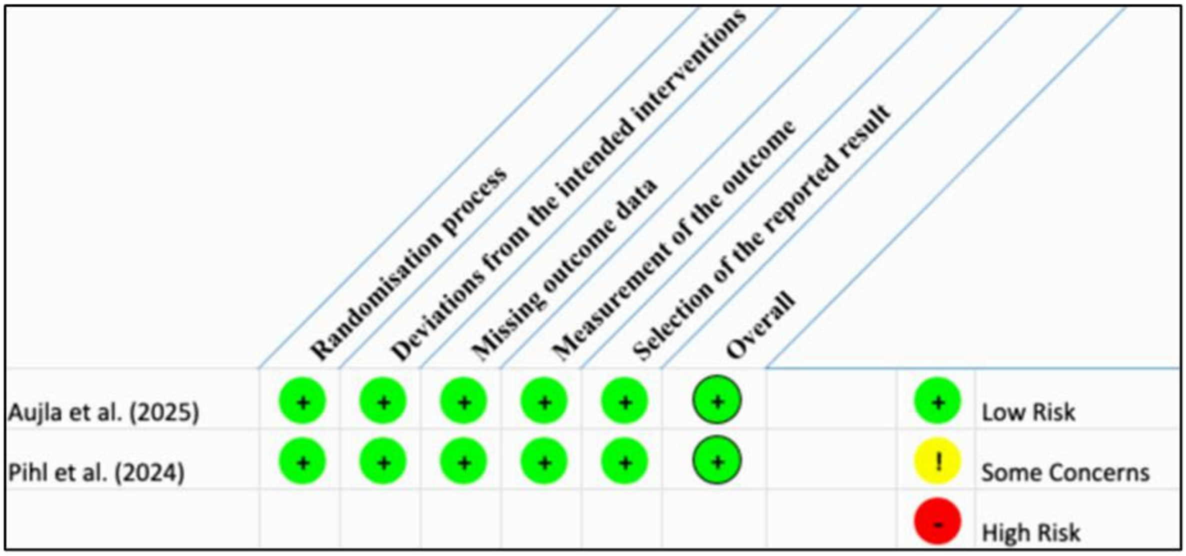

Figure 3: Representation of the quality and bias assessment for 2 randomized controlled trials included in this systematic review, using the Revised Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2.0) [9].

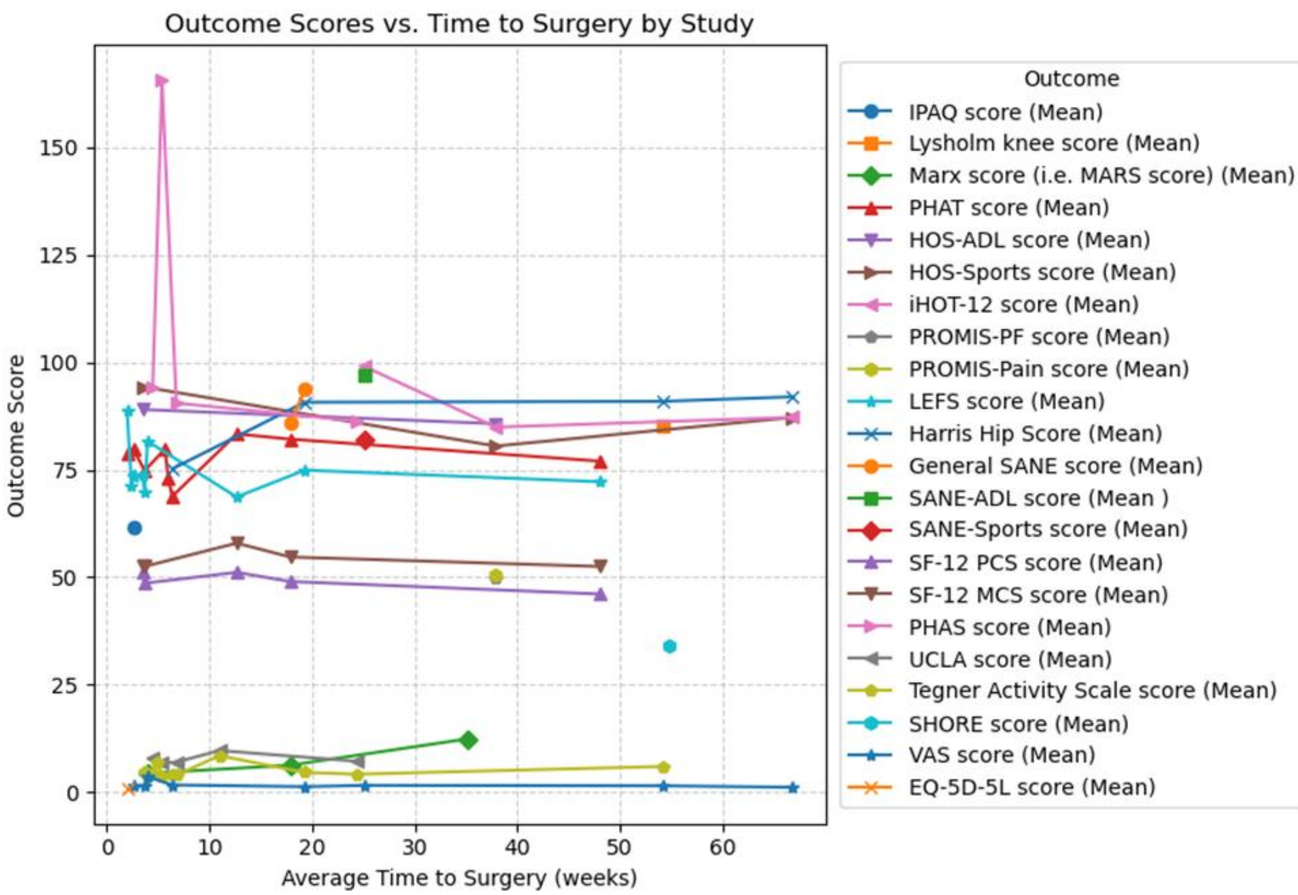

Figure 4: Combined trends of postoperative patient outcomes based on time to surgery for proximal hamstring repair.

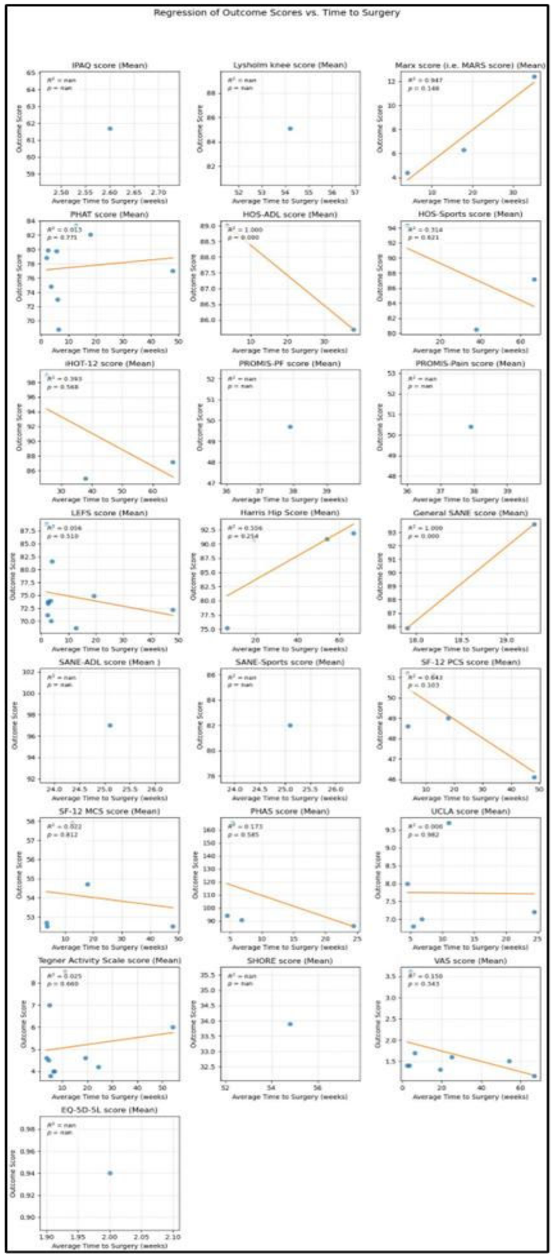

Figure 5: Fitted linear regressions of individual postoperative patient outcomes based on time to surgery for proximal hamstring repair.

First author	Publication year	Level of evidence	Study type	Number of patients	Average age *Mean (SD) [Range]*	Average BMI *Mean (SD) [Range]*	% Female	Injured side *(N)*	Avg time to surgery? (weeks) *Mean (SD) [Range]*	Average follow-up (months) *Mean (SD) [Range]*	% Patients with Return to Sports	% of Patients with Return to Pre-injury level
Aujla	2025	1	Randomized controlled trial	30	45.6 (13.4) [21-65]	28.0 (4.6) [17.6–38.3]	43.3	Right (18)	3.7 (1.8), [0.5-6]	6		
Chahal	2012	4	Retrospective case series	15	44.6 [26-58]		46.7	Left (6)	19.3 [1.3-208.6]	36.9 [27-63]	100%	55%

Fenn	2023	4	Retrospective case series	35	53.6 (7.6)	26.9 (5.5)	65.7		37.9 weeks (range, 1.3-306.9 weeks)	69 [60-95]		
Factor	2020	4	Retrospective case series	6	48 [30-61]		16.7	Right (4), Left (2)	6	28 [12-55]		
Sullivan	2023	3	Retrospective cohort	30	58.0 (8.0)	28.4 (2.9)	43.3		3.5 [2-11]	58.1 (31.8)		41.10%
Willinger	2020	4	Retrospective case series	94	53.8 (12.3)	27.2 (14.2)	43.6	Right (49), Left (46)	54.2	56.2 (27.2)	49.00%	
Ravich	2025	4	Retrospective case series	27	55.9 (8.3)	27.1 (6.5)	63	Right (10), Left (18)	17.9 (12.4)	67 (28.5)	78.60%	
Piposar	2017	4	Retrospective case series	10	50.4 (6.31)		70		30.11 (19.43)	35.47 (30.35)		
Lefèvre	2025	3	Retrospective cohort	298	49.9 (10.4)	24.05 (3.9)	53	Right (161), Left (142)	4.5 [2.7–10.7]	4.47 (2.96)	70.10%	63.70%
Kanakamedala	2023	3	Retrospective cohort	38	51.4 (9.9)	27.2 (4.8)	57.9		6.4 [1.6–18.4]	4.9 (1.6)		
Lefèvre	2025	3	Retrospective cohort	104	49.56 (9)	24.39 (4.64)	63.5	Right (60), Left (44)	5.4 [14.2–14.9]	58.99 (44.61)		
Rothrauff	2025	4	Retrospective case series	53	47.4 [16.3-67.0]		73.6	Right (29), Left (28)		121.2 [61.2–194.4]	94.70%	
Chocholáč	2023	4	Retrospective case series	13	64.2 [52.1–80.4]	28.5 [23.5–45]	61.5	Right (7), Left (6)	2	46.2 [11.2–75.1]		
Johnson	2022	3	Retrospective cohort	40	51.5 [22–65]	31.8 [23–55]	60	Right (20), Left (20)	4	68.4 [14.4–121.2]		87.10%
Pihl	2024	1	Randomized controlled trial	58	54.4 [49.7–59.6]	26.0 [23.8–29.1]	55.1	Right (25), Left (33)	2.6 [1.9–3.1]	24 (0)		57.40%
Kaila	2023	2	Prospectivespective cohort	18	14.6 (1.8)		27.8		54.8 [1-358]	102 [12–180]	100%	100%
Maldonado	2021	4	Retrospective case series	50	46.13 (13)	25.43 (5.14)	68		66.73 (25.31) [5.14-215.14]	58.07 (37.27)		
Lefèvre	2025	4	Case report	145	49.0 (9.0)	24.4 (4.0)	50.3		6.8 [3.0–29.3]	46.8 (41.0)	60.70%	
Pihl	2019	3	Retrospective cohort	33	50 (9)		51.5		2.6 (2.4)	49.0 (16.0)	94%	
Best	2021	4	Retrospective case series	174	48.9 (14.6) [11-79]		48.9	Right (102), Left (72)	5.7 (12.8) [1-76]	26.2 (15.5)		

Bowman	2019	4	Retrospective case series	58	51.1 (12.0) [17-77]	25.3 (4.4)	56.9	Right (33), Left (25)	25.1 (50.9)	29.0 (9.9)	88%	72%
Lefèvre	2024	4	Prospective case series	64	27.3 (8.9)	24.5 (3.8)	17.2	Right (27), Left (37)	11 (29.9)		98.40%	96.90%
Spoorendonk	2024	2	Prospective cohort	11	50 (16)	24 (4)	45.5		2.1 [1.6-4]	12	100%	55%
Bajwa	2021	4	Retrospective case series	11	[19-47]		27.3		[.4-5.9]			100%
van der Made	2022	2	Prospective cohort	26			42.3	Right (14), Left (12)	4.3	12	74%	27%
Ebert	2019	4	Prospective case series	6	47.5 [30-61]	25.9 [21.3-28.9]	66.7		48 [30-77]	24		83.33%
Sanderson	2020	4	Case report	1	27		0	Left (1)	3	24		100%
Wilson	2017	3	Retrospective cohort	67	48.3 (11.7)	27.7 (5.6)	55.2		26.4	3.7		
Skaara	2013	4	Retrospective case series	31	51 [27-73]	26 [20-35]	100	RIght (11), Left (20)	2.43	30 [12-66]		58%
Olowofela	2023	4	Case report	1	53		0	Both (1)		24	100%	100%
Sallay	2008	4	Retrospective case series	25	43.5 [20-69]		48		11.91 [0.71-83.86]	8.52 [0.27-31.47]		100%
Salido	2023	3	Prospective case series	3	61 (7.81)		100	Right (2), Left (1)	12.67 (11.55)	12		100%
Kirkland	2008	4	Case report	1	24	29.3	100	Right (1)		7	0%	100%
Kayani	2020	4	Prospective case series	41	38.7		24.4	Right (24), Left (17	35.1 (7.7) [25.7-60]	24	100%	
Falotico	2025	4	Retrospective case series	13	37 (13.2) [14-53]		30.8		4.93 (3.77) [.28-12]	23.2 (20.8)		
Lefevre	2024	3	Retrospective cohort	95	53.4 (7.7) [32-69]		55.8	Right (36), Left (59)	24.4 (41.1)	50.7 (31.1) [12- 131.8]	68.4%	
Subbu	2015	4	Prospective case series	112	29 (8.5) [18-52]		32.1		9.31 [5-512]	19.1	96.4%	
SD: standard deviation; N: number of patients; %: percentage												

Table 1: Study characteristics and patient demographics.

First author	Publication year	Avg time to surgery? (weeks) *Mean (SD) [Range]*	**Complications** *(N)*
Aujla	2025	3.7 (1.8) [0.5-6]	Deep infections (2), Re-ruptures (2)
Chahal	2012	19.3 [1.3-208.6]	Numbness/Tingling (1), Stiffness (6)
Fenn	2023	37.9 [1.3-306.9]	Persistent neuropathy (3), Persistent numbness (2), Superficial cellulitis (2), Prolonged sitting pain (1), Deep infection requiring evacuation (1)
Factor	2020	6	Lysis of adhesions for subcutaneous scarring (1)
Sullivan	2023	3.5 [2-11]	0 complications
Willinger	2020	54.2	Hematoma (1), Paresthesia (4), Wound infection (1), DVT (2)
Ravich	2025	17.9 (12.4)	Deep vein thrombosis with Pulmonary Embolism (1), Postoperative sitting pain (2)
Piposar	2017	30.11 (19.43)	*Not applicable*
Lefèvre	2025	4.5 [2.7–10.7]	Infection (3), chronic pain (1), hyperaesthesia (4), exacerbation of sciatica (2), compressive haematoma (2), deep venousthrombosis (1), local wound haematoma (1)
Kanakamedala	2023	6.4 [1.6–18.4]	sciatic nerve sensory issues (2), deep vein thrombosis and pulmonary embolism (1), atraumatic re-rupture (1), superficial wound infection (1), chronic draining sinus tract (1)
Lefèvre	2025	5.4 [14.2–14.9]	*Not applicable*
Rothrauff	2025	*Not applicable*	*Not applicable*
Chocholáč	2023	2	superficial wound infection (1), local skin-dehiscence (1)
Johnson	2022	4	*Not applicable*
Pihl	2024	2.6 [1.9–3.1]	Surgical site infections (1), Neurologic (3), Thromboembolic (3), Rerupture (1), Other (1)
Kaila	2023	54.8 [1-358]	Suture knot abscess (1)
Maldonado	2021	66.73 (25.31) [5.14-215.14]	posterior thigh numbness (2), hematoma (1), sciatic neurapraxia (1)
Lefèvre	2025	6.8 [3.0–29.3]	Rerupture (15), Hyperesthesia of posterior thigh (4), Superficial scar inflammation not necessitating antibiotics (1), Superficial infection necessitating antibiotics (1), Deep venous thrombosis with pulmonary embolism (1), Contralateral rupture (1)
Pihl	2019	2.6 (2.4)	postoperative pulmonary thrombosis (1), wound infection (1), severe persistent pain postoperatively (1)
Best	2021	5.7 (12.8) [1-76]	*Not applicable*
Bowman	2019	25.1 (50.9)	minor wound infections (3), unresolved numbness at the surgical site (2), continued cramping, pain or fatigue in the hamstrings (4)
Lefèvre	2024	11 (29.9)	superficial infection (1), re-rupture (2)
Spoorendonk	2024	2.1 [1.6-4]	*Not applicable*
Bajwa	2021	[0.4-5.9]	*Not applicable*
van der Made	2022	4.3	*Not applicable*
Ebert	2019	48 [30-77]	Deep vein thrombosis (1), irritable staple from previous operation (1)

Sanderson	2020	3	*Not applicable*
Wilson	2017	26.4	motor deficit (2), sensory deficit (1), pain (1)
Skaara	2013	2.43	superficial wound infection (2), injury of the posterior femoral cutaneous nerve (1)
Olowofela	2023	*Not applicable*	*Not applicable*
Sallay	2008	11.91 [0.71-83.86]	stiffness with strenuous activity (4), constant stiffness (2), DVT (chronic - 1)
Salido	2023	12.67 (11.55)	*Not applicable*
Kirkland	2008	*Not applicable*	*Not applicable*
Kayani	2020	35.1 (7.7) [25.7-60]	chronic regional pain syndrome (1), bruising distal of operative site (4), superficial wound infection (1)
Falotico	2025	4.93 (3.77) [.28-12]	0 complications
Lefevre	2024	24.4 (41.1)	Compressive hematoma (1), Pulmonary embolism (1), pudendal nerve paresthesia (1), Re-rupture (2)
Subbu	2015	9.31 [5-512]	superficial wound infection (6), local neural symptoms (12)
SD: standard deviation; N: number of patients.			

Table 2: Complications based on mean time to surgery for proximal hamstring.

Complication Categories	Total # of Patients with Repair ≤6wks	Total # of Patients with Repair >6wks	Total # with Complication + Repair ≤6wks	Total # with Complication + Repair >6wks	Odds Ratio (OR)	OR LL 95% CI	OR UL 95% CI	OR p-value	Chi-squared statistic	Chi-squared p-value
Hematoma/Bruising (hematoma, compressive hematoma, local wound hematoma, bruising, bleeding)	596	230	2	3	0.25	0.04	1.53	0.135578	2.588743	0.107626
Infection (infection, cellulitis, abscess, superficial/deep wound infection, sinus tract, scar inflammation)	430	660	5	10	0.76	0.26	2.25	0.626517	0.238185	0.62552
Neurologic (numbness, neuropathy, nerve injury, paresthesia, sensory deficit, hyperesthesia, neural symptoms)	329	627	2	9	0.42	0.09	1.96	0.268921	1.299083	0.254381
Pain/Stiffness (pain, stiffness, cramping, sciatica, chronic regional pain syndrome (CRPS))	596	201	2	6	0.11	0.02	0.55	0.007018	10.618492	0.00112
Re-rupture (re-rupture, contralateral rupture, atraumatic re-rupture)	88	487	2	5	2.24	0.43	11.74	0.339271	0.96226	0.326618
Thromboembolic (DVT/PE) (deep vein thrombosis (DVT), pulmonary embolism (PE), thromboembolic event)	356	329	2	5	0.37	0.07	1.90	0.231705	1.551325	0.21294
Other (subcutaneous scarring, draining sinus, other miscellaneous)	77	95	3	1	3.81	0.39	37.39	0.250864	1.513811	0.218559

Table 3: Odds ratio and chi-square statistic by type of complication for mean time to surgery above and below 6 weeks.

Complication Categories	Total # of Patients with Repair ≤8wks	Total # of Patients with Repair >8wks	Total # with Complication + Repair ≤8wks	Total # with Complication + Repair >8wks	Odds Ratio (OR)	OR LL 95% CI	OR UL 95% CI	OR p-value	Chi-squared statistic	Chi-squared p-value
Hematoma/Bruising (hematoma, compressive hematoma, local wound hematoma, bruising, bleeding)	596	230	2	3	0.25	0.04	1.53	0.135578	2.588743	0.107626

Infection (infection, cellulitis, abscess, superficial/deep wound infection, sinus tract, scar inflammation)	651	439	8	7	0.77	0.28	2.13	0.612287	0.258294	0.611295
Neurologic (numbness, neuropathy, nerve injury, paresthesia, sensory deficit, hyperesthesia, neural symptoms)	512	444	4	7	0.49	0.14	1.69	0.259768	1.322444	0.250154
Pain/Stiffness (pain, stiffness, cramping, sciatica, chronic regional pain syndrome (CRPS))	596	201	2	6	0.11	0.02	0.55	0.007018	10.618492	0.00112
Re-rupture (re-rupture, contralateral rupture, atraumatic re-rupture)	416	159	5	2	0.95	0.18	4.97	0.956373	0.002993	0.956369
Thromboembolic (DVT/PE) (deep vein thrombosis (DVT), pulmonary embolism (PE), thromboembolic event)	539	146	4	3	0.36	0.08	1.61	0.180012	1.95714	0.16182
Other (subcutaneous scarring, draining sinus, other miscellaneous)	77	95	3	1	3.81	0.39	37.39	0.250864	1.513811	0.218559

Table 4: Odds ratio and chi-square statistic by type of complication for mean time to surgery above and below 8 weeks.

Discussion

Favorable postoperative outcomes and minimal complications were seen when proximal hamstring repairs were treated within 6 weeks of injury. Pain and stiffness was the only statistically significant complication of our findings after surgical delay. This suggests orthopedic surgeons may effectively repair proximal hamstring tears despite surgical delay, but should be mindful of possible stiffness and pain postoperatively.

Patient Outcomes after Surgical Delay

Shorter time to surgery was generally associated with superior post-operative outcomes, which is consistent with previous studies that had demonstrated better outcomes in pain relief4, strength recovery1, return to sports and outcome scores [3,4,10]. Specifically, expedited time to surgery was associated with improvements in several patient-reported measures, including PHAS, HOS-ADL, HOS-Sports, LEFS, VAS. These combined findings support existing recommendations that timely surgical repair optimizes restoration of function and minimizes chronic pain or strength deficits1.

However, the results for some outcome measures suggest that the optimal window for surgery may lie after the acute phase of intervention. That is, for SF-12 and PHAT, the highest scores appeared sometime between 10- and 20-weeks average time to surgery. Several authors had mentioned that, for some patients, the surgical approach was only taken after failure of conservative management of hamstring avulsions, which may provide an explanation for an increase in outcome measures later on [11,12]. Such an approach could allow for spontaneous improvement in partial injuries, while still achieving favorable outcomes when surgery is ultimately required.

Overall, while the aggregate evidence supports earlier surgical repair for optimal recovery, these findings suggest that in certain patient populations, particularly those undergoing an initial trial of conservative management, a moderate delay before surgery does not necessarily preclude favorable functional outcomes.

Complications after Surgical Delay

Fourteen papers reported no post-operative complications. Eight of these had a mean time to surgery of less than five weeks, suggesting that early intervention is associated with a lower incidence of complications. This trend is consistent with prior findings that early repair facilitates easier tendon mobilization and reattachment by minimizing fibrosis, scarring and muscle retraction, all of which can increase technical difficulty and surgical risk when surgery is delayed [10]. The remaining papers that did not report complications included one with an average delay of 12.7 weeks and one with an average delay of 30.1 weeks [14,15]. These cases suggest that while earlier surgery may be protective, complication rates are also likely influenced by additional factors such as patient selection, surgical technique, postoperative rehabilitation and reporting practices. For instance, one paper with an average time to surgery of 12.7 weeks only had three patients who went through surgical intervention14 and one paper had a cohort composed entirely of professional athletes [16].

In contrast, 23 studies documented at least one postoperative complication. The most common included wound infection, deep vein thrombosis, re-rupture and neurological symptoms, which are in line with previously described risks following hamstring repair [17]. These papers represent a wide range of average delays, from 2 weeks to 66 [7]. Two studies mention "stiffness" as a complication, one with an average time to surgery of 11.9 weeks18 and six patients experiencing some kind of stiffness and another with an average time to surgery of 19.3 weeks and six patients experiencing stiffness [19]. In addition, "hematoma" only appeared in three studies with an average time to surgery of 24.4 weeks and above which may suggest that delayed surgical intervention carries a risk of additional complications beyond those typically expected for hamstring repair [3,20,21]. Pain/stiffness was the only complication category to demonstrate a statistically significant association with surgical delay in our threshold analysis (Table 3,4). Interventions after both the 6-week and 8-week cutoffs were associated with higher odds of pain/stiffness (OR 0.11; 95% CI 0.02-0.55), suggesting that delayed repair may be associated with increased risk of postoperative pain and stiffness. This can possibly guide future counseling and informed decision-making with patients that are considering surgical treatment options for proximal hamstring tears.

Barriers leading to Surgical Delay

Patients' social influencers of health could act as barriers to timely proximal hamstring repair. Factors such as limited access to specialty care, transportation difficulties and socioeconomic status can delay both injury diagnosis and referral to surgery [22,23]. Insurance-related barriers, such as a lack of coverage for advanced imaging (MRI) or specialist visits, can further delay surgical intervention, especially given MRI's status as the gold standard for diagnosis and treatment decisions [24]. Patients with lower health literacy or limited resources are more susceptible to delays in presentation and referral and such delays are associated with worse functional outcomes and a greater risk of re-rupture [25]. Re-rupture rates are higher in patients with injury-to-surgery delays greater than 32 days [25]. Insurance approval processes and preauthorization requirements can further extend a patient's time to surgery, magnifying the impact of socioeconomic disparities on care [26]. Hospital-related barriers can also delay timely intervention, including institutional factors such as operating room availability, hospital overflow and resource allocation, which can lead to scheduling delays for elective procedures such as proximal hamstring repair. Cost constraints may also limit access to specialized surgical tools or endoscopic equipment, particularly in settings with limited resources potentially restricting the use of minimally invasive techniques that may offer faster patient recovery [27]. Technical complexity and longer operating times for chronic repairs also contribute to scheduling challenges, as acute repairs are less complex and require less operative time [28]. Institutional prioritization of higher-acuity cases and limited availability of surgeons experienced in hamstring repair further exacerbate delays, which are associated with inferior outcomes and increased complication rates when surgery is postponed [26].

Limitations

This systematic review is subject to several limitations inherent to the available evidence. The heterogeneity of the included studies was pronounced in terms of outcome measures, sample sizes and follow-up durations, limiting the comparability of results across studies. Another limitation is this heterogeneity made it difficult to generate weighted regressions, so all articles were standardized as the same weight for our linear regression tests. Outcome-reporting and complication-reporting were also inconsistent across articles, making it challenging to identify trends and quantify complication rates with consistent risk factors. Several studies that reported no complications did not explicitly describe their methods for capturing adverse events and minor complications may have gone undocumented. Specifically, the smaller number of pain/stiffness events detected in our timing analyses limits our ability to make definitive conclusions and emphasizes the need for higher-quality prospective data. Most included studies were levels III-IV, with only two RCTs, limiting the ability to establish causation and meta-analysis. Many studies also lacked preoperative functional data, limiting the ability to objectively quantify postoperative improvement.

Conclusion

This systematic review found that earlier surgical repair of proximal hamstring tears is generally associated with improved functional outcomes and fewer complications, reinforcing the current recommendations for timely intervention. Complications such as pain/stiffness were significantly present after surgical delay and should still be considered in treatment plans and confirmed in future studies. Several other outcomes showed many patients still did well despite moderate delays. Inevitable delays can result from socioeconomic barriers to timely care or alternative treatment approaches such as initial conservative management of the rupture. Nonetheless, patient- or system-level barriers may still diminish outcomes following surgical delay, which prompts a call for action against these barriers in the field.

Conflict of Interest

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Data Availability Statement

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Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement

Informed consent was taken for this study.

Authors' Contributions

All authors contributed equally to this paper.

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