Acute or chronic pectoralis major tendon rupture repaired with direct suture: Clinical and functional outcomes with a mean follow-up of 5 years

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Background: Acute pectoralis major tendon ruptures can be treated with direct tendon repair, while chronic ruptures may benefit from graft.

Purpose: To assess the clinical and functional outcomes after direct tendon repair through suture anchors in both acute and chronic tendon rupture of pectoralis major.

Methods: A retrospective chart review of consecutive patients of a single surgeon who underwent direct tendon repair of both acute and chronic (6 weeks post injury) pectoralis muscle rupture was performed. Outcomes collected were shoulder ranges of motion (flexion, abduction, external rotation, internal rotation), functional recovery during follow-up (subjective shoulder value; SSV), score of the American Shoulder and Elbow Surgeons (ASES), Bak criteria, auto-Constant score, patient satisfaction and complications.

Results: A total of 15 patients (mean age, 34.3 years) were analyzed: 6 with acute and 9 with chronic pectoralis major rupture. Mean (SD) follow-up was 5.2 (3.4) years (minimum, 2.2 years). Shoulder movement parameters were satisfying both in the acute and chronic rupture groups. Mean (SD) SSV was 88.3 (9.3) for acute and 87.8 (10.9) for chronic tendon rupture. Mean (SD) ASES scores were 95.8 (5.3) and 95.9 (4.8), respectively. Bak criteria were good or excellent in 6 (100%) and 7 (78%) patients, respectively. Mean (SD) auto-Constant total score was 98.3 (2.0) for acute rupture and 98.0 (3.0) for chronic rupture. All acute rupture patients were satisfied, and 7 of 9 (78%) patients with chronic rupture. The two dissatisfied patients were those with the longest repair delay (83 and 99 weeks). No other surgery and no complications were reported during the follow-up.

Conclusion: Direct tendon repair for both acute and chronic pectoralis major tendon rupture led to satisfactory clinical and functional results up to a mean of 5 years after surgery.

What this study adds: The number of cases of pectoralis major muscle rupture reported in the literature remains limited, particularly for chronic ruptures that may benefit from graft. This study reports 15 cases of pectoralis major muscle rupture (6 acute and 9 chronic) all repaired with direct suture.

Potential impacts on research, practice, or policy: Direct tendon repair is technically possible in chronic ruptures and satisfying outcomes can be obtained 6 weeks or more after the rupture.

Type of Study: Retrospective study with no comparison group

Level of Evidence: Level IV

Keywords: Shoulder injury; Pectoralis major; Tendon rupture; Muscle tendon repair; Sports injury

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INTRODUCTION

The pectoralis major muscle, a large and powerful muscle located in the anterior chest wall, plays a pivotal role in shoulder adduction, internal rotation, and flexion [1]. Ruptures of this muscle, though relatively uncommon, predominantly occur in active young individuals and athletes, particularly during activities involving heavy lifting or abrupt, forceful movements, specifically during bench-press movements [2]. A correlation with anabolic steroid use has also been shown [3]. These injuries can significantly impair upper body function and aesthetics, necessitating timely and effective surgical intervention to ensure optimal recovery [4].

The pectoralis major muscle includes two heads, the clavicular and the sternal head, both of which converge in two layers, where the clavicular layer stays superficially to the sternal layer, to attach to the humerus [5]. Ruptures typically occur at the tendon near this humeral insertion [6][7]. In most injuries, the

sternal layer is involved, a complete tear of both clavicular and sternal heads is uncommon. The surgical management of pectoralis major tendon ruptures involves reattaching the tendon to its anatomic footprint on the humerus, aiming to restore the original biomechanics and functions of the muscle. Various surgical techniques have been described in the literature, including direct suture repair, suture anchors, and autograft or allograft reconstruction in cases of chronic rupture [5]. Early surgical intervention is generally preferred, as it is associated with better functional recovery and lower complication rates compared to delayed repair [8].

The aim of this study was to report clinical and functional outcomes of a monocentric retrospective case series after direct pectoralis major tendon repair in both acute and chronic cases.

MATERIALS AND METHODS

Study design and patient eligibility

This was a retrospective case series study of patients who had undergone direct suture repair through suture anchors of acute and chronic of pectoralis tendon rupture. The objective of this study was to assess clinical and functional outcomes in patients with acute and chronic pectoralis major muscle rupture repaired with direct suture. Chronic rupture was defined as surgical management at least 6 weeks after the injury.

Consecutive patients were eligible if they had been operated between December 2011 and December 2021 in our center for a pectoralis major tendon rupture, either acute or chronic. All patients were operated with direct suture by the same surgeon.

The study was conducted in accordance with the Declaration of Helsinki. The study was non-interventional and did not modify usual medical care. It complied with the French regulatory methodology MR-004 for studies in the field of health. Patients were informed of the objectives and conditions of the study, and could object to their participation.

Surgical technique for pectoralis major tendon suture

A 10-cm incision was made in the deltopectoral approach, along the anterior border of the deltoid, slightly medial to find the tendon of the pectoralis major. The torn end of the pectoralis tendon was identified, even though it is sometimes retracted, especially in chronic cases. Most of the time, the tendon was not so retracted, even in some chronic cases, due to the adhesions. Any scar tissue or adhesions around the superficial and deep tendon and muscle were gently removed, taking care of the medial and lateral pectoral nerves. Then, the footprint of the pectoralis major tendon was exposed. A Hoffman retractor was placed on the lateral cortex of the proximal humeral diaphysis, on the deep side of the deltoid (**Figure 1**). The anatomic insertion of the pectoralis major tendon is on the lateral lip of the intertubercular groove, lateral to the insertion of the latissimus dorsi and teres major, approximately 4 cm distal to the anatomical neck of humerus. The footprint was sharpened and decorticated with curette or punching scissors. Once the preparation was done, 3 non-resorbable wires No2 (Tornier) were used and Mason-Allen stitch was made on the pectoralis major tendon (upper, middle and lower part).

The anatomical humeral insertion of the pectoralis major tendons was restored using 3 anchors 1 cm apart on the outer edge of the long biceps groove at the inferior part below the subscapularis tendon insertion (**Figure 1**). Each wire was inserted in one corresponding piton 3.5-mm knotless fixation implant (piton implant manufacturer: historically, Tornier®, then Wright® and now Stryker®). A pilot hole was made with a 3.5 mm drill and each anchor was introduced into the anatomical zone of the pectoralis major tendon fixation. At that time, the arm was in slight internal rotation and adduction to reduce the tension. Each suture was progressively pulled to reduce the lesion from proximal to distal, thanks to the Mason-Allen knot which is a gliding system. The suture was reinforced with the wire provided with the anchor by making additional knots. After irrigating the surgical site and the wound, the subcutaneous tissue and the skin were closed in a standard way.

The postoperative protocol was the same for acute and chronic cases. After the operation, the patient remained in the sling for 6 weeks after surgery: 3 weeks with a strict immobilization and then the patient started passive mobility in balneotherapy and at home on his/her own. At 6 weeks, the patient stopped wearing the sling and could use is arm for daily activity. Strength exercises could be started at 3 months.

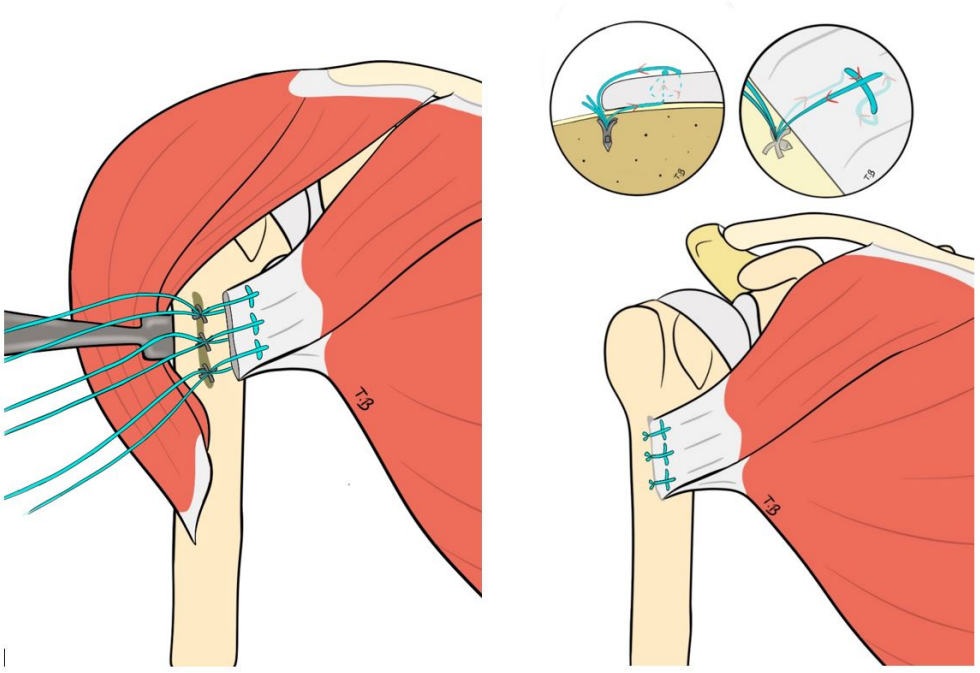


Figure 1. Overview of the surgical technique for pectoralis major tendon rupture repaired with direct suture.

Data collected

Study data collected in patient files were age, time between injury and surgery, operated side, dominant side, use of steroids, type of trauma, sport and level before trauma. The following data were obtained at the last follow-up visit (clinical visit or video call): follow-up duration, sport and level after trauma, return to work, palpation of tendon and type of tendon, asymmetry/hollow compared to contralateral side, loss of strength, satisfaction, shoulder ranges of motion, subjective shoulder value (SSV), score of the American Shoulder and Elbow Surgeons (ASES), Bak criteria, auto-Constant score, other surgery and complications.

The subjective shoulder value (SSV) is defined as a patient's subjective shoulder assessment which is expressed as a percentage of a completely normal shoulder (from 0% to 100%, with 100% being normal) [9].

The ASES (American Shoulder and Elbow Surgeons) score is a standardized questionnaire designed to measure pain and functional limitations in patients suffering from musculoskeletal disorders of the shoulder and elbow [10]. It is a composite score assessing pain, mobility, strength, stability and function. The ASES score is a 100-point scale with two assessment dimensions: pain and activities of daily living [11].

The Bak criteria evaluate the functional outcome of shoulder after pectoralis major tendon repair [6]. These criteria associate three subjective parameters (pain, cosmetic complaints and activities) and two objective parameters (range of motion and strength) which are rated from "poor" to "excellent".

The Constant-Murley score provides a subjective and objective clinical assessment of shoulder function. The "Auto-Constant" questionnaire is made up of closed-ended questions accompanied by photographs, and patients are asked to tick the boxes corresponding to their situation. This self-administered questionnaire, which provides a good assessment of the Constant-Murley score in daily practice, includes all the Constant-Murley items: Pain, Activity, Mobility and Strength [12].

Statistical analysis

Descriptive statistics were used to analyze the data of this case series. Two groups of patients were described: patients with acute pectoralis major rupture, defined as patients who received early intervention (< 6 weeks), and patients with chronic rupture, defined as patients operated at a distance from the initial injury (≥ 6 weeks). Qualitative data were described using the frequency and percentage. Quantitative data were described using mean and standard deviation (SD). All calculations were made with SAS for Windows (v 9.4; SAS Institute Inc).

RESULTS

Patient disposition and characteristics

Sixteen male patients with pectoralis major muscle rupture operated from December 1, 2011 and December 12, 2021 were screened. All patients had been repaired with direct suture. One patient had no follow-up and was excluded. Fifteen patients were included in the analysis population: 6 with acute rupture and 9 with chronic rupture. Among the 9 patients with chronic

rupture, delay repair was > 1 year in 4 of them (80, 82, 83 and 99 weeks).

The mean age of patients was 34.3 (8.1) years (**Table 1**). They all practiced sports and none reported using steroids. The most frequent sports practiced before trauma were rugby (n=5), bodybuilding (n=4), mountain bike (n=4) and swimming (n=2). Prior to the trauma, they practiced sport as a leisure activity (n=9), in competition (n=4) or professionally (n=2). Trauma occurred mainly during rugby (n=5) and bench press (n=3).

The mean (SD) time between injury and surgery was 1.9 (0.6) weeks in case of acute rupture and 45.6 (39.0) weeks in case of chronic rupture (**Table 1**).

Shoulder function and outcomes during follow-up

The mean (SD) follow-up time was 5.2 (3.4) years (minimum, 2.2 years) (**Table 1**). The tendon was tight on palpation in 1 (17%) patient with an acute rupture and in 7 (78%) with a chronic rupture. Asymmetry or hollow was reported in 3 (50%) and 6 (67%) patients, respectively. There was a significant loss of strength in 2 (22%) patients with chronic rupture and in none with acute rupture.

All patients have returned to work. All patients in acute group practiced the same sport and 2 patients in the chronic group practiced another sport. Sport was practiced at the same level for all patients in acute group and 6 (67%) patients in chronic group.

All patients of the acute group were satisfied of the surgery and 7 (78%) of the chronic group (**Table 2**). Reasons for dissatisfaction were loss of strength (n=1) and aesthetics plus loss of strength (n=1). The two dissatisfied patients had the longest repair delays of the series (> 1 year).

Table 1. Patient characteristics

	Acute rupture (N=6)	Chronic rupture (N=9)	Analysis population (N=15)
Age, years			
Mean (SD)	33.8 (11.3)	34.7 (5.9)	34.3 (8.1)
Min; Max	26; 52	25; 41	25; 52
Male gender, n (%)	6 (100)	9 (100)	15 (100)
Time between injury and surgery, weeks			
Mean (SD)	1.9 (0.6)	45.6 (39.0)	28.1 (36.9)
Min; Max	1.3; 3.0	6.1; 98.9	1.3; 98.9
Follow-up duration, years, mean (SD)			
Mean (SD)	3.6 (1.0)	6.3 (3.9)	5.2 (3.4)
Min; Max	2.4; 5.5	2.2; 12.3	2.2; 12.3
Operated side, n (%)			
Right	4 (66.7)	7 (77.8)	11 (73.3)
Left	2 (33.3)	2 (22.2)	4 (26.7)
Dominant side, n (%)			
Right	6 (100)	8 (88.9)	14 (93.3)
Left	0	1 (11.1)	1 (6.7)
Use of steroids, n (%)	0	0	0

Table 2. Clinical examination during follow-up

	Acute rupture (N=6)	Chronic rupture (N=9)	Analysis population (N=15)
Aesthetic aspect Type of tendon, (%)			
Tight	1 (16.7)	7 (77.8)	8 (53.3)
Normal	5 (83.3)	2 (22.2)	7 (46.5)
Asymmetry/hollow, n (%)	3 (50.0)	6 (66.7)	9 (60.0)
Loss of strength, n (%)	3 (50)	6 (66.7)	9 (60)
Significant	0	2 (22.2)	2 (22.2)
Small	3 (50)	4 (44.4)	7 (77.8)
Patient satisfaction, n (%)	6 (100)	7 (77.8)	13 (86.7)

Shoulder ranges of motion were satisfying both for acute and chronic ruptures (**Table 3**).

Functional scores were satisfying both for acute and chronic groups: mean (SD) SSV was 88.3 (9.3) for acute and 87.8 (10.9) for chronic tendon rupture; mean (SD) ASES scores were 95.8 (5.3) and 95.9 (4.8), respectively; mean (SD) auto-Constant total score was 98.3 (2.0) for acute rupture and 98.0 (3.0) for chronic rupture (**Table 4**). Bak criteria were good or excellent in 6 (100%) and 7 (78%), respectively.

The two patients with Bak criteria scored as fair were those for whom the delay repair was the longest (83 and 99 weeks) (**Figure 2**). MRI did not evidence atrophy or fatty infiltration.

No other surgery and no complications were reported during the follow-up.

Table 3. Shoulder ranges of motion during follow-up

	Acute rupture (N=6)	Chronic rupture (N=9)	Analysis population (N=15)
Flexion, n (%)			
170°	1 (17)	2 (22)	3 (20)
180°	5 (83)	7 (78)	12 (80)
Abduction, n (%)			
170°	1 (17)	2 (22)	3 (20)
180°	5 (83)	7 (78)	12 (80)
External rotation, n (%)			
40°	3 (50)	5 (56)	8 (53)
50°	1 (17)	1 (11)	2 (13)
70°	2 (33)	1 (11)	3 (20)
80°	0	2 (22)	2 (13)
Internal rotation, n (%)			
T5	0	1 (11)	1 (7)
T7	2 (33)	6 (67)	8 (53)
T8	1 (17)	0	1 (7)
T10	1 (17)	0	1 (7)
T12	2 (33)	2 (22)	4 (27)

DISCUSSION

Shoulder ranges of motion and functional scores were satisfying both in acute and chronic ruptures in this series of young sportsmen or athletes who had suffered a pectoralis major tendon rupture repaired with direct suture. Only Bak criteria, which grades the outcomes of pectoralis major repair, suggested a difference between acute and chronic groups: the two patients with fair outcome belonged to the chronic group (no patient was rated as poor) and had the longest repair delays of the series. In addition, asymmetry or hollow, loss of strength and palpation of tight tendon were more frequent in chronic group than in acute group. A change of sport or not practicing at the same level was reported only in the chronic group. Therefore, the only two dissatisfied patients were in the chronic group. No complication and no other surgery were reported during the follow-up regardless the group.

The number of cases of rupture of the pectoralis major muscle reported in the literature remains limited especially for chronic rupture. Kretzler and Richardson reported a retrospective case series of 19 patients (including 14 patients with time from injury to repair > 1 month), of whom 16 underwent surgery [13]. No grafts were used during surgery. Thirteen patients returned to full strength and 15 regained full range of motion. Schepsis *et al* reported a retrospective case series of 17 cases of pectoralis major muscle rupture (including 7 cases of chronic rupture) with a mean follow-up of 28 months [14]. No grafts were used to repair tendon rupture. Overall subjective ratings achieved 93% in the chronic group. There were no statistically significant differences for subjective or objective outcomes between patients with acute or chronic injuries. In their retrospective case series in active-duty military personnel, Antosh *et al* reported 14 cases of pectoralis major muscle rupture, including 6 repaired after 6 weeks [15]. Among patients with chronic rupture, the surgical outcomes were good to excellent in 3 out 6. There was a statistically significant difference between outcomes for the acute and chronic groups, with acute group achieving better score for functional scores. There was a 30–40% loss of objective strength after surgery in patients in the acute group. Äärimaa *et al* reported data from a meta-analysis including 73 cases of pectoralis major muscle ruptures compiled from literature single case studies or case series (29 studies), including 19 patients with chronic injury who underwent repair surgery [2]. For these patients, final outcome was excellent for 8 and good for 11. However, early operative

treatment was associated with better outcome than delayed treatment. In the case series of 12 men reported by Merolla *et al*, 8 patients with acute rupture were treated with direct tendon repair and 4 with chronic rupture received allograft reconstruction [16]. Outcomes were good for 3 patients and excellent for 9. Strength assessment was satisfying both for acute and chronic rupture. There was nevertheless a slight but significant poorer performance for internal rotation in chronic patients.

Table 4. Functional scores during follow-up

	Acute rupture (N=6)	Chronic rupture (N=9)	Analysis population (N=15)
SSV			
Mean (SD)	88.3 (9.3)	87.8 (10.9)	88.0 (10.0)
Min; Max	70; 95	70; 100	70; 100
ASES score			
Mean (SD)	95.8 (5.3)	95.9 (4.8)	95.9 (4.8)
Min; Max	87; 100	87; 100	87; 100
Bak criteria			
Excellent	3 (50.0)	5 (55.6)	8 (53.3)
Good	3 (50.0)	2 (22.2)	5 (33.3)
Fair	0	2 (22.2)	2 (13.3)
Auto-Constant score, mean (SD)			
Pain	0.5 (0.8)	0.4 (0.7)	0.5 (0.7)
Daily living	19.8 (0.4)	19.6 (1.0)	19.7 (0.8)
Movement	39.0 (1.1)	39.6 (0.9)	39.3 (1.0)
Strength	25.0 (0.0)	24.3 (2.0)	24.6 (1.5)
Total score	98.3 (2.0)	98.0 (3.0)	98.1 (2.5)

ASES, American Shoulder and Elbow Surgeons; SSV, subjective shoulder value.

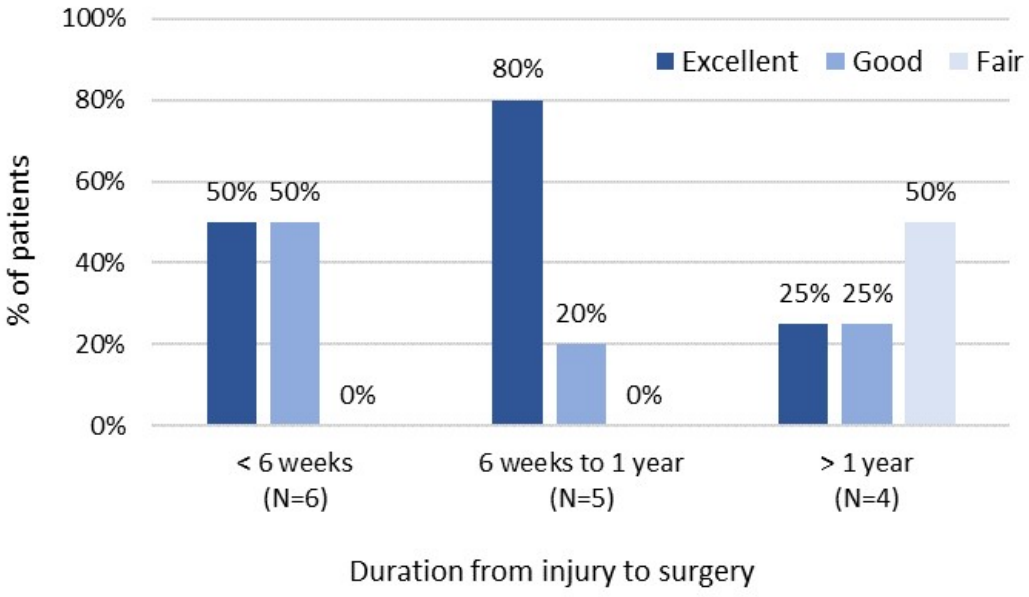


Figure 2. Bak criteria according to duration from injury to surgery.

Overall, the case series and meta-analyses from literature indicate that most patients with chronic rupture had good or excellent outcomes. Nevertheless, strength, patient satisfaction for results and aesthetic appearance are slightly poorer in patients with delayed repair. Early intervention is recommended for young people with rupture of pectoralis major and conservative treatment is preferred for older patients, partial tendon tears and muscle belly rupture because surgery is associated with a poor prognosis in these patients [6][17][18].

Chronic pectoralis major muscle ruptures have characteristics that may require different management from acute ruptures. Indeed, chronic ruptures lead to significant anatomical changes, including muscle atrophy, fibrosis, tendon retraction, and scar tissue formation, which are not present or are minimal in acute ruptures [2][19][20][21]. As a consequence, chronic ruptures are at higher risk of complications, including incomplete healing, persistent weakness, reduced range of motion, and cosmetic deformity. Chronic cases also have a higher likelihood of requiring revision surgeries or accepting some degree of permanent impairment. For this reason, delay in diagnosis has important consequences on the management of chronic rupture: a direct repair is not always possible and reconstruction using graft is often needed [22][23][24]. Our study shows that direct tendon repair is technically possible in chronic patients and satisfying outcomes can be obtained after 6 weeks. Nevertheless, for treatment beyond one year, it is important to inform the patient that results are less certain than if the operation had been performed earlier. This raises the question of whether it is necessary to change the technique for patients operated on with a delay of more than one year and propose a graft. However, the design of our study does not allow to answer this question.

This study has some limitations. Some of them are inherent to a retrospective analysis and a selection bias cannot be excluded. The number of patients in this case series was small, as pectoralis major rupture remains an uncommon injury (16 cases in our center over 10 years). Therefore, no subgroup comparisons were performed. Video-call post-operative visits and the absence of post-operative imaging assessing tendon integrity are also limitations. The sample size of this case series is nevertheless among the largest reported in the literature. The study was monocentric and all surgical procedures were performed by the same surgeon. This ensures the homogeneity of the data, but the generalization of the results requires some precautions.

Conclusion

Direct tendon repair for both acute and chronic rupture of pectoralis major led to satisfactory clinical and functional results up to a mean of 5 years after surgery.

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Conflicts of interest

AG: consultant for Arthrex, Conmed, Move Up and VIMS; royalties from Stryker and Move Up. No conflict of interest for LB, GL, FB, GF, JC and YC.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Use of artificial intelligence in the writing process

The authors did not use any generative AI or AI-assisted technologies to write this manuscript.

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