Journal of Orthopaedic Surgery and Research

RESEARCH

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Polypropylene mesh reinforcement does not improve acute biomechanical properties in superior capsular reconstruction: an ovine model study

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Abstract

Background Superior capsular reconstruction (SCR) is a treatment option for irreparable rotator cuff tears (IRCTs), yet graft failure remains a significant limitation. While fascia (FA) grafts are commonly used, postoperative outcomes can be suboptimal, potentially contributing to higher mechanical failure rates. Polypropylene mesh (PM) augmentation has shown promise in improving soft-tissue repair strength, but its acute biomechanical efficacy in SCR remains insufficiently investigated. This study aimed to evaluate whether PM augmentation enhances the biomechanical stability of FA grafts in SCR using an ovine model.

Methods Ten fresh-frozen ovine cadaveric shoulders were used to model IRCT. Only one shoulder per animal was included to ensure specimen independence. Specimens were randomly assigned to two treatment groups: FA-only SCR (FA-SCR) and PM-reinforced FA-SCR (PMFA-SCR). In the PMFA-SCR group, the mesh was placed within the FA graft prior to folding and suturing. Grafts were fixed to the glenoid and humerus using suture anchors, with two anchors placed on the glenoid anterosuperior/posterosuperior and two on the humerus footprint anterior/posterior in all specimens. Biomechanical testing was conducted with a custom device, with specimens mounted at 30° abduction. Dynamic testing involved cyclic loading from 10 to 50 N at 1 Hz for 1000 cycles, with displacement and stiffness recorded. Immediately afterward, static load-to-failure testing was performed at a crosshead speed of 20 mm/min to determine the ultimate load, yield load, and failure mode. Data were analyzed using the Student's t-test.

Results FA-SCR and PMFA-SCR demonstrated similar biomechanical performance, with comparable displacements both at the initial stage ($p=0.74$) and after 1000 cycles ($p=0.83$). No significant differences were observed in cumulative displacement ($p=0.63$) or cyclic stiffness after the first or final cycle ($p=0.68$ and $p=0.82$). Static testing showed no significant differences in ultimate load-to-failure ($p=0.75$), displacement ($p=0.57$), yield load ($p=0.92$), or final stiffness ($p=0.69$).

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Conclusions In an acute ex vivo ovine model, PM augmentation did not improve the time-zero biomechanical performance of FA grafts in SCR, indicating that any potential benefit of mesh augmentation may be time-dependent and biologically mediated.

Level of evidence V

Keywords Superior capsular reconstruction, Rotator cuff tears, Irreparable rotator cuff tears, Polypropylene mesh, Biomechanical study, Ovine model, Fascia graft

Introduction

Irreparable rotator cuff tears (IRCTs) present substantial challenges in shoulder surgery due to their severe degenerative characteristics and persistently high rates of structural repair failure, reported to be as high as 94%.[1–4] The complexity of IRCTs arises primarily from significant tendon retraction with loss of elasticity, advanced muscle atrophy, and fatty infiltration, collectively rendering complete anatomical tendon reinsertion unfeasible. [3,5] Consequently, surgeons have explored various alternative treatment strategies, such as debridement, partial repair, or tendon transfers. [4,6–8] Of these, superior capsular reconstruction (SCR), pioneered by Mihata et al. in 2012, has emerged as an alternative for IRCTs, particularly in younger, active patients, as it directly addresses biomechanical instability resulting from loss of the superior capsule. [8–11] Despite promising initial outcomes, graft failure rates in SCR vary widely (5–36%), underscoring a critical need for improved graft materials that enhance mechanical durability. [10,12–16]

The integrity and biomechanical properties of the graft material used in SCR are crucial to its clinical success. Various graft materials, including autografts, allografts, xenografts, and synthetic grafts, have been extensively utilized, with fascia (FA) grafts showing promising clinical results. However, concerns remain about their biomechanical properties and failure rates, which range from 12 to 41%. [16–21] An ideal graft would provide robust mechanical reinforcement, support host tissue ingrowth, and exhibit excellent biocompatibility.[22–25] Polypropylene mesh (PM), commonly used in hernia repair, oncologic limb-salvage surgery, and total hip arthroplasty due to its superior tensile strength and favorable biocompatibility, is a promising candidate for augmentation in SCR. [26–28] Although preliminary studies have demonstrated the mechanical benefits of PM augmentation in rotator cuff repairs, its efficacy within SCR contexts remains underexplored. [20]

Prior biomechanical studies investigating SCR have compared various graft materials, including FA and PM mesh, yet none have assessed constructs combining FA grafts reinforced with PM. [9,17,29,30] Given the established potential of PM to significantly augment soft-tissue repairs, we hypothesized that augmenting FA grafts with PM would enhance biomechanical stability during SCR procedures for large rotator cuff tears. Therefore, this biomechanical study aims to compare the mechanical performance of PM-reinforced FA grafts (PMFA-SCR) with that of FA-only grafts (FA-SCR) within an ovine model to determine whether PM augmentation confers mechanical advantages in SCR procedures.

Material and methods

Specimen preparation

The study was approved by the local Institutional Review Board (IRB). All ovine cadaveric shoulders were obtained from a licensed local abattoir that routinely supplies biological specimens for educational and research purposes. The procurement process complied with institutional and national animal welfare regulations, and no live animals were euthanized specifically for this study. The ovine shoulder was selected as the experimental platform because the ovine infraspinatus tendon has been validated as an appropriate anatomical and biomechanical proxy for the human supraspinatus tendon.[31–34] Ten fresh-frozen, cadaveric, skeletally mature ovine shoulders were collected and stored at – 20°C until thawed. To ensure statistical independence, only one shoulder from each animal was included, and no bilateral specimens from the same ovine cadaver were used. After 24 h of thawing at room temperature, the supraspinatus, its tendon, and periarticular soft tissues were dissected to isolate the infraspinatus, simulating the IRCT model. [31]

Randomization and sample size

An a priori power analysis was conducted using G*Power (version 3.1) to determine the required sample size. The primary outcome measure was ultimate load-to-failure. We defined a clinically relevant difference as a 30% increase in load-to-failure compared to the control group. Based on this, we assumed a large effect size (Cohen's $d = 1.5$), set the alpha level (α) at 0.05, and the power ($1-\beta$) at 0.80. The analysis indicated that a minimum of four specimens per group was required. To account for potential specimen attrition or technical exclusions, five specimens were allocated to each group, for a total sample size of $N = 10$. The study was powered to detect a relatively large between-group difference in ultimate load-to-failure, and smaller differences may not have been detectable given the current sample size. A

random-number sequence was generated by an independent researcher to assign specimens to the two treatment groups (FA-SCR and PMFA-SCR).

Surgical procedure

One group underwent SCR using FA grafts alone (FA-SCR), while the other group received SCR with PM-reinforced FA grafts (PMFA-SCR). FA grafts were harvested from the same animal (ovine autograft) to ensure model consistency. FA dimensions were standardized post-harvest (4.0 × 3.0 mm; thickness: 2.0 ± 0.2 mm). Depending on the treatment group, the harvested FA grafts were folded three times, with or without the PM inside. For the PMFA-SCR group, a standard-weight, non-absorbable, knitted polypropylene monofilament mesh PM (PROLENE™, Ethicon Inc., Somerville, NJ) was utilized. The mesh was cut to match the dimensions of the unfolded fascia. The augmentation technique employed a "sandwich" configuration: the mesh was placed centrally on the fascia and folded three times along its longitudinal axis, ensuring it was encapsulated within the graft layers. To create the final patch (4.0 × 3.0 mm; thickness: 2.0 ± 0.2 mm), the construct was secured using a 2–0 Prolene running stitch around the perimeter, ensuring the needle passed through all layers of fascia and mesh to prevent internal delamination (Fig. 1). The FA-SCR group received an identical patch without PM reinforcement.

Two certified orthopedic surgeons performed all procedures. SCR was performed using the prepared graft (FA-SCR or PMFA-SCR) fixed to the glenoid and humeral head using suture anchors (FASTak™ Suture Anchor, 2.8 mm, Arthrex Inc., Naples, FL) (Fig. 2). A standardized four-anchor construct was used in all specimens. On the glenoid side, anchors were placed in the anterosuperior and posterosuperior regions, whereas on the humeral side, anchors were placed in the anterior and posterior portions of the rotator cuff footprint. During fixation to the glenoid and humerus, the suture limbs from the anchors were passed through the full thickness of the construct (fascia-mesh-fascia), thereby mechanically linking the mesh reinforcement directly to the bone anchors. Anchor number and placement were kept identical between groups to isolate the effect of mesh reinforcement. Anchor placement adhered to standardized anatomical coordinates: 1 mm medial to the glenoid rim and 1.5 mm lateral to the humeral articular margin (Fig. 3). Using these suture anchors, the patches were attached to the shoulder joint to treat the IRCT, ensuring consistent and reproducible graft placement and fixation. An overview of specimen preparation, graft construction variants, and subsequent transfer to the biomechanical testing device was provided in Fig. 4.

Biomechanical testing

After the surgical procedure, specimens were mounted on a custom-made biomechanical testing device, Raagen ETM-3-E (Raagen, Ankara, Türkiye). To mount the specimen in the holder, the entire specimen was inserted into the device by clamping the pots. A clamp was used to keep the humerus to maintain the glenohumeral joint

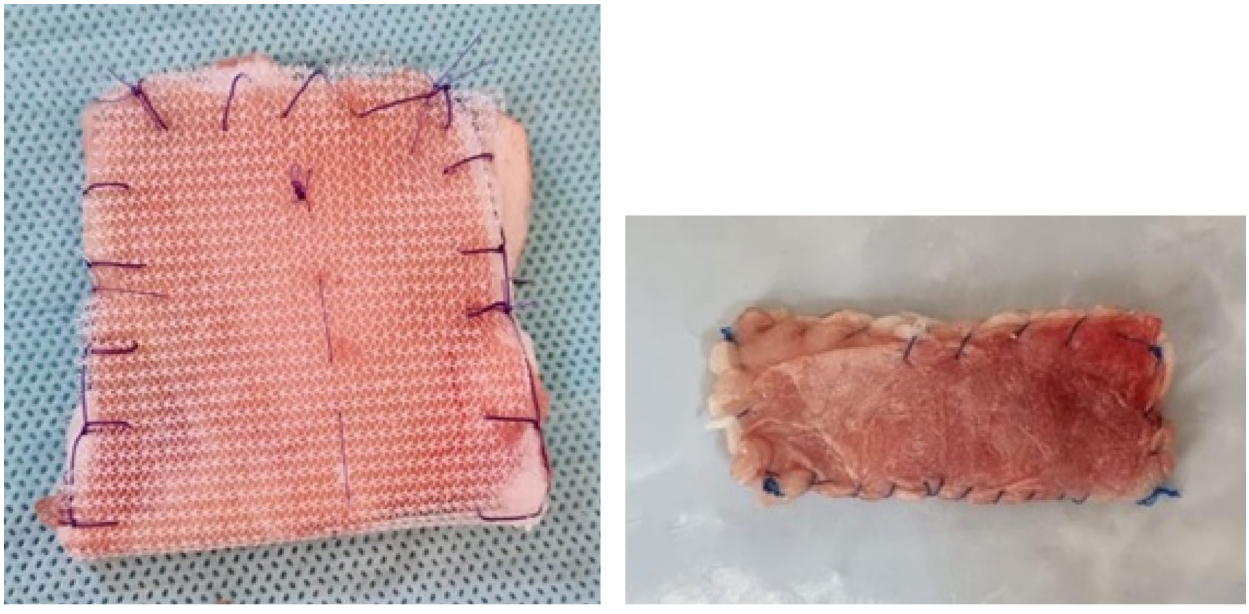


Fig. 1 Fascia (FA) grafts were folded three times and sutured along the edges. The images show the placement of polypropylene mesh into the grafts (**A**) and the final shape of each graft before being placed onto the shoulder model (**B**)

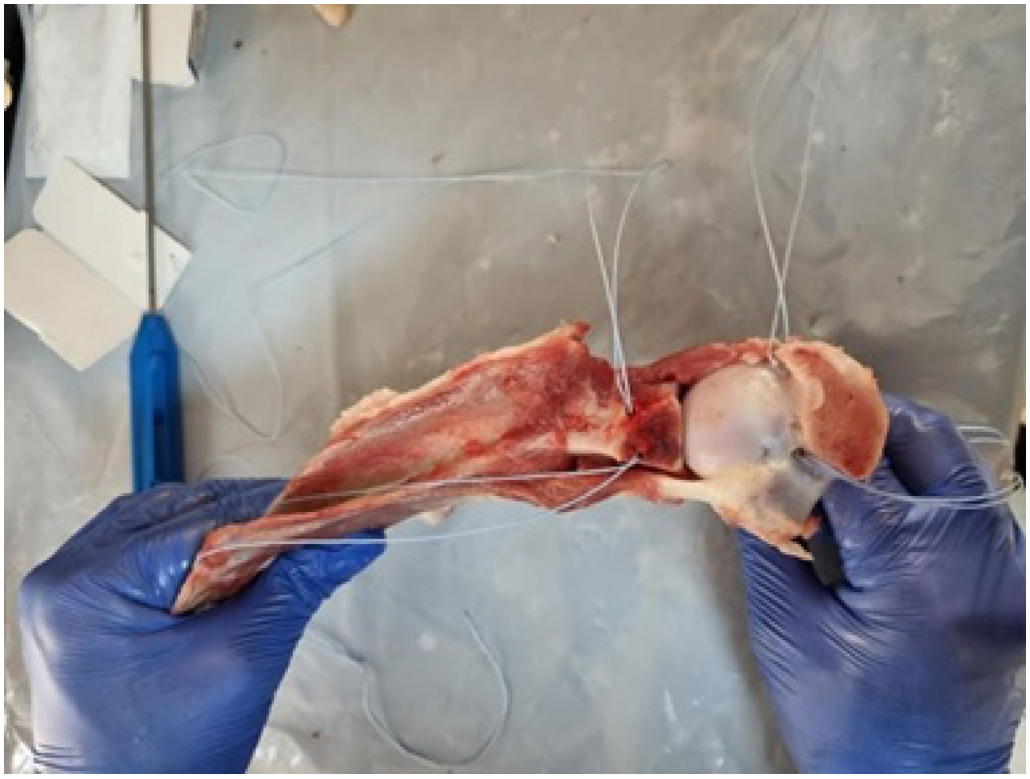


Fig. 2 Superior view of cadaver with the placement of suture anchors around the shoulder capsule

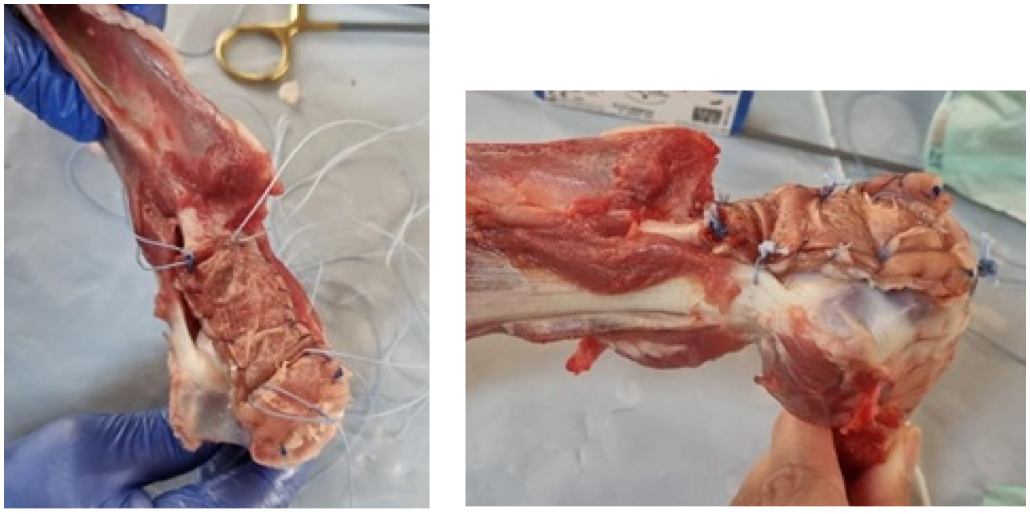


Fig. 3 Superior (**A**) and frontal (**B**) views of the cadaver with the attached graft on the shoulder joint, illustrating the completion of the superior capsule reconstruction (SCR) surgery

at 30 degrees of abduction (Fig. 5). The abduction angle represents the angle between the humeral shaft and the scapula relative to the vertical axis in the direction of cyclic loading. The device enabled controlled movement of the humeral head in the superior-inferior direction.

Biomechanical testing was conducted in two phases: dynamic and static testing. Dynamic testing replicates the repetitive loading conditions experienced by the shoulder joint during daily activities, while static testing assesses the ultimate load-to-failure characteristics of the grafts.

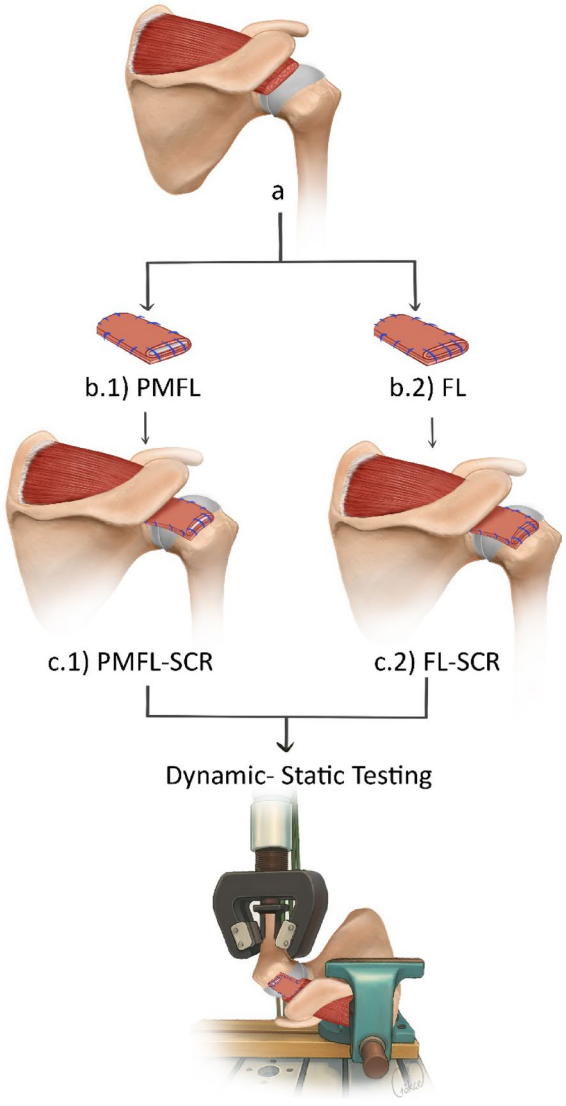


Fig. 4 Stepwise preparation of the superior capsular reconstruction (SCR) graft model. **a** Ovine shoulder model after isolation of the infraspinatus tendon simulating an irreparable rotator cuff tear (RCT). **b.1** Preparation of the folded fascia lata graft (PMFL) and **b.2** fascia lata graft alone (FL). **c.1** Final polypropylene mesh–reinforced fascia lata construct (PMFL-SCR) and **c.2** fascia lata–only construct (FL-SCR) prior to fixation. Both constructs subsequently underwent dynamic and static biomechanical testing

1. **Dynamic testing:** To evaluate the cyclic loading properties of both FA-SCR and PMFA-SCR, a cyclic load ranging from 10 to 50 N was applied at 1 Hz for 1000 cycles. During the test, the device recorded the stress over these cycles and transmitted it to the connected computer. Failure during cycling was defined as > 5 mm graft displacement or > 20% reduction in force. After completing the dynamic testing phase, each specimen was immediately switched to static testing without an intervening period to maintain continuous stress on the grafts.

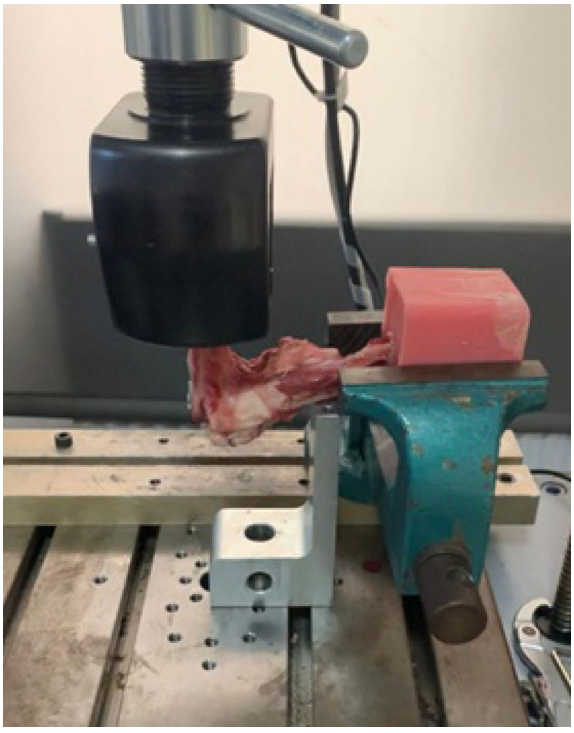


Fig. 5 The image depicts a biomechanical testing setup for the shoulder joint specimen. The specimen is attached to a mechanical testing device using the potted scapula and humerus, with the humerus suspended to enable movement of the shoulder joint along the vertical axis

2. **Static testing:** Immediately post-cycling, a controlled load was applied to each shoulder joint until failure occurred in either the repaired or surrounding material. The load was increased at a rate of 20 mm/min to evaluate the load-to-failure characteristics of the grafts and to determine the ultimate failure load. The biomechanical testing device was stopped immediately after objective identification of failure on the load–displacement curve and visual confirmation (Fig. 6).

Data analysis

All specimens completed testing without attrition. Data from both static and dynamic tests were recorded using the DOLI-Installation Center software, which was connected to the biomechanical testing device. Statistical analysis was performed with SPSS v27.0 (IBM SPSS Statistics, IBM, Armonk, NY), with a significance level of $p < 0.05$. Descriptive statistics were summarized by presenting continuous variables as means with standard deviations (SDs), and categorical variables as frequencies and percentages. The normality of data distribution for all outcome variables was confirmed using the Shapiro–Wilk test. To compare single-time-point biomechanical parameters between the two groups (FA-SCR vs. PMFA-SCR), independent-samples Student's t-tests were used

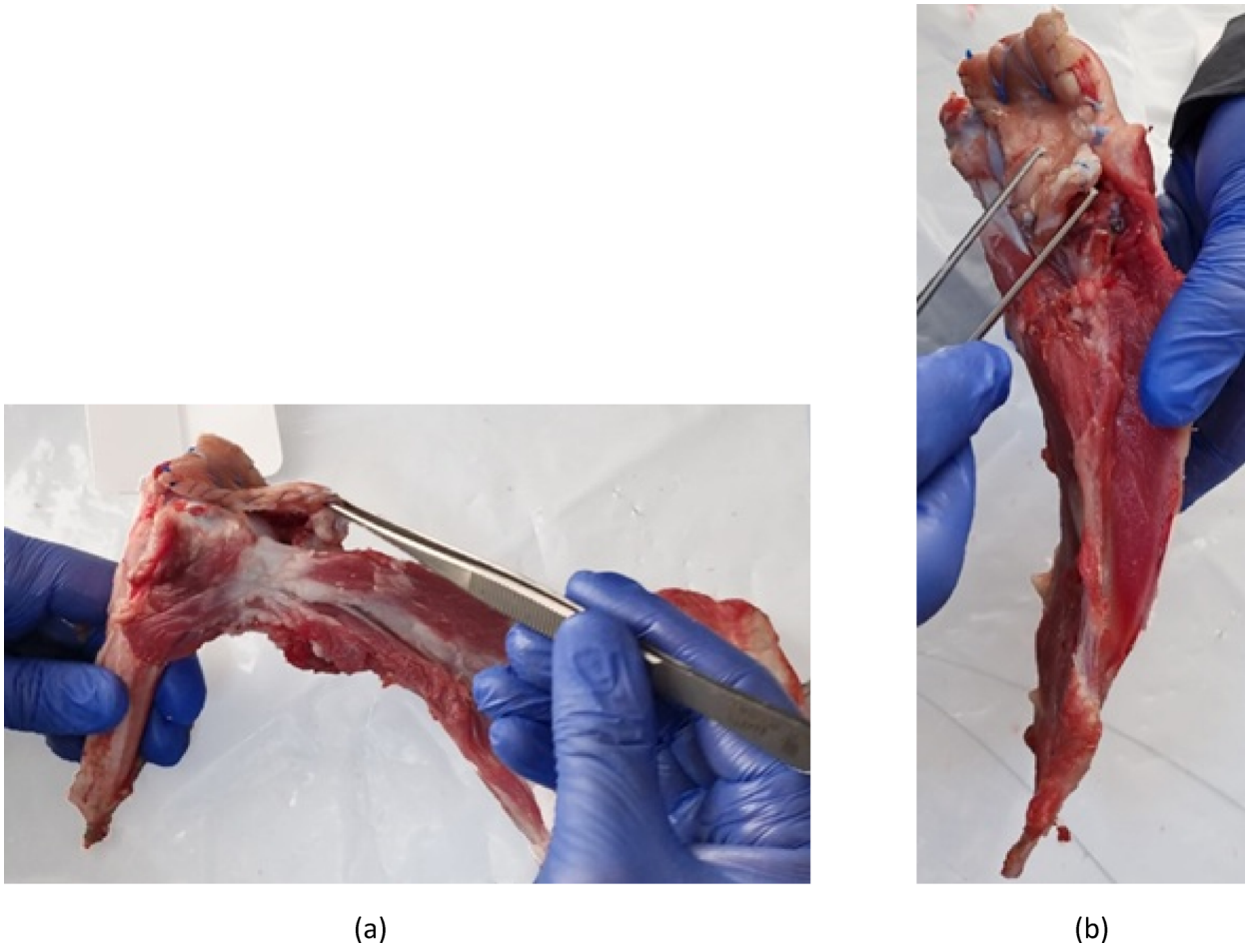


Fig. 6 Frontal (**A**) and superior (**B**) views of the cadaver showing the failed graft

for continuous variables, and Pearson's chi-squared test was used for categorical variables.

Results

Biomechanical testing revealed no statistically significant differences between FA-SCR and PMFA-SCR grafts across all measured parameters (Table 1). Both groups exhibited similar performance in displacement, stiffness, ultimate force, and yield properties under both dynamic and static loading conditions.

Cyclic loading (10–50 N, 1 Hz) over 1000 cycles demonstrated progressive displacement accumulation in both groups. As shown in Fig. 7, displacement increased with the number of cycles, starting from 1.83 ± 0.78 mm (FA-SCR) and 1.48 ± 0.67 mm (PMFA-SCR; $p = 0.74$), reaching 4.23 ± 2.06 mm (FA-SCR) and 3.71 ± 1.18 mm (PMFA-SCR) by the 1000th cycle ($p = 0.83$), with no significant difference in total displacement (FA-SCR: 2.41 ± 1.74 mm vs. PMFA-SCR: 1.48 ± 0.67 mm; $p = 0.63$). Linear stiffness increased over cycles but remained comparable between groups, from 24.36 ± 8.69 N/mm (FA-SCR) and 32.6 ± 16.83 N/mm (PMFA-SCR) at cycle 1 ($p = 0.68$) to 70.63 ± 44.06 N/mm (FA-SCR) and 59.25 ± 22.74 N/mm (PMFA-SCR) at cycle 1000 ($p = 0.82$).

Figure 8 depicts representative force versus crosshead displacement curves for both groups during tensile testing. Ultimate force to failure was comparable between FA-SCR (232.65 ± 87.66 N) and PMFA-SCR (198.53 ± 53.93 N; $p = 0.75$), with corresponding ultimate displacements of 17.47 ± 4.85 mm (FA-SCR) and 13.87 ± 3.59 mm (PMFA-SCR; $p = 0.57$). Yield load (137.66 ± 61.27 N vs. 145.85 ± 48.18 N; $p = 0.92$) and yield displacement (6.84 ± 1.22 mm vs. 6.27 ± 1.75 mm; $p = 0.88$) also showed no significant differences. Final stiffness values were 18.76 ± 8.62 N/mm (FA-SCR) and 23.77 ± 8.76 N/mm (PMFA-SCR; $p = 0.69$).

Regarding failure modes, while a specimen-specific breakdown was not quantified, the predominant mechanism of failure observed in both groups was suture cut-through at the graft fixation sites. There were no observed instances of anchor pull-out from the bone or mid-substance graft rupture. These findings suggest that the fixation interface—rather than graft midsubstance strength—was the primary mechanical weak point

Table 1 Comparing different biomechanical parameters between two groups: superior capsule reconstruction (SCR) and SCR + mesh

Biomechanical parameter	FA-SCR	PMFA-SCR	p-value
Displacement After 1 Cycle [mm]	1.83 ± 0.78	1.48 ± 0.67	0.74
Displacement After 1000 cycles [mm]	4.23 ± 2.06	3.71 ± 1.18	0.83
Total Displacement [mm]	2.41 ± 1.74	1.48 ± 0.67	0.63
Linear Stiffness 1 cycle [N/mm]	24.36 ± 8.69	32.6 ± 16.83	0.68
Linear Stiffness 1000 cycle [N/mm]	70.63 ± 44.06	59.25 ± 22.74	0.82
Ultimate Force [N]	232.65 ± 87.66	198.53 ± 53.93	0.75
Ultimate Xhead (Displacement) [mm]	17.47 ± 4.85	13.87 ± 3.59	0.57
Yield Load [N]	137.66 ± 61.27	145.85 ± 48.18	0.92
Yield Xhead (Displacement) [mm]	6.84 ± 1.22	6.27 ± 1.75	0.88
Stiffness [N/mm]	18.76 ± 8.62	23.77 ± 8.76	0.69

The parameters include displacement after one cycle, displacement after 1000 cycles, total displacement, linear stiffness after one cycle, linear stiffness after 1000 cycles, ultimate force, ultimate Xhead displacement, yield load, yield Xhead displacement, and stiffness. Each parameter is presented as mean ± standard deviation, along with the p-value indicating the statistical significance of the difference between the two groups

determining time-zero performance in both groups. The addition of the PM did not seem to change this failure mechanism, as the sutures likely cut through the composite matrix (fascia and mesh), similar to the fascia-only control.

Discussion

This study evaluated the acute biomechanical performance of PM-augmented FA grafts (PMFA-SCR) compared to FA-only grafts (FA-SCR) in an ovine IRCT model. Under both dynamic and static loading, we found no significant differences between the groups in key mechanical parameters, including graft displacement, linear stiffness, yield load, and ultimate failure load (Table 1, Figs. 7 and 8). Both graft types demonstrated comparable resistance to cyclic elongation and load-bearing capacity during static tensile testing. These results indicate that, in the early postoperative period, adding PM to FA grafts does not offer a mechanical advantage. Importantly, because this was an acute ex vivo (time-zero) ovine cadaveric model, biological healing, graft remodeling, and mesh–tissue integration could not be assessed; therefore, the present findings should be interpreted strictly as immediate biomechanical behavior rather than as long-term clinical effectiveness.

Both patch types showed comparable behavior during cyclic loading, with no significant differences in displacement or stiffness over 1000 cycles (Table 1, Fig. 7). The FA-SCR group exhibited a mean total displacement of 2.4 mm, while the PMFA-SCR group showed 1.5 mm ($p = 0.6$). Similarly, linear stiffness values increased in both groups throughout testing, ending at 70.6 N/mm (FA-SCR) and 59.3 N/mm (PMFA-SCR; $p = 0.8$). The significant finding of this study aligns with several clinical studies demonstrating favorable outcomes using FA grafts without synthetic reinforcement. Studies employing FA autografts reported high graft survival rates (up to 83.3%) and significant improvements in function and pain scores, including, in six studies, mean American Shoulder and Elbow Surgeons (ASES) score improvements exceeding the MCID, as well as VAS and Constant score improvements. [12,14,35] Importantly, these benefits were achieved without using mesh augmentation, suggesting that FA grafts provide sufficient mechanical support for SCR procedures. Clinical observations emphasize the critical role of surgical technique in SCR success.[14,37] For instance, Lee and Min observed that most graft tears occurred at the humeral side in their cohort, and patients who underwent additional posterior remnant repair had higher graft integrity rates compared to those with single-row fixation alone.[14] Similarly, Pennington et al. reported that among patients requiring postoperative MRI evaluation due to persistent symptoms, outcomes were closely related to surgical technique and fixation methods.[38] These findings highlight that successful SCR outcomes depend on a comprehensive surgical approach, including optimal suture technique, anchor configuration, and load distribution, rather than relying primarily on graft material stiffness. This supports our biomechanical findings that both FA and PMFA grafts can provide adequate mechanical properties for SCR when properly integrated into the surgical construct.

The apparent discrepancy between our results and those of prior clinical studies may be attributed to differences in study design and outcome endpoints. For example, Ciampi et al. reported a significant reduction in retear rates and improved functional outcomes (University of California, Los Angeles [UCLA] score, elevation, strength) in patients undergoing open repair of massive RCTs with polypropylene patch augmentation.[39] They proposed that the mechanical durability of PM helped protect the repair during early postoperative rehabilitation, reducing micromotion and facilitating healing. However, their study assessed medium-term outcomes at 1 and 3 years, during which biological integration likely played a major role. In contrast, our cadaveric model was designed to evaluate the acute biomechanical contribution of PM, independent of host response, by isolating the patch's mechanical properties in a controlled setting. The absence of this situation in our study, therefore, does not contradict Ciampi's findings but instead highlights that the clinical success of PM may derive from biological remodeling and long-term tissue integration, rather

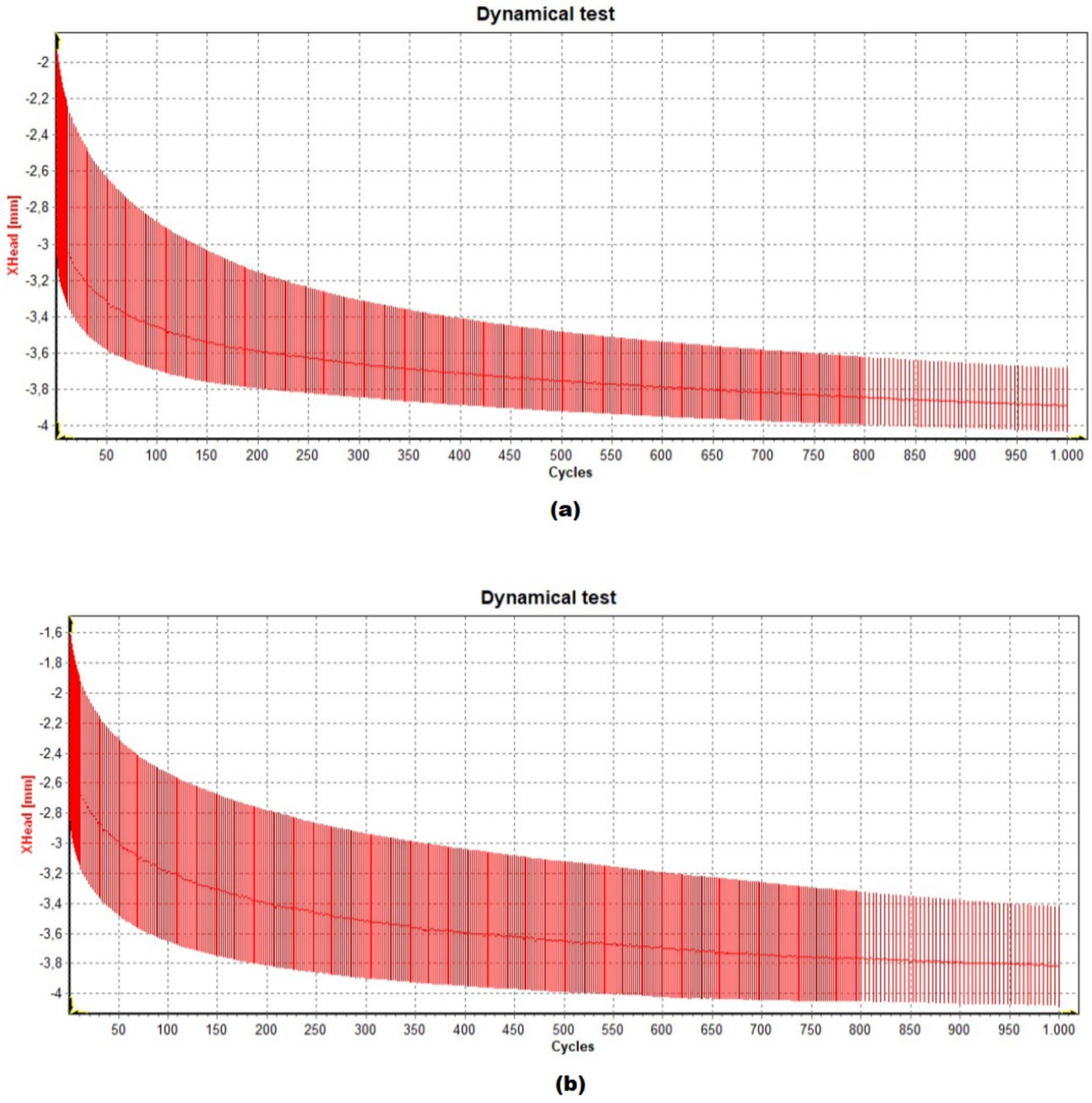


Fig. 7 The relationship between distance (Xhead) and cycle number for samples after superior capsule reconstruction (SCR) surgery, **A** FA grafts alone (FA-SCR) and **B** PM-reinforced FA grafts (PMFA-SCR)

than initial tensile augmentation alone. Similarly, Kholinne et al. demonstrated improved graft survival and superior functional recovery in patients who underwent arthroscopic SCR (ASCR) with mesh-augmented FA autografts.[20] Their data showed lower failure rates (16.7% vs. 41.2%) and higher ASES scores in the mesh group, especially in patients with healed grafts. Most failures in the mesh group occurred after 6 months, suggesting that PM's role may be more protective during later phases of biological remodeling rather than immediately after surgery. Our findings provide complementary insight, showing that in the absence of such remodeling, PM alone does not significantly affect mechanical performance. These contrasting findings collectively emphasize that graft composition alone is not the primary determinant of acute structural success in SCR. Instead, suture technique, anchor configuration, and biologic integration appear to exert a more substantial influence on both early mechanical stability and long-term clinical outcomes.

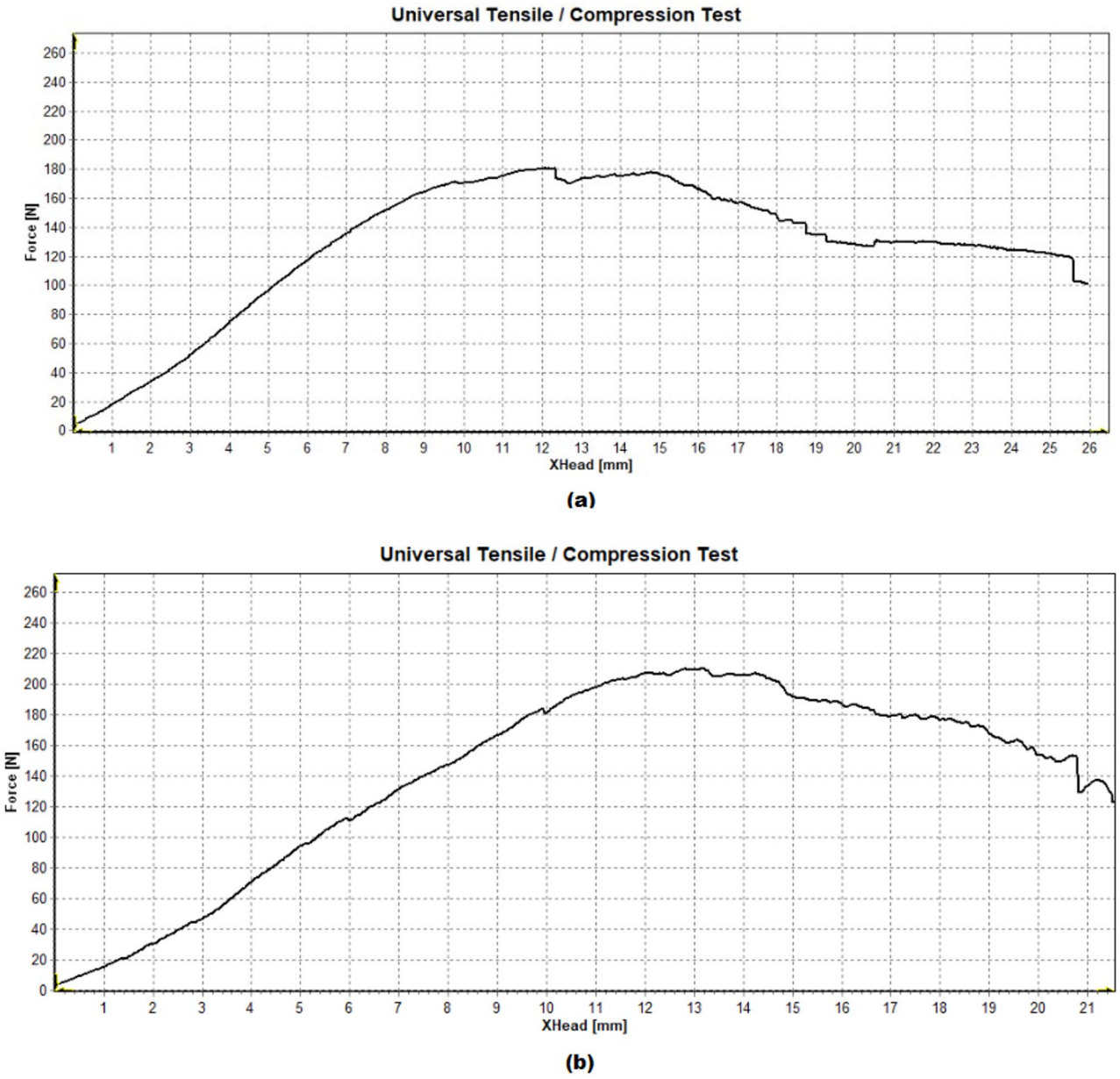


Fig. 8 Showing the force versus crosshead displacement (Xhead) for the average performances of each group after superior capsule reconstruction (SCR) surgery, FA grafts alone (FA-SCR) (**A**)**,** and PM-reinforced FA grafts (PMFA-SCR) (**B**), tested under tensile/compression conditions

Limitations

This study has several limitations. First, although an a priori power analysis was performed, the study was designed to detect relatively large differences between constructs. Therefore, the absence of statistically significant differences should not be interpreted as definitive biomechanical equivalence, and a type II error cannot be ruled out. Secondly, the use of an ex vivo ovine model, while anatomically validated for simulating irreparable rotator cuff tears, inherently excludes biological factors such as host immune response, inflammatory cascades, neovascularization, and long-term graft incorporation.[9,31] These biological processes are central to graft remodeling and clinical success, especially in the context of synthetic augmentation materials, which may exert their full effects only over time.[20,30,36] As supported by clinical studies, the potential benefits of PM augmentation, including reduced retear rates and improved functional outcomes, may become apparent during later phases of healing.[20,39] Third, biomechanical testing was performed immediately after surgical reconstruction, limited to "time-zero" mechanical properties. However, determining acute mechanical stability is clinically important since early fixation failure prevents

the biological scaffold from ever functioning. Extensive research highlights the importance of graft selection, preparation techniques, thickness, and stiffness in promoting graft healing and biological integration, which are directly linked to clinical outcomes in SCR.[17,40] Fourth, although graft dimensions were standardized and fixation techniques were consistent, specimen-specific anatomic variations, such as glenoid-greater tuberosity distance and scapular morphology, were not standardized. This lack of individual graft tensioning based on native anatomy may have introduced a slight variability in load distribution and mechanical performance. Fifth, while the fixation method applied in this study reflects widely used clinical practices, more complex or advanced fixation techniques may yield different biomechanical outcomes and warrant further investigation.[34,37] Sixth, detailed categorical data regarding the specific mode of failure (e.g., suture breakage vs. knot slippage vs. tissue tearing) was not systematically recorded for every specimen. However, the consistent observation of suture pull-through at the graft interface suggests that the fixation points remain the primary site of mechanical weakness in this construct. This study found evidence that supports surgical technique and fixation are more important than graft composition for the initial stability of SCR. However, it should be noted that this study is biomechanical in nature and that in vivo clinical studies are also needed. Future studies should incorporate time-course analyses in in vivo models to evaluate the interplay between mechanical durability and biological integration over the healing timeline. Additionally, investigations that systematically vary fixation techniques and graft configurations could more precisely delineate the specific contribution of synthetic augmentation to construct performance in SCR.

Conclusion

In conclusion, this study demonstrated that PM augmentation did not confer a significant biomechanical advantage over FA grafts alone in an acute, ex vivo ovine SCR model. Both graft constructs exhibited comparable displacement and load-to-failure characteristics at time-zero. These findings indicate that the addition of PM does not confer immediate mechanical superiority to the construct prior to biological healing. Accordingly, these results should not be interpreted as evidence against the potential clinical utility of mesh augmentation but instead suggest that any benefit—if present—may be time-dependent and biologically mediated. Future research may focus on time-dependent in vivo models and optimizing fixation strategies to better evaluate the role of synthetic augmentation in SCR.

Abbreviations

IRCT	Irreparable Rotator Cuff Tear(s)
RCT	Rotator Cuff Tear
SCR	Superior Capsular Reconstruction
FA	Fascia
PM	Polypropylene Mesh
PMFA-SCR	Polypropylene Mesh-Reinforced Fascia Graft in Superior Capsular Reconstruction
FA-SCR	Fascia-only Graft in Superior Capsular Reconstruction
ODA	Ovine Autograft
IRB	Institutional Review Board
VAS	Visual Analog Scale
ASES	American Shoulder and Elbow Surgeons (Score)
MCID	Minimal Clinically Important Difference
MRI	Magnetic Resonance Imaging
ASCR	Arthroscopic Superior Capsular Reconstruction
ASES	American Shoulder and Elbow Surgeons (score)
UCLA	University of California, Los Angeles (shoulder rating scale)
ANOVA	Analysis of Variance
SPSS	Statistical Package for the Social Sciences

Author contributions

GK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing; AD: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing; SKD: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing; EO: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – review & editing; OT: Conceptualization, Investigation, Methodology, Writing – review & editing; AE: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing; ACA: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing.

Funding

This study was supported by Acibadem Mehmet Ali Aydinlar University Scientific Research Projects Coordination Unit (ABAPKO) under the Expedited Grant Support category (Project Decision No: 2023/01–01) with a funding amount of 15,360.00 TL (approximately $820.00 USD at the exchange rate at the time).

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval

This study protocol was conducted in accordance with the Declaration of Helsinki and received approval from the institutional review board (IRB) of Acibadem Mehmet Ali Aydinlar University, which is named Acibadem University Clinical Research Ethics Committee (ATADEK) (No: 2022–14/07). The specimens were not privately owned; therefore, informed owner consent was not applicable. All procurement and use of tissues complied with institutional and national ethical regulations.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that there are no conflicts of interest related to this work.

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Received: 31 October 2025 / Accepted: 2 February 2026
Published online: 21 February 2026

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