

Load to Failure Testing of the Jose Reyes Configuration (JRC) Technique for Arthroscopic Quadriceps Tendon Repair

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Abstract

Background: Espiritu et al. previously described the Jose Reyes Configuration (JRC) technique as a reduced-implant arthroscopic quadriceps tendon repair utilizing two transosseous tunnels and a single central knotless anchor. Although the technique offers theoretical advantages including lower implant burden, reduced patellar bone violation and potential cost savings, objective mechanical data remain unavailable.

Objective: To perform preliminary time-zero mechanical validation of the JRC construct using standardized tensile testing.

Methods: A pilot biomechanical feasibility study was performed using a fresh beef quadriceps tendon surrogate model. The JRC construct was reproduced according to the previously published technique. Testing was conducted using a Micro Universal Testing Machine (100 kN capacity; sensitivity 0.01) at a constant crosshead speed of 10 mm/min until failure. Peak load to failure and failure mode were recorded.

Results: The construct tolerated progressive loading to a peak force of 1250.29 N (1.25 kN; 281.08 lbf). Failure occurred through tendon tissue cut-through without suture rupture or hardware disengagement.

Conclusion: Preliminary testing demonstrated encouraging immediate fixation strength of the JRC construct. Failure at the tissue interface rather than hardware suggests robust fixation characteristics. Further repeated-sample, cyclic, comparative and clinical studies are warranted.

Keywords: Quadriceps Tendon Rupture; Biomechanics; Arthroscopy; Tendon Repair; Extensor Mechanism

Introduction

Quadriceps tendon rupture is an uncommon but potentially disabling injury that disrupts the knee extensor mechanism and often necessitates operative repair to restore function, ambulation and knee extension strength [1-3]. Delayed or inadequate treatment may lead to extensor lag, weakness and impaired mobility. Traditional surgical repair has historically relied on transosseous patellar tunnel fixation. More recently, suture anchor-based constructs have gained popularity because of smaller incisions, reduced soft tissue dissection and potentially simplified fixation [4-6]. Several biomechanical and clinical studies have shown satisfactory outcomes with both methods.

Despite these advances, many anchor-based techniques require multiple implants, increasing cost and implant burden. In response, Espiritu et al. introduced the Jose Reyes Configuration (JRC) technique, a reduced-implant arthroscopic quadriceps tendon repair utilizing two transosseous tunnels and one centrally placed knotless anchor [7]. The technique was designed to decrease implant use while preserving multiple fixation points and to minimize patellar bone violation. Although the JRC technique has been technically described, its mechanical performance has not yet been reported. Therefore, the purpose of this pilot study was to evaluate the preliminary time-zero fixation strength of the JRC construct using universal tensile testing.

Materials and Methods

Study Design

This investigation was designed as a pilot laboratory biomechanical feasibility study intended to generate preliminary objective data regarding the immediate fixation characteristics of the JRC construct.

Specimen Selection

A fresh beef quadriceps tendon specimen was selected as a surrogate soft-tissue model due to its practical availability and gross structural similarity for preliminary tensile testing applications. The specimen was used fresh and prepared on the day of testing.

Construct Preparation

The JRC construct was reproduced according to the previously described technique of Espiritu, et al., (Fig. 1) [7]. Three luggage-tag high-strength suture passes were placed on the medial side of the tendon and three corresponding luggage-tag passes on the lateral side. These suture limbs were routed through two transosseous fixation tunnels representing the patellar tunnels of the JRC configuration.

A central horizontal mattress FiberTape augmentation was then applied and secured using a biocomposite knotless interference screw corresponding to fixation at the superior pole.

This created a three-point fixation construct consisting of:

1. Medial transosseous fixation
2. Lateral transosseous fixation
3. Central anchor augmentation

Mechanical Testing

The prepared specimen was mounted onto a Micro Universal Testing Machine with a maximum load capacity of 100 kN and measurement sensitivity of 0.01 (Fig. 2).

Uniaxial tensile loading was applied at a constant crosshead speed of 10 mm/min until construct failure occurred.

Outcome Measures

Primary outcome:

- Peak load to failure (N)

Secondary outcome:

- Failure mode

Statistical Analysis

As this was a single-specimen pilot feasibility test, only descriptive reporting was performed. No inferential statistical analysis was applicable.

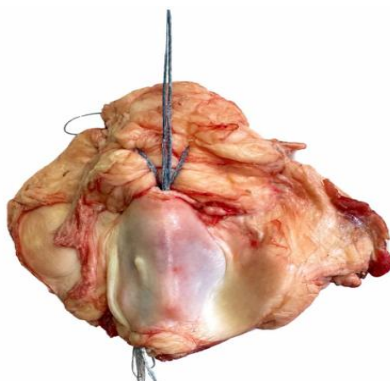


Figure 1: JRC construct on fresh-beef quadriceps tendon specimen.



Figure 2: Specimen mounted onto a micro universal testing machine.

Results

The JRC construct tolerated progressive tensile loading to a peak force of 1250.29 N, equivalent to 1.25 kN or 281.08 lbf. (Table 1) Failure occurred through tendon tissue cut-through at the suture-tissue interface. No suture rupture, screw disengagement or fixation-point failure was observed during testing.

Sample ID	Maximum Pull-out Strength, N	Maximum Pull-out Strength, lbf	Maximum Pull-out Strength
1	1250.29 N	281.08 lbf	1.25 kN

Table 1: Maximum pull-out strength of the tested sample expressed in Newtons (N), pound-force (lbf) and kilonewtons (kN).

Discussion

The most important finding of this pilot study was that the JRC construct demonstrated encouraging time-zero fixation strength, reaching a peak load to failure of 1250.29 N despite employing a reduced-implant strategy. This is clinically relevant because the early postoperative period following quadriceps tendon repair is the most vulnerable phase, during which biologic healing has not yet occurred and the repair relies almost entirely on construct integrity. A strong time-zero construct may reduce the risk of early elongation, gap formation or catastrophic failure during protected rehabilitation.

The mode of failure observed in this study is also notable. Failure occurred through tendon tissue cut-through rather than suture rupture or hardware disengagement. This may suggest that the limiting factor was the substrate itself rather than the fixation construct. In biomechanical terms, this can be interpreted as favorable evidence that the JRC fixation strategy provides substantial holding strength.

Espiritu et al. originally designed the JRC technique to address concerns regarding implant burden and cost associated with multi-anchor techniques [7]. By utilizing two transosseous tunnels and one central anchor, the technique attempts to preserve fixation redundancy while reducing the number of implants required [7].

This philosophy may be especially relevant in cost-sensitive healthcare systems such as the Philippines and other developing

nations, where implant affordability may influence surgical decision-making. A construct capable of providing promising fixation while using fewer implants may offer meaningful practical value and at the same time, allowing the surgeon to perform arthroscopic technique at lesser cost thereby allowing patients to benefit from the advantages of minimally invasive surgery compared with traditional open techniques [8-10].

Additionally, fewer patellar tunnels and fewer implants may theoretically preserve bone stock and simplify future revision options should rerupture occur. Published literature comparing transosseous and anchor-based quadriceps tendon repairs has generally shown satisfactory results for both methods [4-6,8-15]. The present study does not claim superiority over established methods. Rather, it provides preliminary mechanical feasibility data supporting further evaluation of the JRC construct.

An important practical implication of the JRC construct is the ability to pursue fixation efficiency without relying on multiple anchors. In many healthcare settings, implant cost remains a relevant factor influencing treatment accessibility. A technique capable of reducing implant burden while preserving encouraging mechanical strength may therefore offer both economic and clinical value. In addition, the use of only two tunnels may theoretically reduce bone compromise while maintaining secure tendon reattachment. These characteristics make the JRC technique particularly attractive in resource-conscious surgical environments.

Limitations

Several limitations should be acknowledged. First, a beef tendon surrogate rather than human cadaveric quadriceps tendon tissue was used. Second, only a single specimen was tested, preventing statistical analysis and assessment of reproducibility. Third, only monotonic load-to-failure testing was performed; cyclic loading and gap displacement were not measured. Fourth, time-zero testing does not reflect biologic healing, remodeling or clinical rehabilitation variables. Fifth, no comparator group using standard transosseous or multi-anchor repairs was included. Accordingly, the findings should be interpreted as preliminary and hypothesis-generating.

Future Directions

Future studies should include repeated-specimen testing with mean and standard deviation reporting, cyclic loading protocols with gap formation analysis, human cadaveric comparison versus conventional repairs and a prospective clinical outcome studies of the JRC technique

Conclusion

The JRC technique demonstrated encouraging preliminary mechanical performance during standardized universal tensile testing, achieving a peak load to failure of 1250.29 N. Failure occurred through tissue cut-through rather than suture rupture or hardware failure, suggesting robust construct fixation despite a reduced-implant configuration. By combining promising immediate fixation strength, lower implant burden, fewer bone tunnels and arthroscopic applicability, the JRC technique represents a practical and potentially valuable option for quadriceps tendon repair. Further comparative biomechanical studies and prospective clinical outcome investigations are warranted to better define its role among established repair techniques.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

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

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

Not applicable.

Authors' Contributions

All authors contributed equally to this paper.

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