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Reconstruction of a quadriceps tendon tear using Polyvinylidene fluoride sutures and patellar screw fixation: A biomechanical study

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ABSTRACT

Background: Acute quadriceps tendon tears are infrequent injuries requiring surgical treatment. Improved stability after surgical repair may allow for earlier weight-bearing and range of motion. Therefore, a new implant was tested and compared with the "gold standard", using transosseous sutures.
Methods: Quadriceps tendon tears were constructed using a cadaveric model of 12 fresh matched-pair specimens (aged 61–97; mean age: 82 years). The biomechanical testing compared non-absorbable suture anchors (Polyvinylidene fluoride) versus transosseous absorbable sutures (Polydioxanon). Following anatomic reconstruction, the repaired specimens were loaded until they failed (testing machine: Hounsfield H10KM, Redhill, United Kingdom; maximum force: 1000 N; load speed: 25 mm/min; maximum test length: 150 mm; pre-load: 5 N). Values for load until tear displacement, maximum load until complete failure of the construct (pullout or breakage of the sutures or anchors) and stiffness of the reconstruction were recorded.
Results: The stiffness found in the Polyvinylidene fluoride reconstruction (mean 9.83 N/mm) (standard deviation (SD) 7.75) showed a significant increase compared to the Polydioxanon reconstruction (mean 6.66 N/mm (SD 3.32); $P = 0.045$). Transosseous fixation showed comparable results to the suture anchor system. There was no significant difference found in the maximum load to tear displacement (PVDF: 290.88 N (SD 106.01) vs. PDS: 266.75 N (SD 82.61); $P = 0.358$).
Conclusions: Using the Polyvinylidene fluoride thread showed comparable results to the established method in reconstruction of ruptured quadriceps tendon. Stiffness of the Polyvinylidene fluoride thread reconstruction was even greater than Polydioxanon thread.
Clinical relevance: Improved stiffness may facilitate healing and is suggested as clinical relevance in reconstruction.

1. Introduction

Traumatic ruptures of the quadriceps tendon are uncommon injuries and generally only occur following low-velocity or trivial trauma. Their peak incidence occurs in middle-aged individuals [1–4]. However, acute as well as chronic quadriceps tendon ruptures both require early surgical reconstruction [5]. Many authors recommend the use of sutures passed through patellar bone tunnels for managing quadriceps tendon tears. This technique is considered the "gold standard" for reconstruction of this injury [6,7]. Over the last two decades, many surgeons have recommended a period of cast immobilisation over four to six weeks, followed by six to eight weeks of bracing after surgical repair of quadriceps tendon tears [8–10]. However, there are disadvantages of prolonged immobilisation while the tendon heals after reconstruction [11,12]. In contrast, the benefit of early motion and muscle-tendon tension improves vascularity, remodelling and strength [7,13]. It also reduces the co-morbidities of immobilisation [14–17]. Therefore, several authors have advocated new techniques for quadriceps tendon repair aimed at improving stability to enable early motion and weight-bearing [2,7,15,18–22]. The outcome of quadriceps tendon repair has been shown to yield good clinical results, but strength deficits and extension lag have been demonstrated in some cases [10,14]. Thus, for improvements in quadriceps tendon reconstruction, the pattern of failure and the biology of revascularization after suture repair to avoid rerupture or insufficiency have to be considered.

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1.1. Aim of this study

Polydioxanon (PDS) sutures are commonly used in quadriceps tendon rupture repair [23–25]. Using sutures passed through patellar bone tunnels is the "gold standard" [2,6,8,26]. The purpose of this study was to compare a new implant for quadriceps tendon repair with the "gold standard" of reconstruction. The biomechanical testing evaluated the pattern of failure with respect to load to tear displacement, load to complete failure of the reconstruction, as well as the overall stiffness of the reconstruction. Our hypothesis was that the new suture implant would have an improved failure profile compared to the standard reconstruction.

2. Methods

2.1. Material testing

Both the commonly-used absorbable Polydioxanon (PDS) and the new non-absorbable Polyvinylidene fluoride threads (PVDF) were tested prior to use in reconstruction, in order to compare their material characteristics. The non-biodegradable PVDF thread (FEG Textiltechnik GmbH, Aachen/Germany) consisted of 288 monofilaments and is known to show improved biostability, lowered bending stiffness and a minimum foreign body tissue response [27–29]. Threads as well as the prototyped, self-cutting titanium screws (height 14 mm) were tested

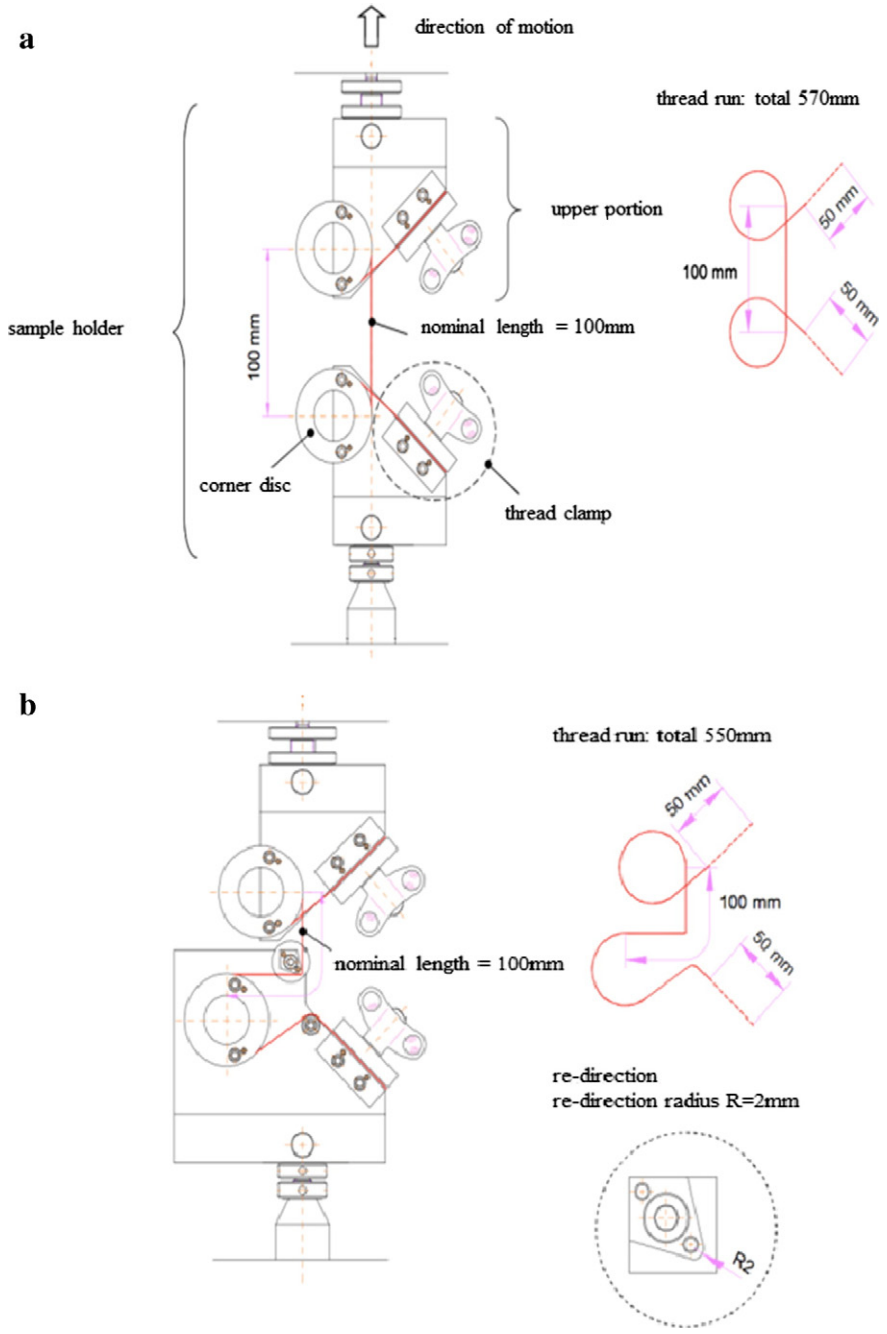

Fig. 1. Testing machine (Hounsfield H10KM) with different clamp devices to determine tensile strength and rigidity of the threads used for reconstruction. Plain linear strength (a) and perpendicular tensile strength were tested. Hereby fulcrum with a diameter of four millimeters realised the redirection of 90° to simulate knee flexion (b).