INTRODUCTION

Polypropylene monofilament (PP) suture has long been recognized as the material of choice for flexor tendon repair, particularly when using the circumferential suture technique. However, degradation and failure phenomena, such as surface fragmentation and fracture at a location distant from the knot, have been observed in both vascular and ophthalmologic surgery. We applied the polyvinylidene fluoride monofilament (PVDF) suture, which had been subjected to special treatment to modify its crystalline form and level of crystallinity, for flexor tendon repair. The purpose of this study was to compare (1) the mechanical properties of PVDF and PP sutures with regard to suture diameter, tensile strength, elongation, knot pull strength, and creep testing, and (2) the performance properties of tendons repaired using PVDF and PP sutures for the circumferential suture technique.

MATERIALS AND METHODS

Experiment 1 – Mechanical properties of suture samples

Mechanical properties such as suture diameter, tensile strength, elongation, and knot pull strength were measured described in the U.S. Pharmacopeia (USP) utilizing the same suture specimens since mechanical properties are directly related to the suture diameter. The tensile testing machine was operated with a 50 N capacity load cell and a gauge length of 100 mm at a constant cross-head speed of 50 mm/min. Ten specimens of each type of suture (5-0 PVDF and PP sutures) were tested.

Creep testing was performed using a previously described method. 1-3 100- mm long specimens were subjected to a constant load, while the resulting extension was measured as a function of time. We selected a 4.50 N load as it was about half the breaking load. The length of the suture and the percent extension were measured at 30 min and at 1, 2, 6 and 12 hr. Five specimens of each type of suture (5-0 PVDF and PP sutures) were tested, and the average percent extension was calculated for each type of suture material.

Statistical analysis of the obtained data was performed using unpaired Student’s t-test with significance set at p = 0.05.

Experiment 2 – Mechanical properties of repaired tendons

32 canine flexor digitorum tendons were removed from 4 pairs of fresh frozen canine front paws. The specimens were divided into two equal groups, according to whether a PVDF or a PP suture would be used.

Repaired tendons were lacerated in Zone 2 and repaired utilizing the technique, which consisted of the 2-strand locking Kessler core suture in combination with the simple running or cross-stitch circumferential suture. A 4-0 polybutylate-coated braided polyester was used as the core suture, and a 5-0 PVDF or PP suture was used as the circumferential suture.

All the repaired tendons were secured tightly in tendon clamps on a tensile testing machine and loaded to failure with a 200 N capacity load cell and a gauge length of 40 mm at a constant cross-head speed of 25 mm/min. During distraction of the specimens, a video camera was used to determine the accurate displacement between each of the tendon ends. The force, measured in Newtons (N), at which 2 mm of displacement between each of the tendon ends was observed, was recorded as the gap strength, while the force at which the repair failed was recorded as the ultimate strength.

Statistical analysis of the obtained data was performed using two-way repeated measures analysis of variance (ANOVA) followed by Tukey’s post hoc test to determine the effect of the repair technique as the repeated factor (PVDF and PP suture) and the type of circumferential suture technique (simple running and cross-stitch technique).

RESULTS

Experiment 1 – Mechanical properties of suture samples

The overall results are shown numerically in Table 1. The type of suture material was a statistically significant factor for gap and ultimate strength (ANOVA, p< 0.002 and 0.003, respectively). The type of circumferential suture technique was also a statistically significant factor for gap and ultimate strength (both ANOVA, p< 0.001).

Type of suture material. Statistically significant differences were detected for gap and ultimate strengths between the PVDF and PP sutures both in the simple running groups (Tukey’s test, p< 0.018 and 0.045, respectively) and in the cross-stitch groups (Tukey’s test, p< 0.003 and 0.015, respectively).

Type of circumferential suture technique. Statistically significant differences were detected for the gap and ultimate strengths between the simple running and cross-stitch suture techniques both in the PVDF groups (both Tukey’s test, p< 0.001) and in the PP groups (both Tukey’s test, p< 0.001).

DISCUSSION

Our study showed that the PVDF suture provided greater creep resistance and a greater knot pull strength, although the PVDF suture had a finer suture diameter than the PP suture. This demonstrated that intrinsic elastic properties of PVDF suture under tension assures easier and improved knot making with less of a tendency for the knot to move or become untied by itself. Tendons repaired using PVDF sutures had a significantly greater gap and breaking strength than those repaired using PP sutures in both the simple running and the cross-stitch groups. This increased gap resistance and higher tensile strength would reduce the risks of tendon rupture and would enable postoperative mobilization to be undertaken more safely. PVDF sutures offer a possible alternative to the current use of PP sutures for flexor tendon repair. Further in vivo studies are needed to fully clarify the effect of PVDF sutures on healing tendons.