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EFFECT OF SUTURE TYPE ON THE MECHANICAL PERFORMANCE OVER A SUTURE ANCHOR EYELET

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Abstract

An understanding of the mechanical properties of different suture materials is valuable when selecting the most appropriate suture and repair technique. Sutures should be strong, easy to handle and have high knot security. Although monofilament sutures are stronger, a braided structure improves handling characteristics and knot security. The introduction of suture anchors adds an additional variable regarding the effect of stress risers over the eyelet. Improving the mechanical properties of a suture may help avoid failure over stress risers such as the eyelet of suture anchor. This study examined the static and viscoelastic properties of a new polyethylene based suture (Fibrewire) over the eyelet of a standard anchor compared to braid polyester suture (Ethibond). Fibrewire had superior static properties compared to Ethibond when tested in uniaxial tension over an anchor eyelet. Fibrewire demonstrated greater stress relaxation compared to Ethibond. Differences in the viscoelastic properties of suture may have implications in the post operative period or during rehabilitation.

Key words: Suture anchors, Suture, Mechanical Testing

Introduction

A durable surgical repair is required for patients to undergo early rehabilitation, which can promote healing and maximize function. Surgeons need to understand the relative mechanical properties of different suture materials when selecting the most appropriate suture and repair technique [2]. Sutures should be strong, easy to handle and have high knot security. Although monofilament sutures are stronger, a braided structure improves handling characteristics and knot security. Suture anchors have become very popular for reattachment of soft tissues to bone but this has introduced concerns regarding the effect of the eyelet as a stress riser [1, 5]. Improving the mechanical properties of a suture will reduce the effect of a stress riser such as the eyelet of a suture anchor [3, 4]. The static properties of a suture are particularly relevant at the time of surgery. These properties include stiffness, ultimate load to failure and deformation at peak load and reflect behaviour during initial securing of the repair and the initial loading. The viscoelastic, time dependent, properties of sutures may be clinically relevant in the post-operative period of rehabilitation while healing is occurring.

Fibrewire (Arthrex, Naples FL) is a composite, braided suture incorporating polyethylene strands. It has been recently introduced to the market and has been promoted for its high tensile strength. This study examined the static properties of this polyethylene based suture over the eyelet of a standard anchor compared to Ethibond (Ethicon, Sydney), which is a braided non-absorbable suture trusted by surgeons in many different surgical specialties. In addition, the stress relaxation behaviour of these 2 sutures was examined to determine if any differences existed.

Methods

Seven samples of # 2 Ethibond (Ethicon, Sydney, AU) and # 2 Fibrewire (Arthrex, Naples, FL) were tested over the eyelet of a Mitek G2 anchor (Mitek, Marlboro, MA). The anchors were fixed in a steel clamp and the suture placed over the eyelet (figure i). Samples were distracted at 50 mm per minute to failure on an MTS 858 Bionix Testing Machine (MTS Systems Corporation, Eden Praire, MN). The stiffness, load to failure, deformation at peak load and failure mode were determined for all samples. The stress relaxation of 7 samples of # 2 Ethibond and # 2 Fibrewire were also determined. A gauge length of 20 mm was secured in the testing grips of a Mach-1™ Micromechanical Tester (Biosyntech, Canada). Tests were performed in phosphate buffered saline at 37°C. The stiffness and stress relaxation was determined following a 500 microns displacement at 100 microns per second and held for a fixed relaxation time of 600 seconds. The stiffness was determined from the load versus displacement curve and the maximum load and load at 600 seconds used to assess percent relaxation. Mechanical data was analyzed using a Student's T-test using SPSS for Windows.

Results

In the static testing both suture types tested failed at the anchor eyelet. Fibrewire demonstrated a linear behaviour during loading while Ethibond had a noted reduction in stiffness during the tensile test to failure (figure ii). The ultimate load and stiffness for Fibrewire was significantly greater compared to Ethibond ($p<0.001$) (Figure iii). The deformation at peak load for Fibrewire was significantly less than Ethibond ($p<0.001$). The viscoelastic stress relaxation results revealed

Fibrewire to relax significantly more compared to Ethibond under the testing conditions examined ($p < 0.05$) (figure iv).

Discussion

The selection of a suture material needs careful consideration and requires an understanding of the static as well as the viscoelastic properties. The anchor design, quality of the tissue within the repair, repair method and rehabilitation protocol are other important factors to consider. While anchors often come preloaded with suture, surgeons have the opportunity to change suture during the procedure. We chose to model the mechanical performance of 2 different sutures in the eyelet of a well-accepted suture anchor (Mitek). The mechanical testing was performed in uniaxial tension, which represents a worse case scenario for anchor pullout but may not reflect what happens when the load is applied off axis. However, the comparisons between the 2 suture types are appropriate.

The static mechanical data revealed the performance of Fibrewire was superior to Ethibond over a standard anchor eyelet (figure ii) in terms of load and stiffness. Failure of the suture during surgery when using suture anchors has the potential to complicate the procedure and require additional anchors to be used or prolong the surgical procedure. The static mechanical data suggests that in surgical repairs with Fibrewire, the suture would be less likely to break and would deform less under initial loading that could occur during the surgical procedure of tying the knots and tightening the repair to oppose soft tissue to bone.

Fibrewire demonstrated greater stress relaxation compared to Ethibond (figure iii). This may have implications in the post operative period or during rehabilitation.

The reduction in stress within the suture may make it less likely to fatigue or break however the repair may not be held as securely under a fixed displacement due to the response of the suture with the possibility of a gap developing at the repair site over time. This could be determined more accurately from the creep, which has not been reported here. This study is also limited in that we did not examine the effect of other testing rates or fatigue loading. Wear of the Fibrewire and potential of generating polyethylene wear particles and subsequent biologic reaction with Fibrewire abrasion against bone or a metal anchor are important but are beyond the scope of this study. Although the clinical benefit of improving the properties of sutures has yet to be proven, surgeons must be able to interpret the data presented when selecting materials for suturing.

Figures

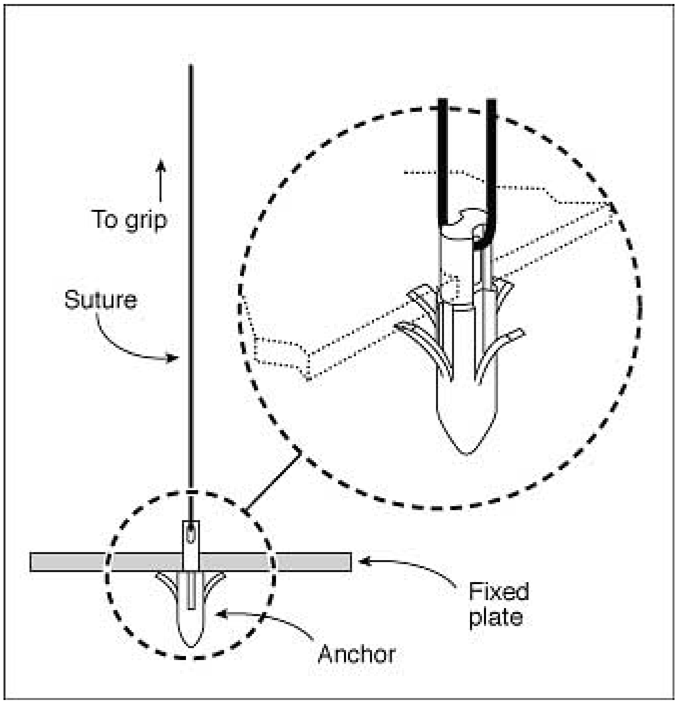

Figure i

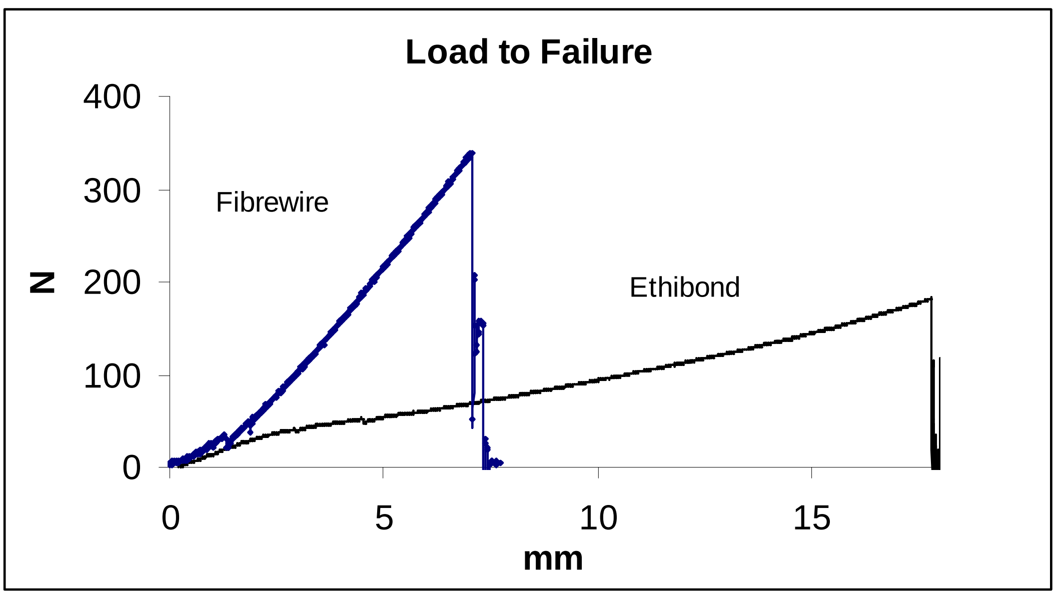

Figure ii

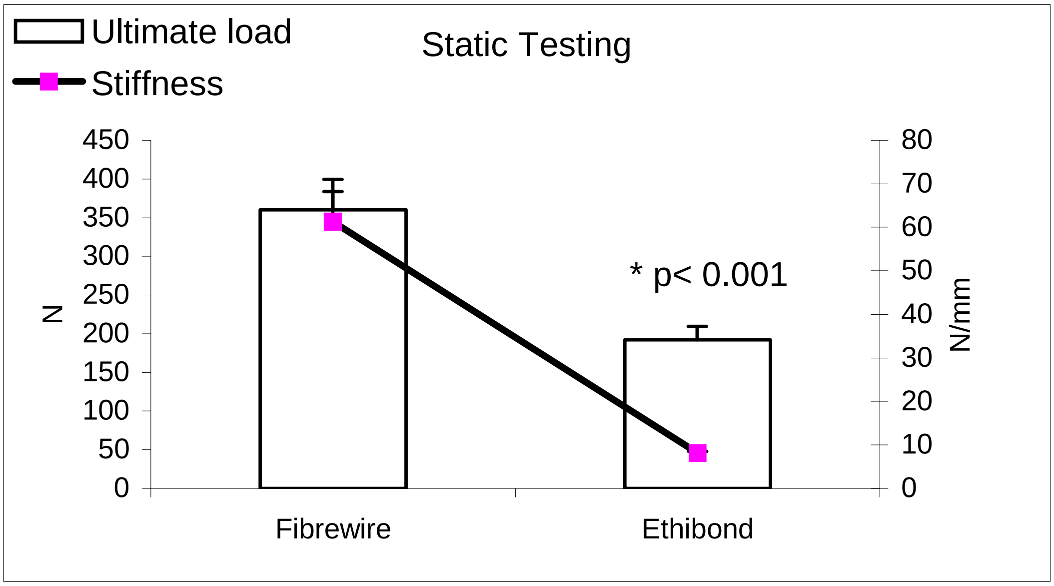

Figure iii

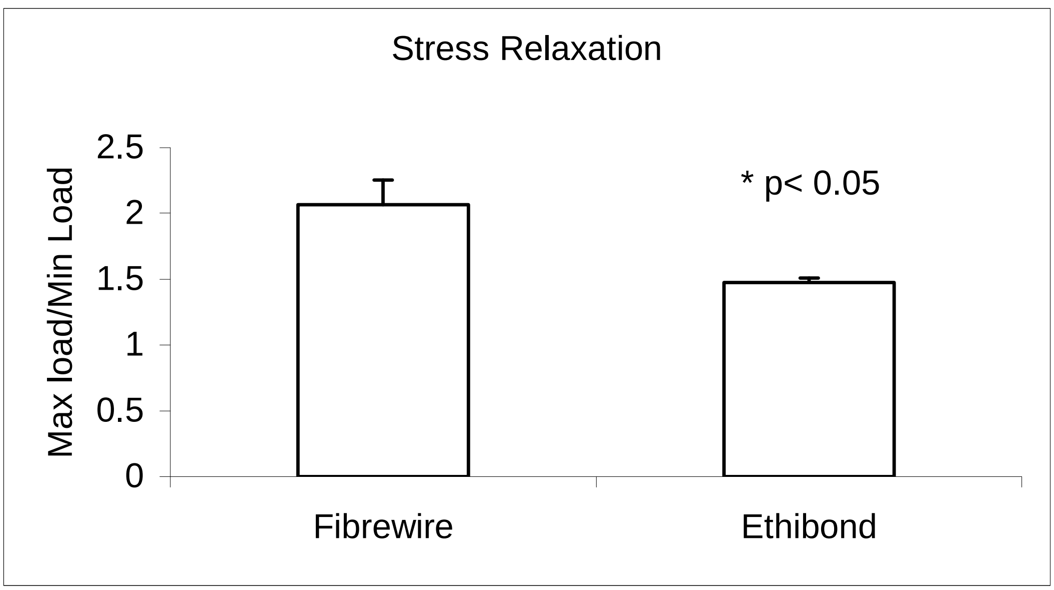

Figure iv

Figure legends

Figure i: Diagram shows setup for mechanically testing the static properties of each suture strand.

Figure ii: Graphs of load v displacement for Fibrewire and Ethibond.

Figure iii: Graphs showing differences in ultimate load and stiffness for Fibrewire and Ethibond (mean, standard deviation).

Figure iv: Graph presenting stress relaxation as a ratio of maximum load to minimum load.

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