EFFECT OF SUTURE TYPE, ANCHOR AND TESTING ORIENTATION ON THE STATIC PROPERTIES OF SUTURE ANCHORS

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INTRODUCTION:

Suture anchors have gained widespread acceptance in surgical procedures to reattach soft tissue to bone. The wide range of designs with regards to fixation, eyelet design, as well as the method of surgical implantation, complicates their use. Insertion of suture anchors often results in variable placement due to anatomical and surgical limitations. Stress risers over metal edges of the anchor eyelet can contribute to early suture failure. Clinical failure of the suture anchor complex can occur at the interfaces created as a result of the device in the bone, suture through the device and suture through the tissue. While the pullout strength of suture anchors has been well reported,[1] recent studies on the influence of the eyelet design and testing orientation (suture pull angle (SA) and anchor rotation angle (RA) [2]) have highlighted the increasing complexity with regards to suture anchor use.[2-4] The introduction of new suture materials, such as polyethylene based Fibrewire (Arthrex, Naples, FL) adds an additional parameter that has the potential to influence clinical results. This study examined the effect of SA, RA and suture type in two standard metal anchors and a biodegradable suture anchor where the eyelet consists of a suture loop inside the anchor body.

METHODS:

The Mitek GII (Mitek, Westwood, MA), Corkscrew and Biocorkscrew 5.0 (Arthrex, Naples, FL) were tested in this study using 1 or 2 loops of #2 Ethibond or #2 Fibrewire. Anchors were tested to failure using an MTS 858 Bionix testing machine in phosphate buffered saline at room temperature similar to Meyer and co-workers,[3] with a constant gauge length of 60 mm with a displacement rate of 60 mm per minute. The anchors were rigidly fixed distally in a custom vice grip to ensure anchor pull out would not occur. The sutures were proximally fixed over a stainless steel bar and clamped. The static properties were evaluated in the best-case scenario of 0° SA and RA as well as with an SA 45º or 90º and RA in either a sagittal or coronal plane. A sample size of $n = 8$ per testing condition resulted in a 224 individual experiments. The peak load, stiffness, energy to peak load and failure mode were analysed using MANOVA using SPSS for Windows followed by a Tukey HSD post hoc test.

RESULTS:

The number of suture loops (1 vs. 2) and type of suture (Ethibond vs. Fibrewire) had a statistically significant effect on the properties for all testing conditions ($p < 0.05$). Devices tested with Fibrewire were significantly stiffer compared to Ethibond ($p < 0.05$). The use of 1 loop of #2 Fibrewire resulted in superior static properties compared to either 1 or 2 loops of Ethibond ($p < 0.05$).

Testing under best case loading (SA and RA = 0º) resulted in loads equivalent to the tensile failure loads of the sutures themselves with the metal anchors for both suture types. Fibrewire performed significantly better on both metal anchors compared to Ethibond (Fig 1). Failure loads were significantly reduced with the Mitek GII with an SA 45º or 90º ($p < 0.05$), while RA alone was not a significant factor for both suture types with this anchor. Failure loads for the Corkscrew only became significant with an SA of 90º. In contrast, SA did not affect the result of Biocorkscrew, which has a loop of #5 suture as the eyelet, when using Ethibond, which failed in all cases (Fig 2). The failure mode occurred at the suture eyelet of the Biocorkscrew at significantly lower loads when Fibrewire was used compared to the metal Corkscrew anchor ($p < 0.05$) (Fig 3).

Figure 2: Biocorkscrew and Corkscrew anchors demonstrating the eyelets and failure mode.

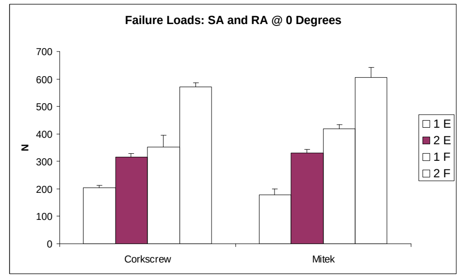

Figure 1: Comparison of failure loads for the metal anchors with 1 and 2 loops of Ethibond (E) and Fibrewire (F) revealed a significant increase in load for Fibrewire compared to Ethibond ($p < 0.05$). Both anchor designs performed similarly at this testing orientation.

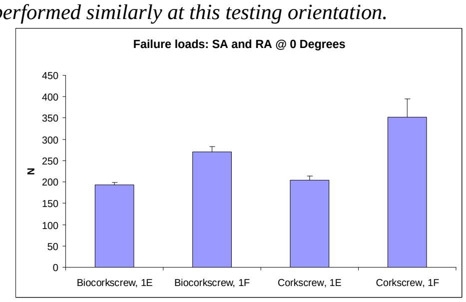

Figure 3: Comparison of failure loads for the Biocorkscrew versus the metal Corkscrew revealed a significant increase in load with Fibrewire compared to Ethibond and a decrease in load with Fibrewire between the Biocorkscrew and Corkscrew ($p < 0.05$).

DISCUSSION:

In surgical practice, suture anchors are often employed in situations in which the axis of loading differs from that of the anchor. Arthroscopic use of anchors has the potential to further complicate suture pull angle (SA) and anchor rotation angle (RA). The current study incorporated these concepts introduced by Bardana[2] and two sutures with vastly different properties. Under ideal testing conditions, the SA and RA have no influence on the properties evaluated while the suture type is a significant factor.

The eyelet design of metal anchors becomes important with respect to orientation of the loading. Interestingly, the Biocorkscrew anchor which has a suture serving as the eyelet is not influences by SA and by design has no RA to consider. The use of a suture as the eyelet results in a polyaxial suture anchor that may have some advantages over anchors with rigid eyelets in the clinical setting, to avoid premature failure due to stress risers as a result of placement and the direction of loading. The use of Fibrewire with a suture eyelet however, demonstrated the weak point to be the suture eyelet itself, compared to the suture when using Ethibond, which is significantly less stiff and strong as Fibrewire. While the mechanical differences between these combinations is clear and may provide surgeons with more margin for error in placement, the clinical benefit of such a polyaxial anchor has yet to be assessed.

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