by 46% and stiffness by 54%.[5] Rittmeister et al. looked at graft strain in cadaveric models in various configurations. They found parallel preparations were the strongest and that braided, bolo-plaits and twisted grafts all led to increased viscoelastic properties and with permanent elongation when compared to the parallel grafts.[6] Sidwell et al. used a mathematical model based on the four-bar linkage model (based on passive and loading behavior) to compare parallel and twisted hamstring ACL grafts. They concluded there was no benefit in braiding grafts in increasing the maximum load they can support and that it provides no evidence that it reduces joint laxity throughout a range of movement.[7]

Given the studies looking at the effects of braiding in hamstring grafts, and the evidence suggesting it weakens both the strength and stiffness, a recommendation is made for further biomechanical and clinical data on the published technique prior to its adoption.

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Author Reply to "Regarding 'Hamstring Braid Graft Technique for Anterior Cruciate Ligament Reconstruction'"

We appreciate the interest and comments from Manara et al. regarding our Technical Note, "Hamstring Braid Graft Technique for Anterior Cruciate Ligament Reconstruction."[1] In our article we described a step-by-step technical note presenting a novel "in vivo" hamstring braid graft configuration for anterior cruciate ligament (ACL) reconstruction that could potentially overcome some of the known disadvantages of hamstring autograft.

We would like to indicate that several studies cited by Manara et al. are "in vitro" cadaver lab studies with fresh-frozen cadaveric hamstring grafts and the authors use different braid graft constructs configurations from the one that was described in our study. Graft fixation devices used "in vitro" differ from the conventional fixation systems used "in vivo", which poses a limitation in comparing these studies. Unlike the studies referenced, Stapleton et al.[2] have found an increased stiffness of the woven young hamstring graft, similar to the bone−patellar tendon−bone (BTB) graft. In addition, the grafts were tested inside the knee, thus, mimicking a joint environment that more closely resembles a clinical scenario.

Please see below a more detailed summary of limitations of the proposed studies in comparison to our braid graft constructs configuration described in our article.

In the Tis et al.[3] study, the authors used cadaveric fresh-frozen grafts with a mean age of 79 years, which might have different histological and biomechanical properties when compared to young hamstring autografts or allografts. Also, the authors used the Stapleton technique for weave braiding: each tendon is braided with itself forming two different braid grafts with two strands each, which are tensioned separately. This represents a completely different braid configuration technique from our description (one braid using 4-strand from the two hamstring tendons fold in half). In addition, the authors used clamps instead of interference screws for fixation, which can flatten the tendons and weaken the hamstring graft when clamped. The study concluded that braided and unbraided hamstring configurations had less strength than BTB grafts; however, this finding contrasts with the available published literature. Several biomechanical studies have shown that hamstring grafts have higher failure strength than BTB grafts.[4,5]

In reference to the Kim et al.[6] study, the authors have also used a different weave braided technique and a cryogrip fixation system, where each strand is fixed separately. The purpose of a braided configuration is to behave as a unit, favoring the grip with the interference screw, which may translate into a stronger tibial fixation and potentially decrease the graft "cutting through phenomena" of independent strands.

According to the Millet et al.[7] study, the median age of fresh-frozen grafts used in the study was 85 years and the unbraided grafts were compared to a woven four-strand construct, which are different from our braid configuration technique. In the discussion section, the authors suggested precisely that braided constructs were still stronger than most BTB grafts.

In the Nicklin et al.[8] study, the "in vitro" braided tendon fresh-frozen grafts used had a French plait and four-stranded weave configurations. The study described a different braiding built, with grafts secured in brass grips. Another limitation in comparing our technique with the described method is that the grafts were frozen with carbon dioxide, changing the biomechanical and histological properties of the grafts.

According to the Rittmeister et al.[9] study, the authors described a configuration with medial and lateral hoof extensor bovine tendons and a different construct. Regarding the Sidwell et al.[10] study, cited by Manara et al., the authors have studied the effects of twisting, suggesting that the results "can also be extended to graft braiding." We believe that braiding does not have the same biomechanical characteristics as twisting, thus, these techniques are not precisely comparable.

Stapleton et al.[2] found an increased stiffness of the woven young hamstring graft, similar to the patellar tendon graft. The difference between this study and the previous cited studies is that the grafts were tested inside the knee, thus, mimicking a joint environment that more closely resembles a clinical scenario. Freeman et al.[11] demonstrated that the addition of twisting to a braid scaffold resulted in a significant increase in the ultimate tensile strength.

As we know from the Śmigielski et al.[12] anatomical study, the ACL has a flat ribbon appearance. The final braid graft configuration described in our original article is also flat and we believe it may mimic the flat ribbon appearance of the native ACL. In addition, when the braid graft is positioned inside the knee, we suggest that the braid graft twists itself intra-articularly, possibly increasing its strength.

Once again, we appreciate the contribution from Manara et al. and do agree that disruptive innovation in surgery must be supported by the highest quality of evidence available. As discussed above, the biomechanical models presented in the aforementioned studies were not comparable to our technique. Our article is aligned with the scope of *Arthroscopy Techniques* and is intended to be a technical note, showing alleged advantages that surgeons could choose to freely incorporate in their armamentarium. Our technique uses a well-established graft that has been tested and proven to be safe and reliable with multiple configurations. We are confident in our clinical observations: using the aforementioned braided construct, we consistently obtain a thicker and more uniform graft with similar tensioning of the four strands, which may affect the tibial fixation positively "in vivo". We acknowledge the myriad of factors influencing the ACL graft reconstruction outcomes, including and not limited to graft size and "in vivo" configurations. We agree with Manara et al. that in addition to well-designed clinical comparative studies, further biomechanical testing is needed to simulate the graft-joint environment that could determine if our braided configuration has clinical significance in the long-term.

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