Permanent and Absorbable Suture-Bridge Osteochondral Fixations with Knotless All-Suture Anchors Both Demonstrate Greater Time-Zero Security over Bio-Absorbable Compression Screw Fixation

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INTRODUCTION:

Fixation security is important for outcome success in the treatment of unstable osteochondral fracture and osteochondritis dissecans (OCD). The trans-fragmentary screw/nail implants commonly used for fixation are mechanically disadvantaged to secure the typically thin, mainly cartilaginous osteochondral fragment (OCF), increasing the number of implants needed and raising the risks of uneven compression, joint damage from loose implants, and fixation failure.

Although suture OCF fixation techniques have been reported, its fixation security relative to current techniques is unknown. In addition, permanent-suture presence on articular surface may raise concerns for opposing-surface cartilage abrasion.

The purpose of this study was to evaluate the time-zero osteochondral fixation security of two novel suture-bridge constructs: 1) **interlinked knotless all-suture anchors (KASAs)** (Fig 1A), and 2) **hybrid absorbable-suture/KASA construct** (Fig 1B). Both suture-bridge constructs were compared to an established trans-fragmentary repair technique with bio-absorbable compression screws (BCS).

We hypothesized that both novel suture-bridge repair options will demonstrate higher loads to distraction and failure, compared to the established trans-articular method.

METHODS:

5-mm thin OCFs were sectioned from the femoral condyles of 12 cadaveric knees in 6 matched pairs (avg 44.7 yo, 4M/2F), 1 OCF from each condyle.

In 3 matched pairs, 6 OCFs from 3 knees were each repaired with **three 1.8 mm interlinked KASAs (IKASA)**, their repair sutures creating an overlying suture bridge that compresses the OCF (Fig 2A). In the other 3 matched knees, the 6 OCFs were each repaired with **three 3.0 mm BCS** (Fig 2C).

In the other 3 matched pairs, 6 OCFs in 3 knees were repaired using a **hybrid "absorbable suture bridge" (ASB) construct**, with overlying multi-strand size-0 absorbable suture bundle secured under tension with 3 recessed 1.8 mm KASAs serving as "eyelets" to compress the OCFs (Fig 2B). In the other 3 matched knees, the 6 OCFs were each repaired with **three 3.0 mm BCS** (Fig 2C).

Each repair was done with a thin-base metal stud embedded between the condyle and OCF, the stud base recessed into the condyle to allow for flush OCF/condyle reduction, and stud shaft protruding through the OCF. The studs were then distracted at 1 mm/s until construct failure.

Data collected: Loads to 1 and 2 mm displacements; maximum failure load (MFL); failure mode. Results were analyzed with paired t-Tests. Post-hoc power analyses based on MFL findings were performed.

RESULTS:

MFLs were significantly higher in both IKASA (*P* = .30) and ASB repairs (*P* < .001) compared to their matched-knee BCS repairs (Fig 3A, 4A)**.**

ASB showed significantly higher load to 1 mm displacement (*P* = .025) compared to their matched-knee BCS repairs**,** but not IKASA (*P* = .42). Loads to 2 mm displacement could not be compared, as **9 out of 12 BCS constructs failed before reaching 2 mm**, while **no IKASA or ASB construct failed at 2 mm** (Fig 3B, 4B).

All BCS repairs failed with fragment-screw separation. All ASB and IKASA repairs failed with suture/anchor pull-outs. Post-hoc analysis ($\alpha = 0.05$) demonstrated sufficient power ($\beta = 98.1 - 100\%$).

DISCUSSION AND CONCLUSION:

In this first biomechanical examination of OCF fixation using knotless all-suture anchors, **both permanent and absorbable suture-bridge constructs demonstrated significantly higher MFLs and no early failures**, compared to the established trans-fragmentary compression screw fixation.

Thin, unstable OCFs are commonly seen in patellar dislocations and OCD. Although they have shown satisfactory healing potential if securely fixed, the thin fragments are especially challenging to secure with current trans-fragmentary fixation options, consistent with the early fixation failures at lower loads seen in 75% of BCS repairs in the present study. Fixation via overlying compression with a suture-bridge construct, however, may be less compromised by fragment thinness.

The two suture-bridge constructs offer distinct potential advantages. **The IKASA option is more technically streamlined and may better facilitate arthroscopic fixation**. While the significance of opposing surface abrasion by permanent sutures is unknown, since the scenario has long been present in meniscus repairs, **the ASB option eliminates permanent suture presence on joint surface to reduce abrasion concerns**, while still providing greater fixation security than current-standard screw repair.

In conclusion, **both absorbable and permanent suture-bridge options for thin osteochondral fragment repair offer greater time-zero fixation security over the current-standard repair with trans-fragmentary implants**, and may represent a viable new approach for osteochondral fixation.

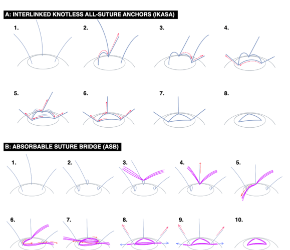

FIGURE 1. SURGICAL TECHNIQUES, IKASA AND ASB

A: Interlinked knotless all-suture anchor (IKASA) osteochondral repair. 1: three knotless all-suture anchors are placed through the osteochondral fragment (OCF) and into the condyle. **2 – 4:** the repair sutures of the anchors are shuttled through other anchors to create a triangular suture bridge over the OCF. **5 –7:** the repair sutures are tensioned to tighten the suture bridge over the OCF, compressing it down on the condyle. **8:** excess sutures are trimmed on the surface once the suture bridge is optimally tightened and the OCF stabilized.

B: Absorbable suture bridge (ASB) osteochondral repair. 1: three knotless all-suture anchors are placed through the osteochondral fragment (OCF) and into the condyle. **2:** each anchor's repair suture is shuttled through itself, creating an "eyelet." **3:** a multi-strand bundle of absorbable sutures (purple) is shuttled through one eyelet. **4:** that anchor is fully tensioned to secure the bundle down. **5 – 7:** the two halves of the suture bundle are shuttle through the other two eyelets in opposite directions. **8 – 9:** with tension held on the absorbable suture bundle ends, the remaining two anchors are fully tensioned to hold the absorbable suture bundle down under tension, which compresses the OCF. Note: upon completion, *only the absorbable suture bridge is on the OCF surface*. **10:** the excess repair sutures and absorbable suture bundle are trimmed on the surface.

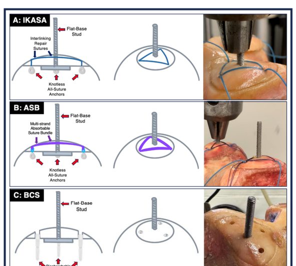

FIGURE 2. Repair of 5-mm thin osteochondral fragment. A metal stud with thin flat base is embedded between the fragment and the condyle, with the base recessed into the condyle to maintain full fragment-condyle contact. **(A) Novel interlinking knotless all-suture anchor (IKASA) construct**. The 1.8 mm knotless soft anchors are placed through the fragment and into the condyle, and the repair sutures are passed sequentially through adjacent anchors, creating a "suture bridge" overlying compression effect. **(B) Novel absorbable suture-bridge (ASB) construct**. Note the 1.8 mm knotless soft anchors and their permanent repair sutures are recessed below the articular surface, and only the multi-strand absorbable suture bundle is on the joint surface, held down under tension by the repair sutures. **(C) Current-standard bio-absorbable compression screw (BCS) repair**, with each screw recessed 2 mm below articular surface according to manufacturer directions.