Technical Note

# Arthroscopic Transosseous-Equivalent Double-Row Rotator Cuff Repair Augmentation With Interpositional Demineralized Bone Fiber Implant

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**Abstract:** Failure of rotator cuff repairs contributes to decreased patient satisfaction and quality of life. Biologic enhancement of repairs represents a novel augmentation strategy attempting to reproduce native healing while concomitantly potentially decreasing the existing high failure rates associated with rotator cuff repairs. Scaffolds placed on top of the rotator cuff have been widely studied, yet no recreation of the native enthesis is achieved via this augmentation strategy. Several strategies involving placement of demineralized bone matrix scaffolds on an inlay configuration (between bone and tendon) have been reported demonstrating enhanced recreation of the native bone-tendon unit. This Technical Note describes the surgical technique of inlay demineralized bone fiber scaffold augmentation of rotator cuff repairs to enhance biological healing in aims of recreating the native enthesis.

Rotator cuff tears are a common injury in the aging population, with a prevalence of up to 20% in patients older than 50 years.[1] Although tears can be surgically managed, retear rates remain high, posing a challenge, as failure contributes to impaired clinical and functional outcomes as well as poor patient satisfaction.[2] Several strategies have been designed to enhance the biologic healing of repairs by facilitating tendon-to-bone healing, which is the location at which most repairs fail.[1,3] Among these strategies, patch or scaffold augmentation has been an increasing area of interest.[3,4]

Rotator cuff repairs augmented with collagen scaffolds placed on top (onlay) of the repairs have been largely studied yet have only shown mechanically inferior scar tissue formation with no recreation of the native tendon-bone interface.[1,3,5,6] The native enthesis is composed of a transitional zone from the tendon to fibrocartilage to mineralized fibrocartilage and ultimately bone.[1] Newer scaffolds, placed between the tendon and bone (inlay), have been manufactured with the goal of providing the necessary biological factors in an optimal location for recreation of the native enthesis configuration.

In an attempt to further enhance the recreation of the native enthesis, interpositional (inlay) scaffolds composed of demineralized bone matrix (DBM) have been used.[5,7] DBM scaffolds provide an osteoinductive environment, given their porosity and composition (extracellular matrix components and growth factors), which have been shown to enhance tendon-bone healing in animal models.[7] In this regard, we sought to present the surgical technique for an all-arthroscopic transosseous-equivalent double-row rotator cuff repair augmented with an interpositonal demineralized bone fiber scaffold.

## Surgical Technique

### Patient Positioning

An interscalene nerve block is administered in the preoperative area. After the induction of general anesthesia, the patient is placed in the beach-chair position with 30° of hip flexion. Surgical arm positioning is

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achieved by using an articulated arm-holding device (SPIDER 2 Limb Positioner; Smith & Nephew, Andover, MA). After sterile draping, bony landmarks are identified and marked before creation of the arthroscopic portals.

### Portal Placement and Glenohumeral Diagnostic Arthroscopy

The complete, detailed presentation of the described technique is demonstrated in Video 1. A standard posterior viewing portal is first established 2 cm medial and 2 cm inferior to the posterolateral angle of the acromion. Next, an anterior-based interval portal is created in an outside-in fashion with the use of spinal needle localization. This interval portal is placed just lateral to the coracoid process and superior and inferior to the borders of the infraspinatus and supraspinatus tendons, respectively. After portal placement, a complete 2-portal diagnostic arthroscopy ensues, allowing visualization of the rotator cuff (Fig 1).

### Accessory Portal Placement and Subacromial Space Evaluation

A lateral portal is then created, located 2 to 4 cm off the lateral edge of the acromion in line with the posterior clavicular border, for better assessment of the subacromial space. An additional accessory anterolateral portal with a screw-in cannula (Twist-In Cannula; Arthrex, Naples, FL), used to facilitate instrument and material management, is created off the anterolateral edge of the acromion. Finally, a spinal needle is then used to accurately position the portal used for percutaneous anchor placement, as depicted in Figure 2.

Arthroscopic assessment of the subacromial space follows, allowing improved visualization of the rotator cuff (Fig 1). While in the subacromial space, extensive subacromial bursectomy and decompression are achieved using a bone-cutting arthroscopic shaver.

### Rotator Cuff Repair and Scaffold Placement

Before the repair, the edge of the torn tendons is debrided, and greater tuberosity footprint decorticated with an arthroscopic shaver. Next, the torn tendons are mobilized, and medial- and lateral-row anchor placement is chosen. Attention is then shifted to the placement of 2 double-loaded medial-row 2.6-mm all-suture anchors (FiberTak; Arthrex) 8 to 10 mm anteroposterior distance apart (Fig 3). All 8 sutures are then passed along the length of the rotator cuff tear in a mattress configuration aided by a tissue penetrator (Figs 4 and 5).

Before anchoring the sutures into the lateral row, the interpositional allograft, demineralized bone fiber implant (Tetrous Inc., Sherman Oaks, CA) is placed between the bone and inferior aspect of the repaired tendon at the footprint on the humeral head. Implant deployment begins with an awl placed through the anterolateral portal off the edge of the acromion. The arm should be adducted to allow for as close to vertical penetration of the bone as possible. The pilot hole is prepared in the center of the tuberosity to allow for optimal footprint coverage. A punch is then used to prepare the implant site to create a flush circular bone cut out allowing for seating of the implant flush with the surrounding bone. Next, implant is placed percutaneously into the prepared pilot hole. The bone fiber implant is then tapped into position flush with the surrounding bone, allowing for seamless completion of a transosseous-equivalent rotator cuff repair while achieving placement in the center of the footprint, lateral to the medial row of anchors, and just medial to the edge of the greater tuberosity on the humeral head (Figs 6-8).

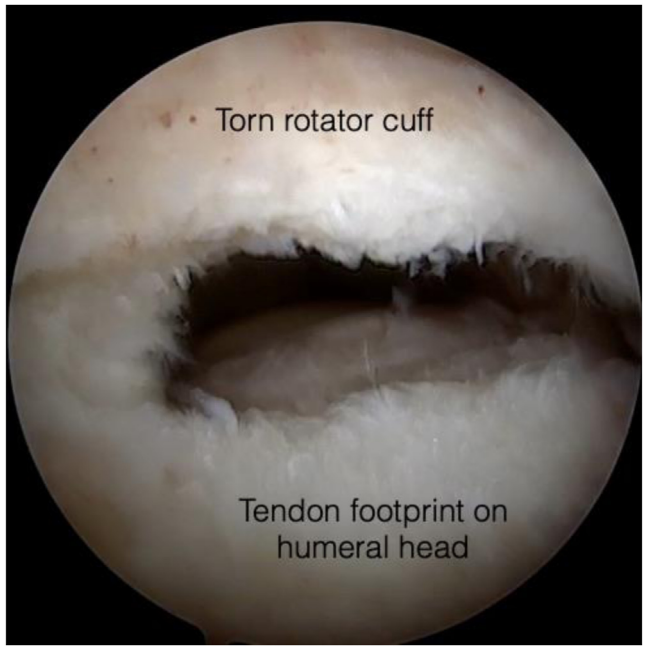


**Fig 1.** Arthroscopic image of the 1.5- to 2-cm right shoulder rotator cuff tear as viewed from the lateral portal within the subacromial space approached via beach-chair positioning.

The previously passed mattress sutures are then brought down to the lateral row in an over-the-top manner, achieving reduction of the torn tendons over the tuberosity with the demineralized bone fiber scaffold left between the inferior aspect of the tendons and the bone (Fig 9). Two lateral-row 4.75-mm biocomposite anchors (SwiveLock; Arthrex) are then used to secure the repair in place by creating a transosseous-equivalent double-row rotator cuff repair (Fig 10). Advantages and disadvantages of the procedure can be found in Table 1.

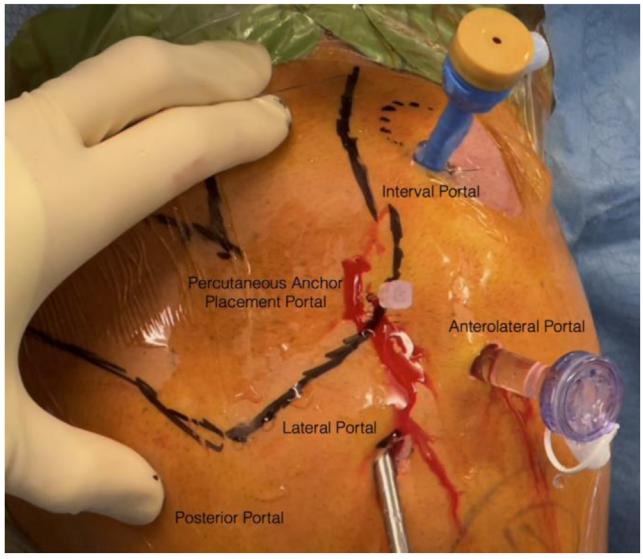


**Fig 2.** Right shoulder, beach-chair approach for arthroscopic portal placement is shown.

## Rehabilitation Protocol

Patients are discharged home in an abduction sling for 6 weeks. Physical therapy is initiated 2 weeks postoperatively with pendulum and wrist/elbow exercises. Active assisted and passive motion is started 6 weeks postoperatively, whereas active motion is delayed until 8 weeks after surgery. Strengthening exercises are delayed until 14 to 16 weeks after surgery.

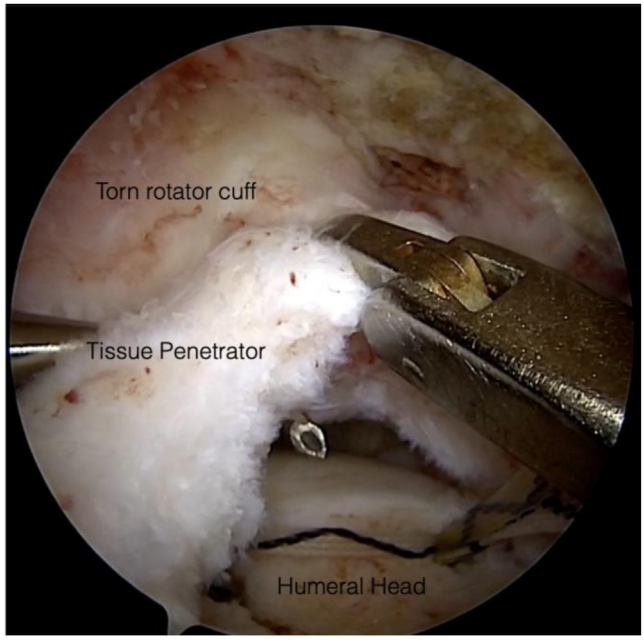


**Fig 4.** Arthroscopic image of the tissue penetrator piercing through the torn right shoulder tendon to shuttle medial-row anchor's sutures through the healthy portion of the tendon for posterior lateral anchorage. Viewed from the lateral portal via a beach-chair approach.

## Discussion

Rotator cuff pathology, with an increasing prevalence in patients older than 50 years, predisposes to low quality of life with poor clinical outcomes and patient

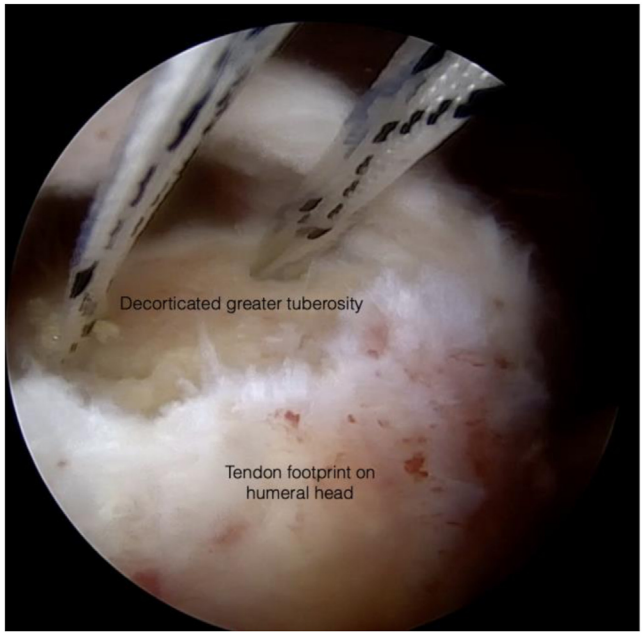


**Fig 3.** Arthroscopic image of double-loaded medial-row suture anchors over decorticated greater tuberosity on the right humeral head as viewed from the lateral portal via a beach-chair approach.

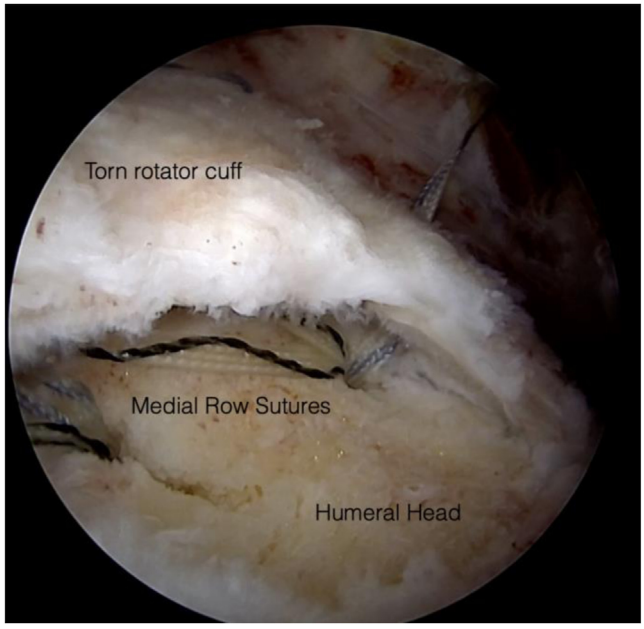


**Fig 5.** Arthroscopic image of all 8 medial-row sutures retrieved through the right shoulder's torn tendon with the tissue penetrator as viewed from a beach-chair approach lateral portal.

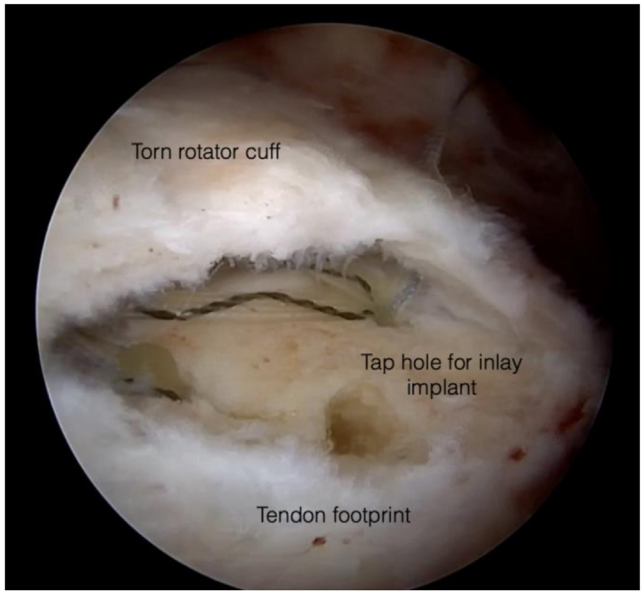


**Fig 6.** Arthroscopic image of the pilot hole and bone cut out, located on top of the right humerus, for preparation of inlay demineralized bone fiber implant placement. Viewed from the lateral portal via a beach-chair approach.

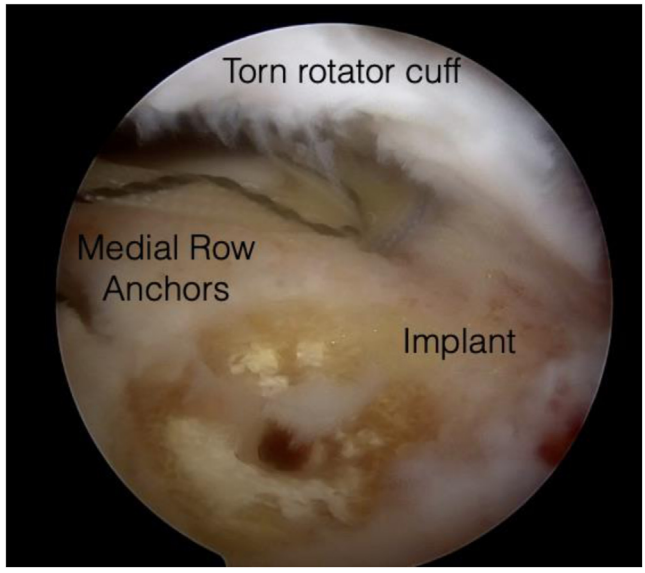


**Fig 8.** Arthroscopic image, viewed from the right shoulder's lateral portal, displaying the implant in place at the center of the tuberosity allowing for optimal footprint coverage.

satisfaction.[1,2] Although multiple surgical augmentation techniques are available for the management of rotator cuff tears, retear rates remain high, reaching up to 40% in the available literature.[1] Given the high failure rates, focus has shifted toward the improvement of the biomechanical and biological properties of the repairs.[1] Thereby, the present article describes the technique used to biologically augment a rotator cuff repair with the use of an interpositional demineralized bone fiber implant while using one of the strongest biomechanically repair construct available, a transosseous double-row repair.[1,8,9]

The importance of recreating the native enthesis lies on the fact that the tendon-bone interface is the location where most rotator cuff repairs fail, thereby suggesting that biological factors play a pivotal role on conserving the integrity of the repair.[1,3] The use of

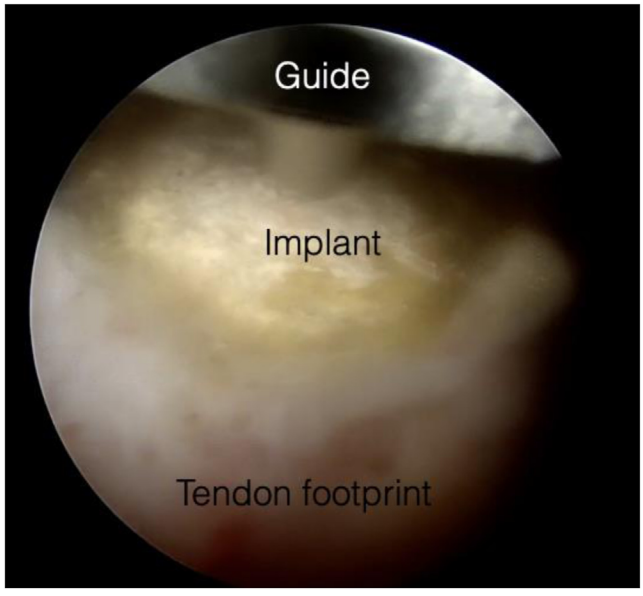


**Fig 7.** Arthroscopic image, as viewed from a beach-chair approach, lateral portal, showing the demineralized bone fiber implant being tapped in between the right shoulder's humeral bone and tendon.

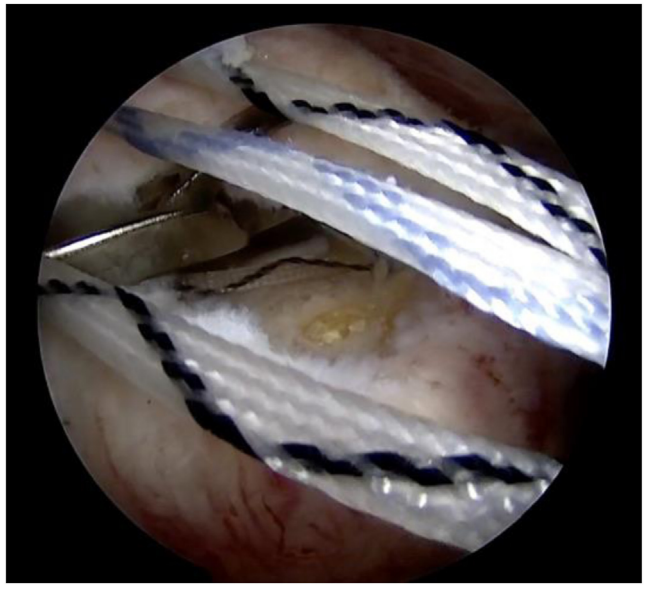

**Fig 9.** Right shoulder, beach-chair approach, lateral portal view of the inlay positioned implant after lateral pulling of the previously anchored medial-row sutures shuttled through the healthy portion of the torn tendon.

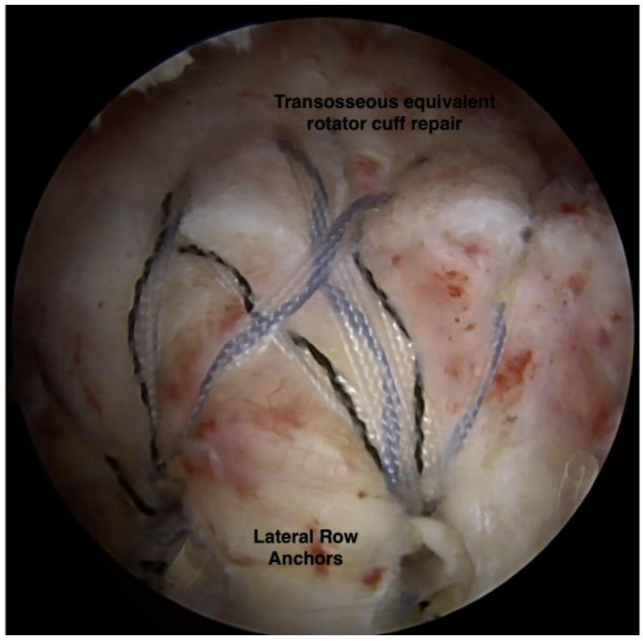


**Fig 10.** Beach-chair approach lateral portal arthroscopic image of the final right shoulder transosseous-equivalent, double-row rotator cuff repair with no visualization of the demineralized bone fiber implant as it lies between the tendon-bone unit (inlay configuration).

demineralized bone, possessing osteoinductive properties, has been studied previously, with investigations reporting enhanced histologic recreation of the tendon-bone unit.[7] Moreover, the application of DBM scaffolds in rotator cuff animal models has shown a greater semiquantitative histologic resemblance to the native enthesis compared with controls.[10-12] Nonetheless, reports of no enhancement also have been published by Thangarajah et al.,[13] who found no differences in enthesis maturation between controls and experimental groups. Regardless, careful interpretation of the results is warranted, as studies in animals do not possess the same level of evidence as clinical studies.

Although most DBM scaffolds have shown promising results, inlay positioned scaffolds composed of synthetic materials or collagen type I also have been tested in in vivo rotator cuff models with mixed results.[5,14-18] For instance, 2 studies[5,17] found no difference in histologic characteristics between repairs augmented with a biphasic allograft and a collagen type I sponge carrier, respectively, and controls. On the contrary, several investigations using synthetic polymers (poly-L-lactic acid, poly-lactide-co-glycoside, polyglycolic acid, and poly-L-lactide-co-caprolactone) and collagen type I scaffolds have reported enhanced histologic results upon augmentation of rotator cuff repairs with inlay positioned implants as native enthesis resemblance was achieved.[14-16,18]

**Table 1.** Advantages, Disadvantages, and Limitations

| |
|---|
| Advantages |
| Enhanced tendon-bone (enthesis) recreation |
| Little-to-no increased surgical time |
| Scaffold placement similar to anchor deployment |
| No need for increased surgical assistance |
| Nontechnically demanding |
| Disadvantages |
| Increased cost |
| Limitations |
| Scarce clinical data available |
| Difficulty to assess histologic enthesis recreation in the clinical setting |

Although a number of animal investigations have evaluated the effect of interpositional scaffolds on biologic augmentation of rotator cuff repairs, the clinical literature is scarce, with only 2 studies in humans reporting on the use of inlay positioned implants.[19,20] One of the studies used an implant composed of poly-lactide-co-glycoside fibers,[20] whereas the other was made of a nanofiber, bioresorbable polymer.[19] Irrespective of material, both studies reported a lower failure rate than that currently reported for onlay-augmented repairs.[3] In addition, improved functional outcomes also were observed in both investigations, yet none presented a control group for direct comparisons between treatment arms, and results should therefore be interpreted with caution.

This Technical Note describes the authors' surgical technique for biological enhancement of a rotator cuff repair while using an interpositional demineralized bone fiber scaffold. Further clinical studies are needed to fully ascertain the clinical effect of the observed histologic enhancement.

## Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: N.N.V. reports board membership, American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, Arthroscopy Association of North America, and Slack Incorporated; funding grants from Arthrex, Smith & Nephew, Breg, and Ossur Americas; and consulting or advisory and funding grants from Stryker. All other authors (J.B.V-E., R.S-B., R.D., Z.A.K., S.B.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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