Editorial Commentary: Biologically-Enhanced Patch Augmentation: The Perfect Marriage of Mechanical Stability and Biology for Rotator Cuff Healing? Unfortunately, Not Yet

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Abstract: Recurrent rotator cuff tears are a frequent cause of shoulder disability. To repair a rotator cuff, the surgeon faces both mechanical and biological challenges. Patch use as a scaffold for rotator cuff repair is well-described, as is biological augmentation, with clinical indications and efficacy being the subjects of ongoing study. However, a clinical report of dermal allograft patch augmentation combined with attempts at supercharging the biology is novel. This technique would benefit from controlled, prospective studies, with tight inclusion criteria.

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The rotator cuff presents 2 unique challenges to orthopaedic surgeons. There is the *mechanical* challenge: the supraspinatus tendon is the only tendon in the body that is in its fully elongated position when in the anatomic position. Couple this with the massive forces on this tendon in the native state,[1] made even greater in cases of retracted, stiffened, and chronically torn tendons, and it becomes clear why revision rotator cuff repair with 2 or more tendons has such a dismal failure rate. Add to this the *biological* challenge: the supraspinatus footprint is a watershed area of poor blood supply and poor healing potential. The biologic insult increases with the further decrease in blood supply brought on by aging, smoking, high cholesterol, and diabetes, and it is clear that for some patients, the biological factors are equally as harmful as the mechanical.[2] As a result of these biological and mechanical challenges, augmentation is a growing field, with the indications for use and efficacy under ongoing investigation.[3-5]

Systematic reviews of rotator cuff augmentation have tended to put rotator cuff augmentations into either biological or mechanical camps.[3] On one end of the spectrum are the purely mechanical solutions—the synthetic patches, which provide structural support without biology. On the other end are the purely biological adjuvants—platelet-rich plasma (PRP) and bone marrow aspirate concentrate (BMAC)—designed to rev up the healing biology but with no structural support. In "Clinical Outcomes Following Biologically-Enhanced Patch Augmentation Repair as a Salvage Procedure for Revision Massive Rotator Cuff Tears" by Muench, Kia, Jerliu, Williams, Berthold, Cote, McCarthy, Arciero, and Mazzocca, the authors have attempted to marry these 2 concepts with a biologically enhanced dermal allograft serving as a scaffold.[6] They present their retrospective review of 22 patients with a mean age of 57 ± 6 years. The patch is decellularized human dermal matrix allograft, a commonly used and frequently studied patch, but they have attempted to "supercharge" this graft by adding the PRP/BMAC cellular pro-healing elements by injecting the graft, soaking the graft, and injecting around the repair site. They further married experimental paradigms by both including clinical follow-up and also a basic science analysis of how many cellular elements really made it into the patch. Many surgeons in practice are currently using

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BMAC and/or PRP combined with allograft augmentation, but the authors should be saluted for systematically analyzing their results on both the clinical and biologic fronts.

Unfortunately, at least in this iteration, it doesn't seem to work. Only 41% of the patients reached the substantial clinical benefit cutoff and only 32% passed the patient-acceptable symptomatic state level. Only 9 of 22 patients were considered a clinical success. However, there is hope for this concept! When the PRP/BMAC-infused patches were incubated, the patients who had clinical success did have a significantly greater amount of cellular activity. In other words, the PRP/BMAC cellular elements added to the allograft dermis may help after all—provided you can get enough of them into the graft. Or perhaps, this just tells us about the biology of clinically successful versus non-successful rotator cuff repair patients—another plausible explanation for the data is that patients with a more vigorous biologic milieu had more cells and/or more vigorously growing cells than patients with clinical failure.

Many questions remain unanswered. First of all, our group systematically reviewed the allograft, xenograft, and patch techniques in the published literature. Meta-analysis demonstrated that graft augmentation or interposition lowered retear rates and improved American Shoulder and Elbow Surgeons scores compared with rotator cuff repair alone.[3] The graft technique appears generally similar to that used by others. For example, studies by Toth, Millett, Synder, and others found improved patient-reported outcomes, range of motion, and low failure rates when using dermal tissue matrix xenograft.[7-13] So why are the results here by Muench et al. *worse* with the addition of the BMAC and PRP?

The main limitation is that the study includes a relatively small and heterogenous cohort. This represents a "real-world" revision rotator cuff scenario, but including 40% of patients who were smokers, 23% patients with diabetes, and an unknown number of patients with Hamada 2 or greater rotator cuff arthropathy (given the average acromiohumeral interval was 6.3 $\pm$ 3 mm) can confound the results and cloud the picture. Including these challenging patients may have stacked the deck against this technique. Furthermore, the details of the pathology are also not clear. Some patients required margin convergence, but how many? The authors note that "Once all medial anchors were placed, the suture was passed through the cuff in a horizontal mattress configuration and tied, restoring as much cuff as possible to the anatomic footprint with minimal tension." However, it is not clear how much of the footprint they were able to cover. Was there a minimal amount of footprint coverage that was deemed acceptable? Furthermore, 14% of the patients had grade 4 atrophy. This is viewed by me and many other surgeons performing arthroscopic rotator cuff repair with patch augmentation as a relative contraindication. These cases were performed some time ago (2009-2014) and in 2020, certainly many of these patients would be indicated for a different procedure, such as superior capsular reconstruction, lower trapezius transfer, or reverse total shoulder arthroplasty. Furthermore, although failure rates were high in this case series, the absence of a control group makes it challenging to draw conclusions about the efficacy of the procedure.

Rotator cuff repair with patch augmentation is an excellent operation with a solid track record.[7-13] It does add cost, but systematic reviews demonstrate added benefit.[3] In this study, it is not clear who paid for the PRP, BMAC, and dermal allografts—the patients, a medical device company, or whether the hospital absorbed the cost. One truth that is clear is that to justify this massive increase in the cost of the operation, a clear benefit must be demonstrated, and none was shown here. The authors should be congratulated for a great start, and we await future prospective studies, a control group, and tighter inclusion criteria to see whether this marriage of mechanical strength and biology has a future.

References

1. Mehta S, Gimbel JA, Soslowsky LJ. Etiologic and pathogenetic factors for rotator cuff tendinopathy. *Clin Sports Med* 2003;22:791-812.
2. Otte RS, Srikumaran U, Lin A, Freehill M, Garrigues GE. Arthroscopic rotator cuff repairLieberman J, Davis C, eds. *Instructional course lectures*, 69 Philadelphia: AAOS/Wolters Kluwer Health, 2020;69, 2020.
3. Bailey JR, Kim C, Alentorn-Geli E, et al. Rotator cuff matrix augmentation and interposition: A systematic review and meta-analysis. *Am J Sports Med* 2019;47:1901-1908.
4. Thon SG, O'Malley L, O'Brien MJ, Savoie FH. Evaluation of healing rates and safety with a bioinductive collagen patch for large and massive rotator cuff tears: 2-year safety and clinical outcomes. *Am J Sports Med* 2019;47:1901-1908.
5. Saltzman BM, Jain A, Campbell KA, et al. Does the use of platelet-rich plasma at the time of surgery improve clinical outcomes in arthroscopic rotator cuff repair when compared with control cohorts? A systematic review of meta-analyses. *Arthroscopy* 2016;32:908-918.
6. Muench L, Kia C, Jerliu A, et al. Clinical outcomes following biologically-enhanced patch augmentation repair as a salvage procedure for revision massive rotator cuff tears. *Arthroscopy* 2020;36:1542-1551.
7. Gupta AK, Hug K, Boggess B, Gavigan M, Toth AP. Massive or 2-tendon rotator cuff tears in active patients with minimal glenohumeral arthritis: Clinical and radiographic outcomes of reconstruction using dermal tissue matrix xenograft. *Am J Sports Med* 2013;41:872-879.

8. Wong I, Burns J, Snyder S. Arthroscopic GraftJacket repair of rotator cuff tears. *J Shoulder Elb Surg* 2010;19:104-109.
9. Lederman ES, Toth AP, Nicholson GP, Nowinski RJ, Bal GK, Williams GR, Iannotti JP. A prospective, multicenter study to evaluate clinical and radiographic outcomes in primary rotator cuff repair reinforced with a xenograft dermal matrix. *J Shoulder Elbow Surg* 2016;25:1961-1970.
10. Bond JL, Dopirak RM, Higgins J, Burns J, Snyder SJ. Arthroscopic replacement of massive, irreparable rotator cuff tears using a GraftJacket allograft: Technique and preliminary results. *Arthroscopy* 2008;24:403-409.
11. Gupta AK, Hug K, Berkoff DJ, et al. Dermal tissue allograft for the repair of massive irreparable rotator cuff tears. *Am J Sports Med* 2012;40:141-147.
12. Neumann JA, Zgonis MH, Rickert KD, et al. Interposition dermal matrix xenografts: A Successful alternative to traditional treatment of massive rotator cuff tears. *Am J Sports Med* 2017;45:1261-1268.
13. Petri M, Warth RJ, Horan MP, Greenspoon JA, Millett PJ. Outcomes after open revision repair of massive rotator cuff tears with biologic patch augmentation. *Arthroscopy* 2016;32:1752-1760.