

# Acellular Dermal Matrix in Rotator Cuff Surgery

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## Abstract

The success of rotator cuff repair (RCR) surgery can be measured clinically (validated outcome scores, range of motion) as well as structurally (re-tear rates using imaging studies). Regardless of repair type or technique, most studies have shown that patients do well clinically. However, multiple studies have also shown that structurally, the failure rate can be very high. A variety of factors, including poor tendon quality, age over 63 years, smoking, advanced fatty infiltration into the muscle, and the inability of the tendon to heal to bone, have been implicated as the cause of the high re-tear rate in RCRs. The suture-tendon interface is felt to be the weakest link in the RCR construct, and suture pullout through the tendon is believed to be the most common method of failure. This review of the published literature seeks to determine if there is support for augmentation of RCR with acellular dermal matrices to strengthen the suture-tendon interface and reduce the re-tear rate.

Rotator cuff repairs (RCRs) can be challenging due to poor tendon quality and the inability of tendon to heal to bone. Smoking, age over 63 years, fatty infiltration, and massive cuff tears are all factors implicated in increased failure rates.<sup>1-3</sup> Tears >3 cm have a structural failure rate ranging from 11% to 95% in the literature.<sup>1-5</sup> Massive tears (tears >5 cm or involving 2 or more tendons) are even more complex and have failure rates of 20% to 90%.<sup>5,6</sup> The weakest link in the RCR construct is the suture-tendon interface, and suture pullout through the tendon is thought to be the most com-

mon method of failure.<sup>6</sup> The purpose of this review is to examine whether literature supports the use of acellular dermal matrices (ADMs) in rotator cuff surgery.

The high rate of structural failures after RCR has led surgeons to seek means to augment repairs and new means of reconstruction for irreparable tears. Freeze dried allograft tendons have been used historically with mixed results, including reports of complete graft failures and foreign body reaction.<sup>7-10</sup> Porcine intestinal submucosal membrane "patches" gained popularity due to off-the-shelf availability of the graft. However, these were found to have poor outcomes with early graft rejection and intense inflammatory reaction.<sup>11,12</sup> Recently, ADMs have gained significant interest due to favorable biomechanical properties and clinical outcomes.<sup>13-19</sup>

An ADM is an allograft composed of mostly type I collagen that is processed to remove donor cells while preserving the extracellular matrix. There are several commercially available ADMs with different methods of processing and sterilization, as well as handling characteristics.<sup>20,21</sup> In vivo studies have demonstrated that removing the cellular components allows infiltration of native cellular agents, such as fibroblasts, vascular tissue, and tenocytes, while causing minimal host inflammatory reaction.<sup>21-23</sup> In addition, superior suture pullout strength has been demonstrated by multiple benchtop and preclinical studies.<sup>23,24</sup> Therefore, ADMs play a dual role of strengthening the repair while allowing infiltration of host cells and growth factors to potentially promote healing at the repair site.

## Emerging Evidence

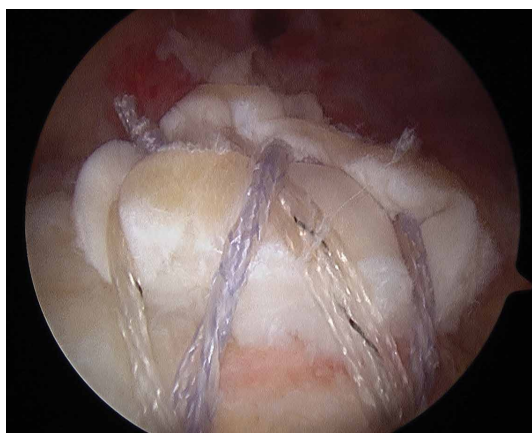
Multiple biomechanical studies have evaluated ADMs in RC models.<sup>24-28</sup> Barber and colleagues<sup>24</sup> demonstrated that ADM had significantly higher loads to failure (229 N) than porcine skin (128 N), bovine skin (76 N), and porcine small intestine submucosa (32 N) ( $P < .001$ ). In another study, Barber

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and colleagues<sup>25</sup> subsequently demonstrated, in a cadaver RC tear model, an increase in mean failure strength in augmented repairs with ADM (325 N) compared to cadaveric controls (273 N) ( $P = .047$ ).

A subsequent study by Barber and Aziz-Jacobo<sup>26</sup> compared ADMs to a control model of allograft RC. The ADMs had significantly higher tensile modulus ( $P < .001$ ) and higher suture retention measure by a single-pull destructive test of a simple vertical stitch ( $P < .05$ ) than the RC allograft. The ultimate load to failure of the ADM model was higher than the RC allograft control ( $523 \pm 154$  N vs  $208 \pm 115$  N); however, this difference did not reach statistical significance.<sup>26</sup> Beitzel and colleagues<sup>27</sup> evaluated ADM augmentation in a cadaver RC model and found a statistically significant increase in load to failure in ADM augmented repairs vs nonaugmented controls, ( $575.8$  N vs  $348.9$  N,  $P = .025$ ). Ely and colleagues<sup>28</sup> also demonstrated that repairs augmented with ADM had a higher load to failure ( $643$  N vs  $551$  N) and less gap formation ( $2.2$  mm vs  $2.8$  mm) compared to controls, although this difference was not statistically significant.

These biomechanical studies have been translated to clinical findings. A level II, prospective, randomized controlled study by Barber and colleagues<sup>29</sup> evaluated 42 patients with  $>3$  cm, 2-tendon RCTs repaired arthroscopically. Twenty-two patients were randomized to single-row arthroscopic repair, and 20 patients to single-row arthroscopic repair augmented by ADM by an onlay technique (**Figure 1**) as described by Labbé.<sup>30</sup> At average follow-up of 24 months, 85% of the augmented repairs were intact on magnetic resonance imaging (MRI) at follow-up, compared



**Figure 1.** Arthroscopically introduced acellular dermal matrix incorporated into a primary rotator cuff repair.

to 40% in the control group ( $P < .05$ ). Agrawal<sup>31</sup> retrospectively reviewed 14 patients with either RCTs  $>3$  cm or recurrent RCT (may be  $<3$  cm) that were arthroscopically repaired with a double-row technique with ADM augmentation. Postoperative MRI obtained at average of 16.8 months revealed 85.7% of repairs to be intact, with 14.3% having recurrent tears of  $<1$  cm. Rotini and colleagues<sup>32</sup> evaluated a smaller subset of 5 patients with large/massive primary cuff tears, arthroscopically repaired with double-row technique and ADM augmentation. Follow-up MRI at an average of 1 year demonstrated 3 intact repairs, 1 partial recurrence, and 1 complete recurrence. These clinical studies demonstrate that RCTs augmented with ADM have a much higher rate of structural integrity on postoperative imaging compared to what has been previously reported in the literature.<sup>1-6</sup>

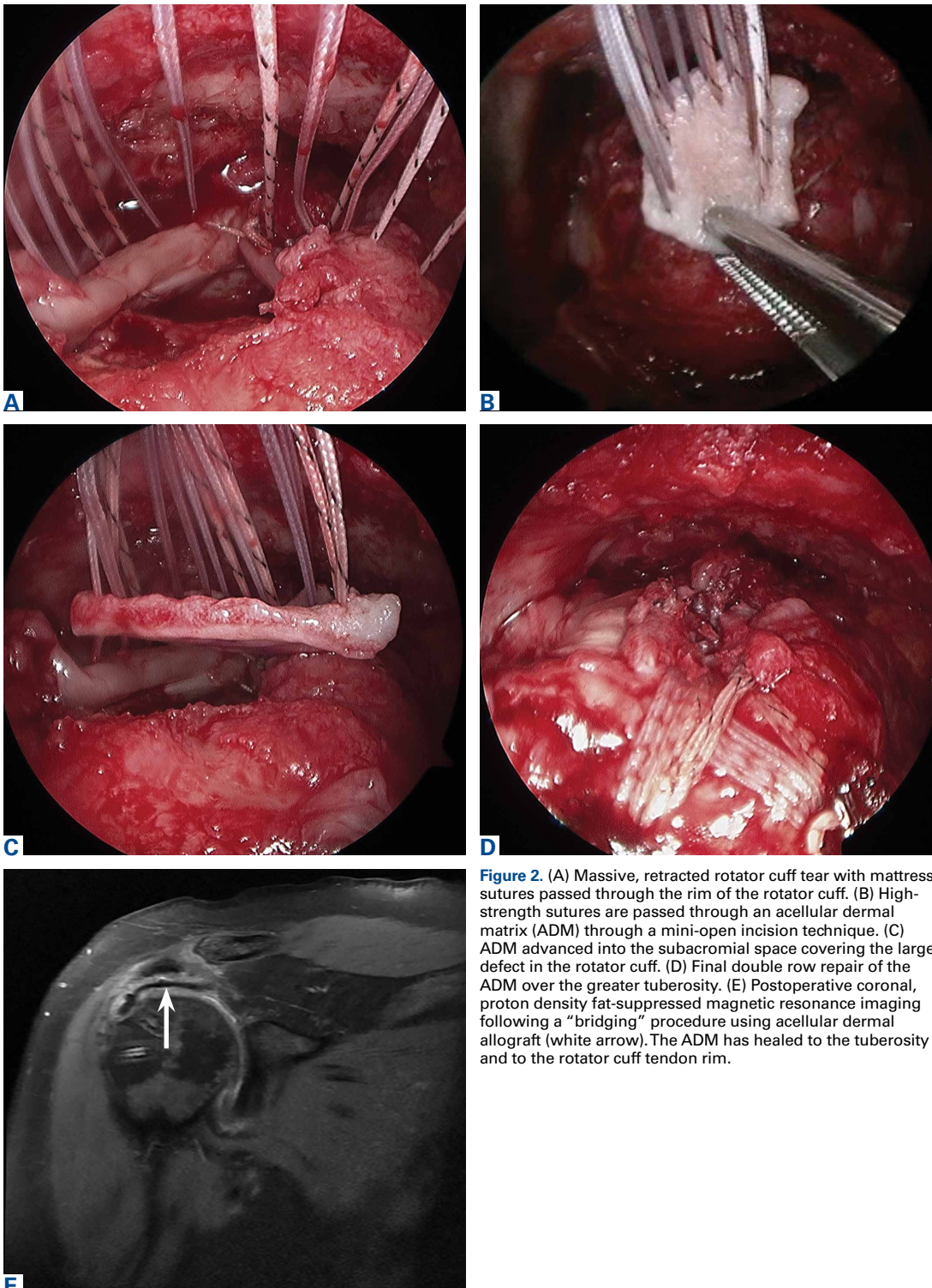
Although an “off-label” indication, the use of ADM in massive RC tears has been described with good clinical results.<sup>14,17,19,33</sup> The ADM is used to bridge the gap by suturing it to the edge of the retracted tendon and anchoring it to the tuberosity (**Figures 2A-2E**). Improvement in pain, function, and active range of motion can be achieved. Burkhead and colleagues<sup>14</sup> obtained postoperative MRIs at average follow-up of 1.2 years and found only 3 of 11 repairs with evidence of re-tear, all noted to be smaller than preoperative tears. Gupta and colleagues<sup>17</sup> obtained postoperative ultrasounds in 24 patients at average 3 years and showed 76% of tears to be fully intact, with the remaining 24% having only a partial tear, and 0% with full re-tears. Venouziou and colleagues<sup>19</sup> evaluated 14 patients with minimum 18-month follow-up and Kokkalis and colleagues<sup>33</sup> evaluated 21 patients with a 29-month follow-up; both described successful clinical outcomes but did not provide postoperative imaging evaluation. Multiple studies have adapted this technique to a fully arthroscopic method and have had similarly positive results clinically and with MRI.<sup>13,16,18,34,35</sup> Bond and colleagues<sup>13</sup> reported 16 cases with massive irreparable tears repaired arthroscopically with ADM to span the tendon gap. At an average follow-up of 26.8 months, 75% had good or excellent clinical results, and at an average of 1 year postoperatively 13 of 16 cases had an intact repair on gadolinium enhanced MRI.<sup>13</sup> These studies suggest that ADM can be used for bridging massive irreparable RC tears with good clinical and radiographic outcomes.

Superior capsule reconstruction is a biomechanically proven concept that has been described in

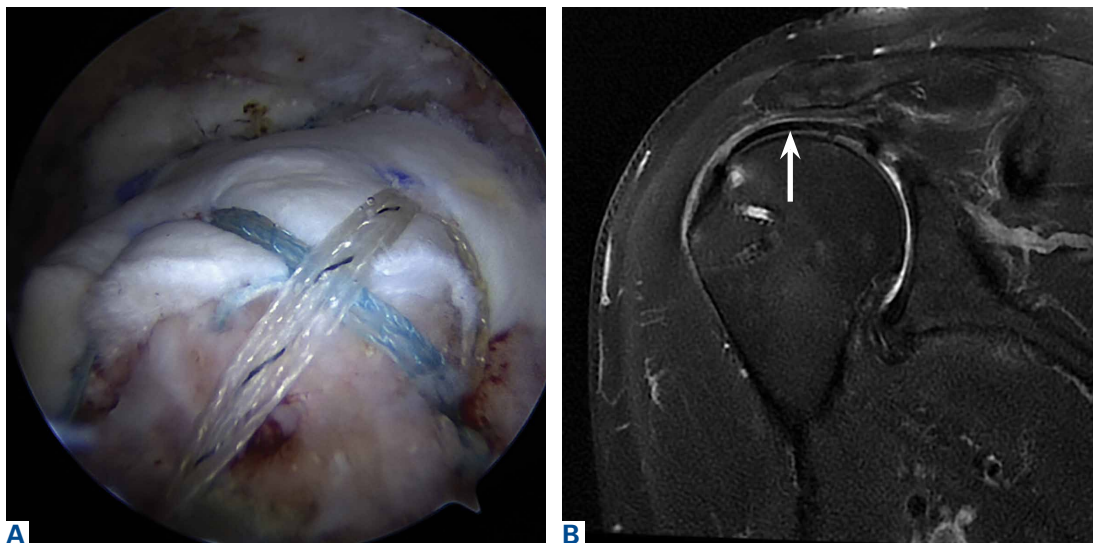


previous studies.<sup>36,37</sup> In the original technique, autologous tensor fascia lata (TFL) is anchored from the glenoid margin to the greater tuberosity footprint to restore the superior stability of the glenohumer-

al joint, without altering the native glenohumeral contact forces.<sup>38</sup> This concept has gained popularity in the United States, but with the use of an ADM instead of harvesting TFL (**Figures 3A, 3B**). However-



**Figure 2.** (A) Massive, retracted rotator cuff tear with mattress sutures passed through the rim of the rotator cuff. (B) High-strength sutures are passed through an acellular dermal matrix (ADM) through a mini-open incision technique. (C) ADM advanced into the subacromial space covering the large defect in the rotator cuff. (D) Final double row repair of the ADM over the greater tuberosity. (E) Postoperative coronal, proton density fat-suppressed magnetic resonance imaging following a “bridging” procedure using acellular dermal allograft (white arrow). The ADM has healed to the tuberosity and to the rotator cuff tendon rim.



**Figure 3.** (A) Superior capsular reconstruction using acellular dermal matrix (ADM). The ADM is secured to the superior glenoid and to the tuberosity with anchors. (B) Postoperative coronal T2 fat-suppressed magnetic resonance imaging 1 year after superior capsular reconstruction with an ADM (white arrow).

er, there are no published biomechanical or clinical studies with the use of ADM in superior capsular reconstruction.

### Conclusion

The use of ADM is an emerging solution for augmenting primary RCRs and the treatment of irreparable RC tears. The biomechanical and clinical studies summarized support the use of ADM in RC surgery. Further randomized studies are needed to add to the growing evidence on the use of ADMs.

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