repair based on biomechanical principles. *Arthroscopy* 2000; 16:82-90.
7. Burkhart SS, Barth JR, Richards DP, et al. Arthroscopic repair of massive rotator cuff tears with stage 3 and 4 fatty degeneration. *Arthroscopy* 2007;23:347-354.
8. Nho SJ, Shindle MK, Adler RS, et al. Prospective analysis of arthroscopic rotator cuff repair: Subgroup analysis. *J Shoulder Elbow Surg* 2009;18:697-704.
9. Boileau P, Brassart N, Watkinson DJ, et al. Arthroscopic repair of full-thickness ears of the supraspinatus: Does the tendon really heal? *J Bone Joint Surg Am* 2005;87:1229-1240.
10. Liem D, Lichtenberg S, Magosch P, Habermeyer P. Magnetic resonance imaging of arthroscopic supraspinatus tendon repair. *J Bone Joint Surg Am* 2007;89:1770-1776.
11. Goutallier D, Postel JM, Gleyze P, et al. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. *J Shoulder Elbow Surg* 2003;12:550-554.
12. Gladstone JN, Bishop JY, Lo IKY, Flatow EL. Fatty infiltration and atrophy of the rotator cuff do not improve after rotator cuff repair and correlate with poor functional outcome. *Am J Sports Med* 2007;35:719-728.
13. Mazzocca AD, Millett PJ, Guanche CA, et al. Arthroscopic single-row versus double-row suture anchor rotator cuff repair. *Am J Sports Med* 2005;33:1861-1868.
14. Huijsmans PE, Pritchard MP, Berghs BM, et al. Arthroscopic rotator cuff repair with double-row fixation. *J Bone Joint Surg Am* 2007;89:1248-1257.
15. Lafosse L, Brozska R, Toussaint B, Gobezie R. The outcome and structural integrity of arthroscopic rotator cuff repair with use of double-row suture anchor technique. *J Bone Joint Surg Am* 2007;80:1533-1541.
16. Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: Single-row versus dual-row fixation. *Arthroscopy* 2005; 21:1307-1316.
17. Lo IKY, Burkhart SS. Double-row arthroscopic rotator cuff repair: Re-establishing the footprint of the rotator cuff. *Arthroscopy* 2003;19:1035-1042.
18. Franceschi F, Ruzzini L, Longo UG, et al. Equivalent clinical results of arthroscopic single-row and double-row suture anchor repair for rotator cuff tears. *Am J Sports Med* 2007;35: 1254-1260.
19. Grasso A, Milano G, Salvatore M, et al. Single-row versus double-row arthroscopic rotator cuff repair: A prospective randomized clinical study. *Arthroscopy* 2009;25:4-12.
20. Gartsman GM, Drake G, Edwards TB, Elkousy H, Hammersman SM, O'Connor D. Ultrasound evaluation of arthroscopic full-thickness supraspinatus rotator cuff repair: Single-row versus double-row suture bridge (transosseous equivalent) fixation—Results of a randomized, prospective study. Presented at the 2009 Closed Meeting of the American Shoulder and Elbow Surgeons, New York, NY, October 2009.
21. Barber FA, Herbert MA, Schroeder A, et al. Biomechanical advantages of triple-loaded suture anchors compared with double-row rotator cuff repairs. *Arthroscopy* 2010;26:316-323.
22. Ko SH, Lee CC, Friedman D, et al. Arthroscopic single-row supraspinatus tendon repair with modified mattress locking stitch: A prospective, randomized controlled comparison with simple stitch. *Arthroscopy* 2008;24:1005-1012.
23. Duquin RT, Buyea C, Bisson LJ. Which method of rotator cuff repair leads to the highest rate of structural healing? A systematic review. *Am J Sports Med* 2010;38:835-841.
24. Reardon DJ, Maffulli N. Clinical evidence shows no difference between single- and double-row repair for rotator cuff tears. *Arthroscopy* 2007;23:670-673.
25. Wall LB, Keener JD, Brophy RH. Clinical outcomes of double-row versus single-row rotator cuff repairs. *Arthroscopy* 2009;25:1312-1318.
26. Nho SJ, Slabaugh MA, Seroyer ST, et al. Does the literature support double-row suture anchor fixation for arthroscopic rotator cuff repair? A systematic review comparing double-row and single-row suture anchor configuration. *Arthroscopy* 2009;25:1319-1320.
27. Voigt C, Bosse C, Vosshenrich R, et al. Arthroscopic supraspinatus tendon repair with suture-bridging technique. *Am J Sports Med* 2010;38:983-991.
28. Trantalis JN, Boorman RS, Pletsch K, Lo IKY. Medial rotator cuff failure after arthroscopic double-row rotator cuff repair. *Arthroscopy* 2008;24:727-731.
29. Cho NS, Yi JW, Lee BG, Rhee YG. Retear patterns after arthroscopic rotator cuff repair: Single-row versus suture bridge technique. *Am J Sports Med* 2010;38:664-671.
30. Yamakado K, Katsuo S, Mizuno K, et al. Medial-row failure after arthroscopic double-row rotator cuff repair. *Arthroscopy* 2010;26:430-435.

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Author's Reply

We welcomed Dr. Burks' letter to the editor because we believe no good "Level V Evidence" report reviewing a controversial topic should be presented without a chance for rebuttal. Thus we were pleased that Dr. Burks took the time and effort to address the issues raised in our Level V article, "Bridging Self-Reinforcing Double-Row Rotator Cuff Repair: We Really Are Doing Better," in the May issue of *Arthroscopy*.[1] We can certainly identify with Dr. Burks' explanation of the "voodoo doll mechanism" of pain generation that occurs when a colleague strongly disagrees with one's findings or beliefs. We too have experienced this phenomenon on multiple occasions over the years, and in the spirit of friendship and collegiality, we apologize for any discomfort that he attributes to our article.[1] In the spirit of resolving controversy (and pain), we are respectfully replying to the objections he has raised in his letter. As an aside, we have all been friends for a long time, and we will remain friends, despite our differences in opinion.

First, Dr. Burks references articles by Burkhart et al.[2-5] dating back to 1997 as evidence that single-row repair is adequate. Certainly this is an interesting chronicle of the evolution from single-row to double-row rotator cuff repair, but all but one of these articles were written before our original description of arthroscopic double-row repair in

2003.[6] Furthermore, Dr. Burks suggests that our bridging self-reinforcing double-row repairs are over-tensioning the cuff, particularly in cases where there may be some tendon loss. Dr. Burks' point is important to consider because technical issues related to how the sutures are positioned and tied remain germane to the success of this procedure and are often poorly clarified in technical descriptions of how the procedure is performed. This is analogous to an anterior cruciate ligament reconstruction where the graft is subject to premature failure by either over-tensioning or placing it nonanatomically.

With the self-reinforcing repair, we are not advocating tensioning the cuff to the lateral part of the greater tuberosity, nor are we advocating muscle-tendon fixation at the junction of the anatomic neck and tuberosity. Rather, sutures from the medial row should be placed through the cuff at a distance of 2 to 3 mm lateral to the musculotendinous junction,[7,8] and bridging sutures are used to compress the cuff tendon to the bone. Our tendon fixation points are defined by the medial-row sutures, and we work with whatever tendon is left to re-create and compress the footprint. In this way, we are able to re-establish physiologic tension in the muscle-tendon unit with minimal risk of over-tensioning. With this technique, we have not observed the medial failure described by Voigt et al.[9]

Dr. Burks suggests that the study by Barber et al.[10] proves that single-row repair with triple-loaded suture anchors is superior to double-row repair and bridging self-reinforcing repair. However, this was a biomechanical study using skeletally immature bovine shoulders, an experimental model that mitigates against the most common form of anatomic failure, cutout at the suture-tendon interface, because of the natural thickness and tenacity of healthy young bovine tendons. Burkhart et al.[11] showed a number of years ago that increasing the number of sutures per anchor will decrease the load carried per suture. Not surprisingly, if there is no cutout of suture through tendon, the strength of the repair construct increases linearly as more sutures are added. It is really restating the adage that "more is better." If 3 sutures are good, why not use 4, 5, or even 6 sutures per anchor? However, when tissue quality is poor, as seen in human retrieval studies of degenerative rotator cuff tears,[12] simple sutures placed laterally are the weak link, and this fact supports the self-reinforcing mechanism of the suture bridge as invaluable in strengthening the total repair construct. Because the study by Barber et al. was done with young bovine specimens and was a time-zero study (i.e., it did not take into consideration the effects of cuff degeneration or healing over time), we do not believe that its results are necessarily generalizable to the human condition.

Having also faced the trials and tribulations of performing a truly good Level I clinical study, we sincerely congratulate and applaud Burks and coauthors,[13] as well as Franceschi and coauthors.[14] Their hours spent were not without benefit and contribution to the body of academic literature. They will continue to be appropriately cited for their pivotal work. Their efforts should never be taken for granted because issues pertaining to study design, the institutional review board process, patient enrollment, and minimizing attrition associated with follow-up are challenging, to say the least. Our comments are not to condemn these efforts but to help further our understanding of what additional efforts will be required to resolve this debate. Even Dr. Burks admits that his study might have suffered from a type 2 error, which in essence renders invalid a conclusion that his single-row and double-row repair groups had equivalent clinical outcomes. Yet he says that "if there were differences, they would likely be fairly small, and their clinical impact might be more difficult to appreciate." However, we submit that if a study is not powered appropriately to detect an expected difference in anatomic outcomes, then the validity of the conclusions remains uncertain.

Rather than criticize, we all have a responsibility to academically approach this problem. Aside from meta-analyses, systematic reviews, and other studies that regroup existing literature, we agree that a definitive clinical study would help to categorically put this debate to rest. In an effort to use Dr. Burks' example of a well-designed study and determine the appropriate number of patients to properly power the study, we recently consulted a statistician regarding 2 scenarios (correspondence with Nik Verma, M.D.). In the first scenario, we assumed conservatively, based on the findings of Duquin et al.,[15] that after a single-tendon repair (size 1 to 3 cm), there would be a 30% failure rate, and after a double-row repair, there would be a 10% failure rate. With an α level of .05 and an 80% power determination, 72 patients would be required in each group to accurately perform a 2-group continuity-corrected χ^2 test of equal proportions. In the second scenario, if we assumed a 30% failure rate in the single-row repair group and a 20% failure rate in the double-row repair group, the study would require 313 patients in each group! Clearly, this will be no simple task.

We have witnessed a progression of the techniques developed for rotator cuff repair ranging from open repair to mini-open and from arthroscopic single-row to double-row to bridging self-reinforcing double-row. On the basis of our clinical experience, we have seen dramatic improvements in strength and outcomes at each stage in the evolution of arthroscopic rotator cuff repair. To further this effort, we are in the process of documenting the improvements in strength that occur with suture-bridge techniques.

We agree with Dr. Burks that we must remain fiscally responsible when delivering care to our patients. Certainly there are economic and sociologic pressures in today's medical environment to deliver good results at the lowest price. However, contemporary economic analyses fail to address the high costs associated with anatomic failure and revision surgery. None of us should accept less than the best for our patients. What remains certain is our need to continue this debate as "painlessly" as possible in the interests of our patients and health care in general. We can all work together

to achieve this common goal. We thank Dr. Burks for engaging and, once again, furthering our goals to seek the truth. His dedication will never go unnoticed or unappreciated. Of course, that is just our humble opinion.

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References

1. Burkhart SS, Cole BJ. Bridging self-reinforcing double-row rotator cuff repair: We really are doing better. *Arthroscopy* 2010;26:677-680.
2. Burkhart SS, Johnson TC, Wirth MA, Athanasiou KA. Cyclic loading of transosseous rotator cuff repairs: Tension overload as a possible cause of failure. *Arthroscopy* 1997; 13:172-176.
3. Burkhart SS, Diaz Pagàn JL, Wirth MA, Athanasiou KA. Cyclic loading of anchor-based rotator cuff repairs: Confirmation of the tension overload phenomenon and comparison of suture anchor fixation with transosseous fixation. *Arthroscopy* 1997;13:720-724.
4. Burkhart SS. A stepwise approach to arthroscopic rotator cuff repair based on biomechanical principles. *Arthroscopy* 2000; 16:82-90.
5. Burkhart SS, Barth JR, Richards DP, Zlatkin MB, Larsen M. Arthroscopic repair of massive rotator cuff tears with stage 3 and 4 fatty degeneration. *Arthroscopy* 2007;23:347-354.
6. Lo IK, Burkhart SS. Double-row arthroscopic rotator cuff repair: Re-establishing the footprint of the rotator cuff. *Arthroscopy* 2003;19:1035-1042.
7. Burkhart SS, Lo IKY, Brady PC. *Burkhart's view of the shoulder: A cowboy's guide to advanced shoulder arthroscopy*. Philadelphia: Lippincott Williams and Wilkins, 2006.
8. Burkhart SS, Adams CR, Burkhart SS, Schoolfield JD. A biomechanical comparison of 2 techniques of footprint reconstruction for rotator cuff repair: The SwiveLock-FiberChain construct versus standard double-row repair. *Arthroscopy* 2009;25:274-281.
9. Voigt C, Bosse C, Vosshenrich R, Schulz AP, Lill H. Arthroscopic supraspinatus tendon repair with suture-bridging technique: Functional outcome and magnetic resonance imaging. *Am J Sports Med* 2010;38:983-991.
10. Barber FA, Herbert MA, Schroeder FA, Aziz-Jacobo J, Mays MM, Rapley JH. Biomechanical advantages of triple-loaded suture anchors compared with double-row rotator cuff repairs. *Arthroscopy* 2010;26:316-323.
11. Burkhart SS, Fischer SP, Nottage WM, et al. Tissue fixation security in transosseous rotator cuff repairs: A mechanical comparison of simple versus mattress sutures. *Arthroscopy* 1996;12:704-708.
12. Wang VM, Wang FC, McNickle AG, et al. Medial versus lateral supraspinatus tendon properties: Implications for doublerow rotator cuff repair. *Am J Sports Med*, in press.
13. Burks RT, Crim J, Brown N, Fink B, Greis PE. A prospective randomized clinical trial comparing arthroscopic single- and double-row rotator cuff repair: Magnetic resonance imaging and early clinical evaluation. *Am J Sports Med* 2009;37:674-682.
14. Franceschi F, Ruzzini L, Longo UG, et al. Equivalent clinical results of arthroscopic single-row and double-row suture anchor repair for rotator cuff tears: A randomized controlled trial. *Am J Sports Med* 2007;35:1254-1260.
15. Duquin TR, Buyea C, Bisson LJ. Which method of rotator cuff repair leads to the highest rate of structural healing? A systematic review. *Am J Sports Med* 2010;38:835-841.

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Treatment of Hyperextension

To the Editor:

I read with great interest the article by Bourke et al.[1] in the March 2010 issue. As a huge fan of the utility of posterior portals and the unique effectiveness of the trans-septal portal, I applaud the authors for their creativity in attempting to expand the use of posterior compartment arthroscopy. However, I do have some significant concerns about the science of their conclusions.

Several researchers, including Kennedy,[2] have reported that symptomatic hyperextension is likely due to more than just posterior capsular redundancy. In fact, Kennedy found that anterior cruciate ligament violation occurred before posterior capsular injury in a cadaveric hyperextension model. Furthermore, more recent studies by Fornalski et al.[3] and LaPrade et al.[4] show that combined injury to the anterior cruciate ligament and posterolateral corner is likely present when significant hyperextension exists.

I am concerned that readers may embark on a relatively "quick-fix" solution to a rather complicated problem. I would predict that the patients in the study of Bourke et al.[1] will ultimately have a gradual return to knee hyperextension in time.

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References

1. Bourke HE, MacLeod IAR, Lewis JC, Williams AM. Arthroscopically induced posterior capsular fibrosis to correct symptomatic hyperextension of the knee. *Arthroscopy* 2010;26:425-429.
2. Kennedy JC. Complete dislocation of the knee joint. *J Bone Joint Surg Am* 1963;45:889-904.