













Most of the surgical options described are aimed at treating the soft tissue abnormalities associated with internal impingement, though some have investigated procedures focused on the bones of the shoulder. For example, Riand et al<sup>18</sup> described a derotational osteotomy with myorrhaphy of the subscapularis muscle as a treatment option. In these patients, the persistent pain after articular debridement was believed to be caused by increased humeral retroversion and prevented the patients from returning to their throwing sports. After the osteotomy, 55% of the patients were able to resume their sport at full level.

## Summary

From the authors' perspective, the literature from the past 2 decades has demonstrated increasing awareness and knowledge of the causes of posterior shoulder pain and internal impingement of the shoulder. More data and long-term follow-up studies can be expected, especially investigating the different treatment options. To date, we know of no prospective studies directly comparing treatment modalities, which is a limitation of the current body of evidence. Most of the current studies are clinical follow-up, not comparative but observational in nature. The condition itself presents difficulties in study design because concomitant shoulder pathologies make matching groups for a study difficult. Anecdotally, the authors have observed increased glenoid retroversion, as described by Crockett et al<sup>21</sup> when comparing dominant to nondominant shoulders in throwers and nonthrowers. In the authors' opinion, the posterior glenoid shape remodeling may lead to a prominence of the posterior glenoid. There is then an increased risk of contact between the articular surface of the rotator cuff and the posterior glenoid margin. Our hypothesis is that this shape change of the glenoid contributes to the internal rotation deficit and may then lead to internal impingement. Though the role of glenoid retroversion in the natural history of the disease is currently unclear, further study may reveal this as a future target for treatment.

The repetitive motions essential to the sports of overhead athletes place supraphysiologic strains on the shoulder and may result in a variety of changes, including exostoses, capsular laxity, increased humeral retroversion, scapular muscle imbalance, and rotator cuff tendonitis. However, distinguishing between pathologic and adaptive processes is difficult for even the most experienced of surgeons. Initially, conservative treatment and nonoperative therapy should be attempted, but failure may result in the necessity of surgical intervention to allow the

patient to resume high levels of competition. For the surgeon, the importance of addressing all comorbidities at the time of surgery cannot be understated, especially capsular laxity and contracture, as failure to do so has demonstrated poor outcomes. Looking to the future, further studies into the role of the Bennett lesion, glenoid version, and a standardized classification system of these shoulder injuries should help to improve our understanding of internal impingement the overhead athlete.

## Conflict of Interest Statement

Steven Behrens, MD, Jeffrey Compas, BA, Matthew E. Deren, BS, and Mark Drakos, MD disclose no conflicts of interest.

## References

1. Walch G, Boileau P, Noel E, Donell ST. Impingement of the deep surface of the supraspinatus tendon on the posterosuperior glenoid rim: an arthroscopic study. *J Shoulder Elbow Surg.* 1992;1:238–245.
2. Jobe CM. Posterior superior glenoid impingement: expanded spectrum. *Arthroscopy.* 1995;11(5):530–536.
3. Edelson G, Teitz C. Internal impingement in the shoulder. *J Shoulder Elbow Surg.* 2000;9(4):308–315.
4. Paley KJ, Jobe FW, Pink MM, Kvitne RS, ElAttrache NS. Arthroscopic findings in the overhand throwing athlete: evidence for posterior internal impingement of the rotator cuff. *Arthroscopy.* 2000;16(1):35–40.
5. Neer CS 2nd, Craig EV, Fukuda H. Cuff-tear arthropathy. *J Bone Joint Surg Am.* 1983;65(9):1232–1244.
6. Neer CS 2nd. Impingement lesions. *Clin Orthop Relat Res.* 1983;173:70–77.
7. Jobe CM. Superior glenoid impingement. Current concepts. *Clin Orthop Relat Res.* 1996;330:98–107.
8. Bennett GE. Elbow and shoulder lesions of baseball players. *Am J Surg.* 1959;98:484–492.
9. Lombardo SJ, Jobe FW, Kerlan RK, Carter VS, Shields CL Jr. Posterior shoulder lesions in throwing athletes. *Am J Sports Med.* 1977;5(3):106–110.
10. Andrews JR, Broussard TS, Carson WG. Arthroscopy of the shoulder in the management of partial tears of the rotator cuff: a preliminary report. *Arthroscopy.* 1985;1(2):117–122.
11. Jobe FW, Kvitne RS, Giangarra CE. Shoulder pain in the overhand or throwing athlete. The relationship of anterior instability and rotator cuff impingement. *Orthop Rev.* 1989;18(9):963–975.
12. Jobe FW, Giangarra CE, Kvitne RS, Glousman RE. Anterior capsulolabral reconstruction of the shoulder in athletes in overhand sports. *Am J Sports Med.* 1991;19(5):428–434.
13. Walch G, Liotard JP, Boileau P, Noel E. Postero-superior glenoid impingement. Another shoulder impingement [in French]. *Rev Chir Orthop Reparatrice Appar Mot.* 1991;77(8):571–574.
14. Kronberg M, Brostrom LA, Söderlund V. Retroversion of the humeral head in the normal shoulder and its relationship to the normal range of motion. *Clin Orthop Relat Res.* 1990;253:113–117.
15. Wilk KE, Meister K, Andrews JR. Current concepts in the rehabilitation of the overhead throwing athlete. *Am J Sports Med.* 2002;30(1):136–151.
16. Borich MR, Bright JM, Lorello DJ, Cieminski CJ, Buisman T, Ludewig PM. Scapular angular positioning at end range internal rotation in cases of glenohumeral internal rotation deficit. *J Orthop Sports Phys Ther.* 2006;36(12):926–934.

17. Laudner KG, Myers JB, Pasquale MR, Bradley JP, Lephart SM. Scapular dysfunction in throwers with pathologic internal impingement. *J Orthop Sports Phys Ther.* 2006;36(7):485-494.
18. Burkhart SS, Morgan CD. The peel-back mechanism: its role in producing and extending posterior type II SLAP lesions and its effect on SLAP repair rehabilitation. *Arthroscopy.* 1998;14(6):637-640.
19. Fleisig GS, Dillman CJ, Andrews JR. Biomechanics of the shoulder during throwing. In: *The Athlete's Shoulder.* New York, NY: Churchill Livingstone, 1994:360-365.
20. Levitz CL, Dugas J, Andrews JR. The use of arthroscopic thermal capsulorrhaphy to treat internal impingement in baseball players. *Arthroscopy.* 2001;17(6):573-577.
21. Crockett HC, Gross LB, Wilk KE, et al. Osseous adaptation and range of motion at the glenohumeral joint in professional baseball pitchers. *Am J Sports Med.* 2002;30(1):20-26.
22. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. *Am J Sports Med.* 2006;34(3):385-391.
23. Osbahr DC, Cannon DL, Speer KP. Retroversion of the humerus in the throwing shoulder of college baseball pitchers. *Am J Sports Med.* 2002;30(3):347-353.
24. Grossman MG, Tibone JE, McGarry MH, Schneider DJ, Veneziani S, Lee TQ. A cadaveric model of the throwing shoulder: a possible etiology of superior labrum anterior-to-posterior lesions. *J Bone Joint Surg Am.* 2005;87(4):824-831.
25. Huffman GR, Tibone JE, McGarry MH, Phipps BM, Lee YS, Lee TQ. Path of glenohumeral articulation throughout the rotational range of motion in a thrower's shoulder model. *Am J Sports Med.* 2006;34(10):1662-1669.
26. Tirman PF, Feller JE, Janzen DL, Peterfy CG, Bergman AG. Association of glenoid labral cysts with labral tears and glenohumeral instability: radiologic findings and clinical significance. *Radiology.* 1994;190(3):653-658.
27. Meister K, Seroyer S. Arthroscopic management of the thrower's shoulder: internal impingement. *Orthop Clin North Am.* 2003;34(4):539-547.
28. Meister K, Andrews JR, Batts J, Wilk K, Baumgarten T. Symptomatic thrower's exostosis. Arthroscopic evaluation and treatment. *Am J Sports Med.* 1999;27(2):133-136.
29. Andrews JR, Dugas JR. Diagnosis and treatment of shoulder injuries in the throwing athlete: the role of thermal-assisted capsular shrinkage. *Instr Course Lect.* 2001;50:17-21.
30. Montgomery WH 3rd, Jobe FW. Functional outcomes in athletes after modified anterior capsulolabral reconstruction. *Am J Sports Med.* 1994;22(3):352-358.
31. Sonnerly-Cottet B, Edwards TB, Noel E, Walch G. Results of arthroscopic treatment of posterosuperior glenoid impingement in tennis players. *Am J Sports Med.* 2002;30(2):227-232.
32. McFarland EG, Hsu CY, Neira C, O'Neil O. Internal impingement of the shoulder: a clinical and arthroscopic analysis. *J Shoulder Elbow Surg.* 1999;8(5):458-460.
33. Meister K, Buckley B, Batts J. The posterior impingement sign: diagnosis of rotator cuff and posterior labral tears secondary to internal impingement in overhead athletes. *Am J Orthop (Belle Mead NJ).* 2004;33(8):412-415.
34. Matava MJ, Purcell DB, Rudzki JR. Partial-thickness rotator cuff tears. *Am J Sports Med.* 2005;33(9):1405-1417.
35. Connor PM, Banks DM, Tyson AB, Coumas JS, D'Alessandro DF. Magnetic resonance imaging of the asymptomatic shoulder of overhead athletes: a 5-year follow-up study. *Am J Sports Med.* 2003;31(5):724-727.
36. Yamanaka K, Matsumoto T. The joint side tear of the rotator cuff. A followup study by arthrography. *Clin Orthop Relat Res.* 1994;304:68-73.
37. Kaplan LD, McMahan PJ, Towers J, Irrgang JJ, Rodosky MW. Internal impingement: findings on magnetic resonance imaging and arthroscopic evaluation. *Arthroscopy.* 2004;20(7):701-704.
38. Halbrecht JL, Tirman P, Atkin D. Internal impingement of the shoulder: comparison of findings between the throwing and nonthrowing shoulders of college baseball players. *Arthroscopy.* 1999;15(3):253-258.
39. Ruotolo C, Price E, Panchal A. Loss of total arc of motion in collegiate baseball players. *J Shoulder Elbow Surg.* 2006;15(1):67-71.
40. Meister K. Internal impingement in the shoulder of the overhead athlete: pathophysiology, diagnosis, and treatment. *Am J Orthop (Belle Mead NJ).* 2000;29(6):433-438.
41. Gross ML, Brenner SL, Esformes I, Sonzogni JJ. Anterior shoulder instability in weight lifters. *Am J Sports Med.* 1993;21(4):599-603.
42. Rokous JR, Feagin JA, Abbott HG. Modified axillary roentgenogram. A useful adjunct in the diagnosis of recurrent instability of the shoulder. *Clin Orthop Relat Res.* 1972;82:84-86.
43. Gusmer PB, Potter HG, Schatz JA, et al. Labral injuries: accuracy of detection with unenhanced MR imaging of the shoulder. *Radiology.* 1996;200(2):519-524.
44. Connell DA, Potter HG, Wickiewicz TL, Altchek DW, Warren RF. Noncontrast magnetic resonance imaging of superior labral lesions. 102 cases confirmed at arthroscopic surgery. *Am J Sports Med.* 1999;27(2):208-213.
45. Yamaguchi K, Ditsios K, Middleton WD, Hildebolt CF, Galatz LM, Teefey SA. The demographic and morphological features of rotator cuff disease. A comparison of asymptomatic and symptomatic shoulders. *J Bone Joint Surg Am.* 2006;88(8):1699-1704.
46. Têtreault P, Krueger A, Zurakowski D, Gerber C. Glenoid version and rotator cuff tears. *J Orthop Res.* 2004;22(1):202-207.
47. Kwon YW, Powell KA, Yum JK, Brems JJ, Iannotti JP. Use of three-dimensional computed tomography for the analysis of the glenoid anatomy. *J Shoulder Elbow Surg.* 2005;14(1):85-90.
48. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy.* 2003;19(6):641-661.
49. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part II: evaluation and treatment of SLAP lesions in throwers. *Arthroscopy.* 2003;19(5):531-539.
50. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part I: pathoanatomy and biomechanics. *Arthroscopy.* 2003;19(4):404-420.
51. Bach HG, Goldberg BA. Posterior capsular contracture of the shoulder. *J Am Acad Orthop Surg.* 2006;14(5):265-277.
52. Yoneda M, Nakagawa S, Hayashida K, Fukushima S, Wakitani S. Arthroscopic removal of symptomatic Bennett lesions in the shoulders of baseball players: arthroscopic Bennett-plasty. *Am J Sports Med.* 2002;30(5):728-736.
53. Park JY, Yoo MJ, Kim MH. Comparison of surgical outcome between bursal and articular partial thickness rotator cuff tears. *Orthopedics.* 2003;26(4):387-390.
54. Lo IK, Burkhart SS. Double-row arthroscopic rotator cuff repair: re-establishing the footprint of the rotator cuff. *Arthroscopy.* 2003;19(9):1035-1042.
55. Meier SW, Meier JD. Rotator cuff repair: the effect of double-row fixation on three-dimensional repair site. *J Shoulder Elbow Surg.* 2006;15(6):691-696.
56. Altchek DW, Dines DM. Shoulder injuries in the throwing athlete. *J Am Acad Orthop Surg.* 1995;3(3):159-165.
57. Payne LZ, Altchek DW. The surgical treatment of anterior shoulder instability. *Clin Sports Med.* 1995;14(4):863-883.
58. Riand N, Leveigne C, Renaud E, Walch G. Results of derotational humeral osteotomy in posterosuperior glenoid impingement. *Am J Sports Med.* 1998;26(3):453-459.2