Optimizing the Management of Rotator Cuff Problems

Robert A. Pedowitz, MD, PhD

Ken Yamaguchi, MD

Christopher S. Ahmad, MD

Robert T. Burks, MD

Evan L. Flatow, MD

Andrew Green, MD

Joseph P. Iannotti, MD, PhD

Bruce S. Miller, MD, MS

Robert Z. Tashjian, MD

William C. Watters III, MD

Kristy Weber, MD

Charles M. Turkelson, PhD

Janet L. Wies, MPH

Sara Anderson, MPH

Justin St. Andre, MA

Kevin Boyer

Laura Raymond, MA

Patrick Sluka, MPH

Richard McGowan, MLS

Abstract

Of the 31 recommendations made by the work group, 19 were determined to be inconclusive because of the absence of definitive evidence. Of the remaining recommendations, four were classified as moderate grade, six as weak, and two as consensus statements of expert opinion. The four moderate-grade recommendations include suggestions that exercise and nonsteroidal anti-inflammatory drugs be used to manage rotator cuff symptoms in the absence of a full-thickness tear, that routine acromioplasty is not required at the time of rotator cuff repair, that non–cross-linked, porcine small intestine submucosal xenograft patches not be used to manage rotator cuff tears, and that surgeons can advise patients that workers' compensation status correlates with less favorable outcomes after rotator cuff surgery.

Overview and Rationale

This clinical practice guideline was approved by the American Academy of Orthopaedic Surgeons (AAOS) on December 4, 2010. It is based on a systematic review of published studies on the management of rotator cuff problems in adults. In addition to providing practice recommendations, this guideline highlights gaps in the literature and areas that require future research.

The purpose of this clinical practice guideline is to help improve treatment based on current best evidence. Current evidence-based practice standards require that physicians use the best available evidence in their clinical decision making. To assist in this, this clinical practice guideline consists of a series of systematic reviews of the available literature regarding the treatment of rotator cuff problems. These systematic reviews include evidence published from 1966 through October 1, 2008, and show where good evidence exists, where evidence is lacking, and what topics future research must target to improve management of patients with rotator cuff problems. AAOS staff and the work group systematically reviewed the available literature and wrote the following recommendations using a rigorous, standardized process.

Musculoskeletal care is provided in many different settings by many different providers. In an effort to improve the quality and efficiency of care, we created this guideline as an educational tool to guide qualified physicians through a series of treatment decisions. This guideline should not be construed as including all proper methods of care or as excluding methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding any specific procedure or treatment must be made in light of all circumstances presented by the patient and the needs and resources particular to the locality or institution.

Potential Harms and Contraindications

Most treatments are associated with some known risks, especially invasive and surgical treatments. In addition, contraindications vary widely based on the treatment administered. Therefore, discussion of available treatments and procedures applicable to the individual patient rely on mutual communication between the patient and physician.

Methods

The methods used to develop this clinical practice guideline were designed to combat bias, enhance transparency, and promote reproducibility. The purpose is to allow interested readers the ability to inspect all of the information the work group used to reach all of its decisions and to verify that these decisions are in accord with the best available evidence. The draft of this guideline was subject to peer review and public commentary, and it was approved by the AAOS Evidence Based Practice Committee; Guidelines and Technology Oversight Committee; Council on Research, Quality Assessment, and Technology; and the Board of Directors. All tables, figures, and appendices, as well as the methods used to prepare this guideline, are detailed in the full clinical practice guideline, which is available at http://www.aaos.org/research/guidelines/RCPGuideline.asp.

Recommendations

Recommendation 1

In the absence of reliable evidence, it is the opinion of the work group that surgery not be performed for asymptomatic full-thickness rotator cuff tears.

Grade of Recommendation: Consensus. No studies were found addressing this recommendation.

Although there is a growing awareness that a large proportion of the population can have full-thickness rotator cuff tears that are asymptomatic, we were unable to find quality

literature that addressed the issue of surgical versus nonsurgical treatment of such patients. The opinion that surgery not be performed for asymptomatic, full-thickness rotator cuff tears was based on the following considerations. (1) Asymptomatic rotator cuff disease is highly prevalent in the older population. (2) For patients with bilateral asymptomatic shoulders, there is no reliable evidence that surgery prevents long-term clinical deterioration of a rotator cuff tear. (3) Postoperative healing rates are inconsistent in elderly patients, who are the patients most likely to have asymptomatic rotator cuff tears. (4) The morbidity and risks of rotator cuff repair are probably not warranted in absence of symptoms. (5) Currently, the primary indication for rotator cuff repair is significant pain. Given these considerations, it is the opinion of this work group that patients with asymptomatic full-thickness tears not be treated with surgical repair.

Recommendation 2

Rotator cuff repair is an option for patients with chronic, symptomatic full-thickness tears.

Grade of Recommendation: Weak. It is addressed by one level III and multiple level IV studies.

One level III study compared nonsurgical to surgical treatment of rotator cuff tears.[1] In this study, 60 patients treated without surgery (group A) were compared with 77 treated with rotator cuff repair (group B). Per this study, in group A, tears were nontraumatic in 73% of cases and traumatic in 27% of cases. In group B, tears were nontraumatic in 32% of cases and traumatic in 68% of cases. Statistically significant less pain on shoulder range of motion (ROM) and at night was seen in those patients who underwent surgery compared with those who had nonsurgical treatment. Eighty-one percent of the surgical patients re-

ported excellent results, compared with 37% with nonsurgical treatment, although the authors did not report statistical significance in this comparison.

Because only one level III study supports this recommendation, we also examined level IV articles. Multiple level IV studies suggested an overall positive outcome of repair despite the potential for muscle disease, which is often present in chronic rotator cuff disease, to negatively influence postoperative outcomes.[2-7] Because this recommendation is supported by a single level III article and several level IV articles, the strength of the evidence that supports it is weak.

Recommendation 3

Recommendation 3a

We cannot recommend for or against exercise programs (supervised or unsupervised) for patients with rotator cuff tears.

Grade of Recommendation: Inconclusive. It is addressed by two level IV studies.

When the patient and physician select nonsurgical management of a rotator cuff tear, the primary objectives are to decrease pain, increase function, and enhance activities of daily living while mitigating potential long-term adverse outcomes. We found no quality evidence that demonstrated a specific impact of an exercise program, compared with the natural history of disease without other interventions. Similarly, we found no reliable evidence demonstrating that the efficacy of an exercise program is predicated on a specific form of education, supervision, or exercise environment.

Two level IV studies reported improvements in outcomes with both supervised[8] and home[9] physical therapy. However, Ainsworth[8] addressed only massive irreparable tears in a

small sample size, and Goldberg et al[9] reported inconsistent results, although they did find some improvement in chronic tears. Reliable evidence was not found to definitively support a positive impact of exercise; however, we also found no such evidence to suggest any adverse effect of exercise programs on rotator cuff disease.

Recommendation 3b

We cannot recommend for or against subacromial injections for patients with rotator cuff tears.

Grade of Recommendation: Inconclusive. It is based on one level II study and three level IV studies.

One level II study found no statistically significant difference in pain or tenderness up to 6 weeks after injection of corticosteroid with lidocaine compared with lidocaine injection alone in patients with rotator cuff tears.[10] In contrast, three level IV studies noted short-term improvement with a corticosteroid injection compared with baseline status, without comparison to a placebo control.[11-13] Although it is logical for clinicians to consider potential adverse effects of corticosteroid injection on rotator cuff tendon biology and healing capacity with rotator cuff repair (based on general concerns across other areas of orthopaedic practice), there was no quality evidence to guide recommendations in this regard. Because the evidence that addresses this recommendation is weak and conflicting, the strength of this recommendation is inconclusive.

Recommendation 3c

We cannot recommend for or against the use of nonsteroidal anti-inflammatory drugs (NSAIDs), activity modification, ice, heat, iontophoresis, massage, transcutaneous electrical nerve stimulation (TENS), pulsed electromagnetic field (PEMF), or phonophoresis (ie, ultrasound) for nonsurgi-

cal management of rotator cuff tears.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

In symptomatic patients with full-thickness rotator cuff tears, treatment objectives are decreased pain, increased function, and enhancement of activities of daily living. Although we found no specific evidence demonstrating treatment efficacy, neither did we find evidence that the following modalities were ineffective nonsurgical treatment alternatives for rotator cuff tears: NSAIDs, activity modification, ice, heat, iontophoresis, massage, TENS, PEMF, and phonophoresis (ie, ultrasound).

Recommendation 4

Recommendation 4a

Partial

We suggest that patients who have rotator cuff–related symptoms in the absence of a full-thickness tear be initially treated nonsurgically using exercise and/or NSAIDs.

Grade of Recommendation: Moderate. It is addressed by five level II studies.

Several level II studies report the beneficial effects of exercise in decreasing pain and improving function in patients with rotator cuff–related symptoms without a full-thickness tear.[14-16] One study reported on 24 patients undergoing an exercise program and noted significantly improved pain scores on the visual analog scale (VAS) after 8 weeks of treatment; post hoc pairwise comparisons of the two groups in this study showed significantly more improvement in the exercise-plus–manual therapy group using a composite pain measure.[14] Another study reported that patients had significant improvements in pain at rest, pain at night, and Constant-Murley scores after 3 months of a home exercise program.[15] A third study randomized patients between a group undergoing exercise and a control group.[16] The group undergoing exercise had statistically significant improvements in pain levels at rest, pain with movement, and upper extremity function (Disorders of the Arm, Shoulder and Hand [DASH] Work Module). No statistically significant difference was reported in patients who participated in supervised and unsupervised exercises.

Our systematic review also identified two level II studies that found better results with NSAIDs than with placebo in the treatment of rotator cuff–related symptoms in the absence of a full-thickness rotator cuff tear.[17,18] The first study was a prospective, double-blinded, placebo-controlled study in which 20 patients treated with oral diclofenac had significant improvements in pain (as measured by VAS) and shoulder function at 4 weeks compared with patients taking a placebo.[17] The second study reported significant improvements in shoulder function VAS scores in 10 patients treated with naproxen compared with 10 patients receiving a placebo.[18]

Recommendation 4b

We cannot recommend for or against subacromial corticosteroid injection or PEMF in the treatment of rotator cuff–related symptoms in the absence of a full-thickness tear.

Grade of Recommendation: Inconclusive. It is addressed by one level I study and five level II studies for subacromial corticosteroid injections and two level II studies for PEMF.

We found one level I study that evaluated the effect of subacromial corticosteroid injections on patients who had previously had 6 weeks of unsuccessful physical therapy and 2 weeks of NSAIDs for rotator cuff–related symptoms in the absence of a full-thickness tear.[19] The authors reported no differences at 3 and 6 months in American Shoulder and Elbow Surgeons (ASES) scores, DASH scores, or pain with impingement testing between groups. However, five level II studies report conflicting results for the effect of subacromial corticosteroid injections for durations between 2 and 6 weeks.[17,20-23] These studies report various results for outcomes of pain and function and also vary in that some studies report results for one corticosteroid injection, whereas others report results for multiple steroid injections. The work group's overall assessment of this evidence was conflicting. Because of these conflicting results, this recommendation is supported by inconclusive evidence.

Two level II studies also examined the use of PEMF in patients diagnosed with rotator cuff–related symptoms.[24,25] One study reported no statistically significant differences in pain or Constant-Murley scores in patients treated with PEMF compared with those treated with sham controls.[24] In the second study, the authors measured pain on the VAS scale and found a statistically significant difference in favor of PEMF.[25] Based on these conflicting results, the work group does not have sufficient evidence to provide specific treatment recommendations in regard to PEMF.

Recommendation 4c

We cannot recommend for or against the use of iontophoresis, phonophoresis, TENS, ice, heat, massage, or activity modification for patients who have rotator cuff–related symptoms in the absence of a full-thickness tear.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

There were no studies identified examining iontophoresis, phonophoresis, TENS, ice, heat, or massage as nonsurgical treatments in patients with rotator cuff–related symptoms. Although we found no specific evi-

dence demonstrating treatment efficacy, neither did we find evidence that these modalities were ineffective nonsurgical treatment alternatives for rotator cuff tears.

Recommendation 5

Early surgical repair after acute injury is an option for patients with a rotator cuff tear.

Grade of Recommendation: Weak. It is addressed by five level IV studies.

Our systematic review did not identify any quality literature that addresses the issue of timing of surgery after acute rotator cuff injury. The evidence that we considered included five level IV case series of rotator cuff repair that focused on early surgical repair of rotator cuff tears.[26-30] One study reported on a series of patients with a history of significant acute injury who underwent surgery within 3 months of injury.[26] This cohort represented <10% of the repairs that the authors performed in their overall experience, thus demonstrating that acute rotator cuff injuries are relatively uncommon. The patients repaired within 3 weeks of injury had better results than did those repaired after 3 weeks. The second study reported the results of rotator cuff repair in a series of 26 patients who had a history of trauma with an acute onset of symptoms and a full-thickness rotator cuff tear.[27] All of the repairs were performed within 3 weeks of the injury. Similar to the findings of the first study, these cases represented approximately 5% of the cases of full-thickness rotator cuff tear that the authors treated. Although they reported a high rate of successful results (20 excellent, 4 good, 1 fair, and 1 poor), they did not determine whether the timing of surgery affected the outcome.

A third study reported the outcome of arthroscopic repair of subscapularis tears.[28] Thirteen of 17 tears

were secondary to trauma. At an average follow-up of 29 months, outcome assessment demonstrated restoration of subscapularis-related function. The authors did not find a correlation between outcome and duration of symptoms. Two additional studies addressed repair of traumatic anterior superior rotator cuff tears with combined subscapularis and supraspinatus tears.[29,30] Namdari et al[29] reported on 30 patients with traumatic tear who underwent open repair at an average of 4.5 months after injury; van Riet et al[30] reported on 24 patients, 22 of whom recalled a specific incident by which the injury occurred. Namdari et al[29] reported no significant correlations between outcome and several preoperative factors, including duration of symptoms, whereas van Riet et al[30] did not provide statistical analyses. Based on these series, the recommendation grade was determined to be weak.

Recommendation 6

We cannot recommend for or against the use of perioperative subacromial corticosteroid injections or NSAIDs in patients undergoing rotator cuff surgery.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

After a systematic search of the literature, we found no clinical data that supported or refuted a negative or positive effect of subacromial corticosteroid injections or NSAIDs on tendon healing or outcomes after rotator cuff repair. Therefore, the work group could not recommend for or against their use in the perioperative period because the evidence was inconclusive.

Recommendation 7

Recommendation 7a

It is an option for physicians to advise patients that the following fac-

tors correlate with less favorable outcomes after rotator cuff surgery: increasing age, MRI tear characteristics, workers' compensation status.

Grades of Recommendation: Weak for increasing age and MRI tear characteristics, Moderate for workers' compensation status. It is addressed by 23 level IV studies for age, 6 level IV studies for MRI tear characteristics, and 1 level II and 2 level III studies for workers' compensation status.

Increasing patient age has been identified as a potential factor influencing outcomes and healing after rotator cuff surgery. Healing and strength (as indirectly measured by the Constant-Murley score) are critical factors in evaluating surgical success. Several studies determined that the Constant-Murley score (as a measure of shoulder strength) was negatively correlated with increasing age after rotator cuff repair.[2,6,9,31,32] Similarly, numerous authors concluded that age was a negative predictor of posterosuperior rotator cuff healing after repair.[33-35] Age has also been shown to correlate with subjective outcomes after rotator cuff repair, although the associations are not as strong as those for healing and strength.

Several studies have found increasing age to be negatively associated with clinical outcomes after rotator cuff surgery.[2,31-33,35-39] However, some studies found no effect of increasing age on clinical outcomes.[4,28,29,40-49] Of the 23 studies included, one author reported a negative correlation between increasing age and a patient-reported outcome measure.[37] This study reported on 80 patients at 2 years after rotator cuff repair and concluded that older age was associated with worse DASH scores. The authors did perform a multivariate analysis confirming the relationship; therefore, this should be recognized as a significant finding. One other

author reported VAS pain and reported age ranges for comparison groups.[38] The findings are statistically significant, but the authors do not define the size or direction of the effect. A third author reported "treatment response," but this outcome is a composite of pain and internal/external rotation. It is therefore a composite of a patient-oriented outcome and a surrogate measure, making it difficult to interpret.

Rotator cuff muscle quality has been implicated as having a direct effect on the ability of a repair to heal and the functional outcome after a repair. Both fatty degeneration (comparative amount of muscle tissue to fat, as determined by MRI or CT) and muscle atrophy (volume of rotator cuff muscle, as determined by MRI or CT) have been evaluated in regard to their effects on tendon repair healing and outcomes. Based on six level IV studies, it is an option for a surgeon to advise a patient undergoing rotator cuff repair about the negative effects of supraspinatus and infraspinatus muscle atrophy and fatty degeneration on both tendon healing and clinical outcomes.[2-7] Based on these studies, preoperative infraspinatus fatty degeneration and muscle atrophy correlated with worse outcomes and healing. Preoperative supraspinatus muscle atrophy also correlated with worse outcomes and healing. Finally, preoperative supraspinatus fatty degeneration correlated with worse healing, but not necessarily with worse outcomes.

Several authors have evaluated the effect of workers' compensation on surgical treatment of rotator cuff disease, including acromioplasty for tendinitis and repair of full-thickness tears.[50-52] Based on one level II study[52] and two level III studies,[50,51] the work group has determined that it is an option for physicians to advise their patients that workers' compensation status correlates with less favorable outcomes after rotator cuff repair. One study prospectively evaluated 107 shoulders (103 patients, 23 of whom were receiving workers' compensation) at an average of 45 months after open rotator cuff repair.[52] As determined by University of California, Los Angeles (UCLA) Shoulder Rating Scale scores, both groups were comparable with regard to patient age, sex, tear size, preoperative strength, and active motion. At final follow-up, patients receiving workers' compensation had significantly worse UCLA scores compared with those not receiving workers' compensation.

Another study prospectively evaluated 106 patients (40 of whom were receiving workers' compensation) at an average of 32 months after arthroscopic acromioplasty for rotator cuff tendinitis; evaluations were by the ASES score, the Simple Shoulder Test (SST), and a VAS pain scale.[50] The authors reported no statistically significant differences between groups in regard to each of these outcomes, although the AAOS work group recalculated the statistics and found that workers' compensation patients had significantly worse SST and VAS pain scores than did those not receiving workers' compensation.

The last study prospectively evaluated, with UCLA scores, 24 patients (12 receiving workers' compensation) at an average of 3 years after open acromioplasty for rotator cuff tendinitis.[51] At final evaluation, workers' compensation patients had significantly worse improvements in pain compared with those not receiving workers' compensation.

Recommendation 7b

We cannot recommend for or against advising patients in regard to the following factors related to rotator cuff surgery: diabetes, comorbidities, smoking, prior shoulder infection, and cervical disease.

Grade of Recommendation: Inconclusive. It is addressed by two level III studies for diabetes, one level IV study for comorbidities, and no studies for smoking, prior shoulder infection, or cervical disease.

Various patient-related factors may influence clinical outcomes after rotator cuff surgery. These factors may affect functional outcomes or tendon healing; hence, the work group systematically searched for data on diabetes, smoking, comorbidities, prior shoulder infection, and cervical disease. Two level III studies compared the outcomes of diabetic and nondiabetic persons after rotator cuff surgery.[53,54] One study found no statistically significant difference between the two groups on postoperative stiffness using the Constant-Murley score at 46 months.[54] The second study found a statistically significant difference and a possible clinically important difference in the ASES score favoring patients without diabetes.[53] This study found no statistically significant difference in the occurrence of infection between the two groups of patients. Because these studies assessed different outcomes with varying results, the work group found this evidence inconclusive.

One level IV study assessed the effect of medical comorbidities in patients undergoing open repair of traumatic anterosuperior rotator cuff tears.[29] The authors reported no statistically significant correlation between medical comorbidities and outcome. They did not provide significance values or define "outcome." Again, the work group evaluated this as a single study with weak evidence. They concluded overall that the evidence is inconclusive concerning the presence of medical comorbidities and patient outcomes. No studies were found that addressed the effects of smoking, prior

shoulder infection, or cervical disease as they relate to rotator cuff surgery outcomes.

Although we found no specific evidence demonstrating a significant effect for any of these factors, neither did we find evidence that the previously mentioned factors had no effect on clinical outcomes after rotator cuff surgery. Therefore, the work group found the evidence to be inconclusive regarding the effects (either positive or negative) of these factors on outcomes after rotator cuff surgery.

Recommendation 8

We suggest that routine acromioplasty is not required at the time of rotator cuff repair.

Grade of Recommendation: Moderate. It is addressed by two level II studies.

Acromioplasty and release of the coracoacromial ligament are often included as part of a rotator cuff repair. Theoretic benefits of an acromioplasty in the setting of a rotator cuff repair include increasing the subacromial space available to facilitate the repair and relieving extrinsic compression on the repair after completion. Despite these theoretic benefits, two studies reviewed the results of removing acromial bone (Bigliani type II and III acromions) and did not find any benefit in postoperative functional results.[37,45]

One level II randomized prospective study compared 47 patients treated with an arthroscopic rotator cuff repair plus an associated anterior acromioplasty and coracoacromial ligament release with 46 patients who underwent rotator cuff repair alone.[45] All patients had isolated supraspinatus rotator cuff tears with Bigliani type II acromion. The patients were evaluated preoperatively and an average of 15 months postoperatively with the ASES score.

The authors reported no significant difference between groups of both final ASES scores and improvement from baseline. Although these results suggest there was no difference in ASES scores between groups, this study was not sufficiently powered to detect minimally clinically important improvement.

Another randomized, prospective level II study compared 40 patients treated with arthroscopic rotator cuff repair, anterior acromioplasty, and coracoacromial ligament release with 40 patients who underwent rotator cuff repair alone.[37] All patients had a repairable full-thickness tear and either a Bigliani type II or III acromion. At 2 years postoperatively, the authors reported no significant differences in final Constant-Murley or DASH scores. The Constant-Murley scores suggest that acromioplasty has no effect on outcome. The work group considered the DASH result a true negative because this study was sufficiently powered to show the nonsignificant result was also not clinically significant. These results suggest that acromioplasty has little or no effect on postoperative clinical outcomes; therefore, it is not required for the management of normal acromial bone (including type II and III morphology at the time of rotator cuff repair).

Recommendation 9

It is an option to perform partial rotator cuff repair, débridement, or muscle transfers for patients with irreparable rotator cuff tears when surgery is indicated.

Grade of Recommendation: Weak. It is addressed by five level IV studies.

Five level IV studies addressed the use of surgical débridement, limited repair, or muscle transfer for an irreparable rotator cuff tear.[55-59] These

studies found an improvement in pain and function after repair of a portion of a chronic full-thickness rotator cuff tear when a complete repair cannot be achieved.[55] They also found a clinically important improvement with arthroscopic débridement without partial repair of the rotator cuff, with or without release of the long head of the biceps,[58] and improvement in pain and function with transfer of the latissimus or teres major for irreparable tears involving the supraspinatus and infraspinatus tendons.[56] Comparative studies on the superiority of one surgical technique or option over another for management of irreparable full-thickness rotator cuff tears have not been reported. All studies reported intermediate term results 3 to 4 years after surgical treatment. Long-term results were not reported. Complications reported after muscle transfer included temporary complex regional pain syndrome and cosmetic deformity of the biceps.

Recommendation 10

Recommendation 10a

It is an option for surgeons to attempt to achieve tendon-to-bone healing of the cuff in all patients undergoing rotator cuff repair.

Grade of Recommendation: Weak. It is addressed by three level IV studies.

Although the primary clinical goal of rotator cuff repair surgery is improvement in pain, strength, and function, a primary biologic goal of surgery is to achieve healing of the tendon to bone. Three level IV studies addressed tendon-to-bone healing of the cuff in patients with full-thickness rotator cuff tears.[33,39,44] The first study reported on the MRI-confirmed status of rotator cuff repair integrity in 53 subjects 2 years after surgery.[33] Patients with intact cuff repairs demonstrated improved

outcomes over those found to have re-tears. The authors also reported a significant negative correlation with age but did not report the magnitude of the correlation.

Similarly, the second study reported superior outcomes in patients with intact cuffs over re-tears in a cohort of 49 subjects who underwent open repair with nonabsorbable suture at follow-up of 4 years.[39] In the last study, the rating of the bone-tendon repair at the time of surgery (ie, good, fair, poor, nonreparable) was correlated with the UCLA scores after surgery.[44] Better bone-tendon repairs, as determined at the time of surgery, correlated with better postoperative UCLA scores, but the authors did not perform a statistical analysis of this correlation.

Recommendation 10b

<mark>We cannot recommend for or against the preferential use of suture anchors versus bone tunnels for repair of full-thickness rotator cuff tears.</mark>

Grade of Recommendation: Inconclusive. It is addressed by four level IV studies.

The primary technical goal of rotator cuff repair surgery is the stable fixation of the torn tendon to the tuberosity of the humerus. Numerous repair techniques have been described, with the two most common relying on the use of either bone tunnels (transosseous technique) or suture anchors. We identified no studies that specifically compared suture anchor to bone tunnel fixation in rotator cuff repair surgery. Three studies addressed the use of suture anchors,[60-62] whereas one study addresses the bone tunnel technique.[39] Because no comparative studies were identified and because the four studies found were evaluated as weak evidence, we cannot recommend one fixation technique over another. Based on the available evidence, either fixation technique, when per-

formed properly, can result in favorable outcomes.

Recommendation 10c

<mark>We cannot recommend for or against a specific technique (ie, arthroscopic, mini-open, or open repair) when surgery is indicated for full-thickness rotator cuff tears.</mark>

Grade of Recommendation: Inconclusive. It is addressed by one level II study and two level III studies.

A recent trend in rotator cuff repair surgery has been an apparent evolution from open repair techniques to mini-open repairs and, most recently, to arthroscopic repairs. The systematic review found no single comparative study that included all three techniques. One level II[63] and two level III[64,65] studies address arthroscopic versus open rotator cuff repair in patients with full-thickness tears.

The first study compared open acromioplasty and rotator cuff repair to arthroscopic subacromial decompression with mini-open repair in a randomized trial with 73 patients.[63] This study found early results favoring the mini-open technique up to 1 year after surgery (ASES score, Rotator Cuff Quality of Life Scale, and Shoulder Rating Questionnaire) but no statistically significant differences at 2-year follow-up. The second study reported no statistically significant differences at 49-month follow-up in results of a nonrandomized comparison of open and arthroscopic repair techniques.[64] Finally, in a nonrandomized but controlled study comparing arthroscopic to mini-open repairs, the authors of the third study reported no differences at 36 months in the ASES and UCLA scores.[65] The lack of comparisons between all three techniques makes it difficult to determine whether any one technique should be preferred over another. Additionally, the apparent disagree-

ment between the results of the included studies makes it difficult to recommend for or against a specific technique.

Recommendation 11

Recommendation 11a

<mark>We suggest surgeons not use a non–cross-linked, porcine small intestine submucosal xenograft patch to treat patients with rotator cuff tears.</mark>

Grade of Recommendation: Moderate. It is addressed by one level II study and one level III study.

One level II study[66] and one level III study[67] evaluated the results of open repair of medium to massive rotator cuff tears with and without the use of a non–cross-linked, porcine small intestine submucosal xenograft as augmentation to the primary tendon-to-bone repair. In these studies, there was a less favorable outcome (pain and function) with the use of this graft compared with primary repair alone. The complication rate of hypersensitivity reaction was approximately 20% to 30% of cases with the use of this graft.[66,67] Based on these results, the work group suggests that non–cross-linked, porcine small intestine submucosal xenograft patches not be used to treat patients with rotator cuff tears.

Recommendation 11b

We cannot recommend for or against the use of soft-tissue allografts or other xenografts to treat patients with rotator cuff tears.

Grade of Recommendation: Inconclusive. It is addressed by two level IV studies.

The work group recognizes that different graft materials and different methods of graft processing have different biologic and mechanical properties, which may result in differences in clinical effectiveness or complications between graft materi-

als. Two level IV studies, one addressing the use of xenograft and one addressing the use of allografts, were included.[68,69] In both cases, the graft was used to close an irreparable rotator cuff defect. These studies had small treatment groups (n = 10 and n = 16, respectively) and were of low quality. Based on the evidence, the work group had insufficient data to make specific recommendations for or against the use of other xenografts or allografts to treat reparable or irreparable full-thickness rotator cuff tears.

Recommendation 12

In the absence of reliable evidence, it is the opinion of the work group that local cold therapy is beneficial to relieve pain after rotator cuff surgery.

Grade of Recommendation: Consensus. No studies were found addressing this recommendation.

We found no quality studies to help decipher any potential clinical differences between intermittent crushed ice, continuous cold therapy, and other forms of cryotherapy after rotator cuff surgery. Based on the expert opinion of the work group, local cold therapy is a reasonable treatment of pain control after rotator cuff surgery.

Recommendation 13

Recommendation 13a

We cannot recommend for or against the preferential use of an abduction pillow versus a standard sling after rotator cuff repair.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

After a systematic search, no clinical data were found supporting or refuting a negative or positive effect of a sling, shoulder immobilizer, abduction pillow, and/or abduction brace after repair of a full-thickness rotator cuff tear on tendon healing

or outcomes after rotator cuff repair. Therefore, the work group could not recommend for or against their use in the postoperative period.

Recommendation 13b

We cannot recommend for or against a specific time frame of shoulder immobilization without ROM exercises after rotator cuff repair.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

After a systematic search, no clinical data were found supporting or refuting a negative or positive effect of ROM exercises (passive, active, or active-assisted) for postoperative rehabilitation after repair of a full-thickness rotator cuff tear on tendon healing or outcomes after rotator cuff repair. Therefore, the work group could not recommend for or against the timing of ROM exercises in the postoperative period.

Recommendation 13c

We cannot recommend for or against a specific time interval before initiation of active resistance exercises after rotator cuff repair.

Grade of Recommendation: Inconclusive. No studies were found addressing this recommendation.

After a systematic search, no clinical data were found supporting or refuting a negative or positive effect of active resistance exercises for postoperative rehabilitation after repair of a full-thickness rotator cuff tear on tendon healing or outcomes after rotator cuff repair. Therefore, the work group could not recommend for or against the timing of active resistance exercises in the postoperative period.

Recommendation 13d

We cannot recommend for or against home-based exercise programs versus facility-based rehabilitation after rotator cuff surgery.

Grade of Recommendation: Inconclusive. It is addressed by two level II studies.

Our systematic search of the literature yielded two quality studies providing data comparing the efficacy of a home-based exercise program to referral to a facility-based rehabilitation program following rotator cuff repair.[70,71] Both studies reported large loss to follow-up at longer durations (24 and 52 weeks) and found conflicting results among the outcomes reported at shorter durations (6 and 12 weeks). Further, patient compliance was not measured in either study. Based on the conflicting results and varied outcomes reported, the work group could not recommend for or against a specific postoperative rehabilitation protocol.

Recommendation 14

We cannot recommend for or against the use of an indwelling subacromial infusion catheter for pain management after rotator cuff repair.

Grade of Recommendation: Inconclusive. It is addressed by one level II study.

One level II study compared intravenous injection of fentanyl and ketorolac tromethamine with subacromial infusion of bupivacaine up to 120 hours after rotator cuff repair.[72] There was no statistically significant difference in pain measured by VAS between the two groups. Impact on long-term clinical outcome was not measured. The authors did not compare these treatments against a clinically relevant control group (eg, oral analgesic medications only). It is not possible to extrapolate the findings of this study to typical clinical situations because intravenous fentanyl and ketorolac are not routinely used in general orthopaedic practice. Therefore, we cannot provide specific recommendations about the use of subacromial indwelling infusion

catheters, particularly in the setting of outpatient rotator cuff repair.

Future Research

This evidence-based process underscores the strong need for quality evidence that orthopaedic surgeons can rely on in providing clinical care to patients with rotator cuff disease. Given the clinical importance of rotator cuff disease, the absence of good evidence represents a serious knowledge deficit. The issue regarding evidence was not volume related—it was related to quality problems. Although several research publications exist on the treatment of the rotator cuff, the overall quality of the studies was disappointing, given modern criteria for good evidence. The lack of previous, high-level research does not necessarily disprove previous findings or undermine current standard-of-care practices. It is entirely possible that higher level studies will simply confirm the use of popular treatment strategies, such as corticosteroid injections, tendon-to-bone repair of rotator cuffs, and physical therapy. Additionally, no high-level studies refuted current popular treatment practices; however, future high-level research will be important to improve confidence in specific treatment practices and to better standardize care.

The work group concluded that higher quality research that addresses the most important issues of rotator cuff treatment is needed. In particular, the following areas would benefit from high-quality level I or II studies.

1. Identifying risk factors for progression of rotator cuff disease. Some rotator cuff tears, both partial and full thickness, enlarge or degenerate with time. Because early treatment intervention in these cases may be important, identifying risk factors is essential to formulating treatment indications.

2. Determining the effectiveness of multiple commonly employed nonsurgical treatment measures, such as the use of corticosteroid injections or anti-inflammatory medications, on the long-term prognosis of nonsurgical management of rotator cuff tears.

3. Establishing whether and in whom rotator cuff healing is important. Rotator cuff repair and healing are generally the goals of surgical treatment; however, some patients have good results even though the tear does not heal. Identifying who requires healing and who does not will be important to determining what type of surgical treatment is necessary.

4. Determining the optimal rehabilitation protocol after rotator cuff repair. Issues such as when to start motion (early versus delayed) and when to start resistive exercises are still controversial.

5. Determining the preferred surgical repair strategy. Multiple options, such as double-row versus single-row repair, remain controversial. Evidence is needed to better standardize repair methods.

6. Increasing our understanding of the role of comorbidities—such as age, diabetes, or smoking history—on the prognosis after rotator cuff repair. These factors can affect surgical indications.

7. Determining the best surgical practice to treat the large, chronic tear that has a lower likelihood of healing after repair. These repairs may benefit only from débridement or, conversely, from larger reconstructions, such as tendon transfers or the use of biologics.

References

1. Tabata S, Kida H, Takahara M, Yamaguchi S, Masuda K: A comparative study of non-surgical treatment and surgical treatment of complete tears of the rotator cuff, in Takagashi N, ed: *The Shoulder: Proceedings of the Third International Conference on Surgery of the Shoulder*. Tokyo, Japan, Professional Postgraduate Service, 1987, pp 241-244.

2. Shen PH, Lien SB, Shen HC, Lee CH, Wu SS, Lin LC: Long-term functional outcomes after repair of rotator cuff tears correlated with atrophy of the supraspinatus muscles on magnetic resonance images. *J Shoulder Elbow Surg* 2008;17(1 suppl):1S-7S.

3. Gladstone JN, Bishop JY, Lo IK, 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(5):719-728.

4. Gerber C, Schneeberger AG, Hoppeler H, Meyer DC: Correlation of atrophy and fatty infiltration on strength and integrity of rotator cuff repairs: A study in thirteen patients. *J Shoulder Elbow Surg* 2007;16(6):691-696.

5. Mellado JM, Calmet J, Olona M, et al: Surgically repaired massive rotator cuff tears: MRI of tendon integrity, muscle fatty degeneration, and muscle atrophy correlated with intraoperative and clinical findings. *AJR Am J Roentgenol* 2005;184(5):1456-1463.

6. Liem D, Lichtenberg S, Magosch P, Habermeyer P: Magnetic resonance imaging of arthroscopic supraspinatus tendon repair. *J Bone Joint Surg Am* 2007;89(8):1770-1776.

7. Thomazeau H, Boukobza E, Morcet N, Chaperon J, Langlais F: Prediction of rotator cuff repair results by magnetic resonance imaging. *Clin Orthop Relat Res* 1997;(344):275-283.

8. Ainsworth R: Physiotherapy rehabilitation in patients with massive, irreparable rotator cuff tears. *Musculoskeletal Care* 2006;4(3):140-151.

9. Goldberg BA, Nowinski RJ, Matsen FA III: Outcome of nonoperative management of full-thickness rotator cuff tears. *Clin Orthop Relat Res* 2001;(382):99-107.

10. Darlington LG, Coomes EN: The effects of local steroid injection for supraspinatus tears. *Rheumatol Rehabil* 1977;16(3):172-179.

11. Shibata Y, Midorikawa K, Emoto G, Naito M: Clinical evaluation of sodium hyaluronate for the treatment of patients

with rotator cuff tear. *J Shoulder Elbow Surg* 2001;10(3):209-216.

12. Fearnley ME, Vadasz I: Factors influencing the response of lesions of the rotator cuff of the shoulder to local steroid injection. *Ann Phys Med* 1969; 10(2):53-63.

13. Weiss JJ: Intra-articular steroids in the treatment of rotator cuff tear: Reappraisal by arthrography. *Arch Phys Med Rehabil* 1981;62(11):555-557.

14. Bang MD, Deyle GD: Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. *J Orthop Sports Phys Ther* 2000;30(3): 126-137.

15. Walther M, Werner A, Stahlschmidt T, Woelfel R, Gohlke F: The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: Results of a prospective, randomized study. *J Shoulder Elbow Surg* 2004; 13(4):417-423.

16. Lombardi I Jr, Magri AG, Fleury AM, Da Silva AC, Natour J: Progressive resistance training in patients with shoulder impingement syndrome: A randomized controlled trial. *Arthritis Rheum* 2008;59(5):615-622.

17. Adebajo AO, Nash P, Hazleman BL: A prospective double blind dummy placebo controlled study comparing triamcinolone hexacetonide injection with oral diclofenac 50 mg TDS in patients with rotator cuff tendinitis. *J Rheumatol* 1990;17(9):1207-1210.

18. England S, Farrell AJ, Coppock JS, Struthers G, Bacon PA: Low power laser therapy of shoulder tendonitis. *Scand J Rheumatol* 1989;18(6):427-431.

19. Alvarez CM, Litchfield R, Jackowski D, Griffin S, Kirkley A: A prospective, double-blind, randomized clinical trial comparing subacromial injection of betamethasone and xylocaine to xylocaine alone in chronic rotator cuff tendinosis. *Am J Sports Med* 2005;33(2): 255-262.

20. Withrington RH, Girgis FL, Seifert MH: A placebo-controlled trial of steroid injections in the treatment of supraspinatus tendonitis. *Scand J Rheumatol* 1985;14(1):76-78.

21. Blair B, Rokito AS, Cuomo F, Jarolem K, Zuckerman JD: Efficacy of injections of corticosteroids for subacromial impingement syndrome. *J Bone Joint Surg Am* 1996;78(11):1685-1689.

22. Vecchio PC, Hazleman BL, King RH: A double-blind trial comparing subacromial methylprednisolone and lignocaine in acute rotator cuff tendinitis. *Br J Rheumatol* 1993;32(8): 743-745.

23. Akgün K, Birtane M, Akarirmak U: Is local subacromial corticosteroid injection beneficial in subacromial impingement syndrome? *Clin Rheumatol* 2004;23(6): 496-500.

24. Binder A, Parr G, Hazleman B, Fitton-Jackson S: Pulsed electromagnetic field therapy of persistent rotator cuff tendinitis: A double-blind controlled assessment. *Lancet* 1984;1(8379):695-698.

25. Aktas I, Akgun K, Cakmak B: Therapeutic effect of pulsed electromagnetic field in conservative treatment of subacromial impingement syndrome. *Clin Rheumatol* 2007;26(8): 1234-1239.

26. Bassett RW, Cofield RH: Acute tears of the rotator cuff: The timing of surgical repair. *Clin Orthop Relat Res* 1983; (175):18-24.

27. Lähteenmäki HE, Virolainen P, Hiltunen A, Heikkilä J, Nelimarkka OI: Results of early operative treatment of rotator cuff tears with acute symptoms. *J Shoulder Elbow Surg* 2006;15(2):148-153.

28. Lafosse L, Jost B, Reiland Y, Audebert S, Toussaint B, Gobezie R: Structural integrity and clinical outcomes after arthroscopic repair of isolated subscapularis tears. *J Bone Joint Surg Am* 2007;89(6):1184-1193.

29. Namdari S, Henn RF III, Green A: Traumatic anterosuperior rotator cuff tears: The outcome of open surgical repair. *J Bone Joint Surg Am* 2008;90(9): 1906-1913.

30. van Riet RP, O'Leary ST, Hooper A, Bell SN: Rotator cuff strength following open subscapularis tendon repair. *Acta Orthop Belg* 2008;74(2):173-179.

31. Lam F, Mok D: Open repair of massive rotator cuff tears in patients aged sixty-five years or over: Is it worthwhile? *J Shoulder Elbow Surg* 2004;13(5):517-521.

32. Prasad N, Odumala A, Elias F, Jenkins T: Outcome of open rotator cuff repair: An analysis of risk factors. *Acta Orthop Belg* 2005;71(6):662-666.

33. Lichtenberg S, Liem D, Magosch P, Habermeyer P: Influence of tendon healing after arthroscopic rotator cuff repair on clinical outcome using single-row Mason-Allen suture technique: a prospective, MRI controlled study. *Knee Surg Sports Traumatol Arthrosc* 2006; 14(11):1200-1206.

34. Bhattacharyya T, Yeon H, Harris MB: The medical-legal aspects of informed consent in orthopaedic surgery. *J Bone Joint Surg Am* 2005;87(11):2395-2400.

35. Cole BJ, McCarty LP III, Kang RW, Alford W, Lewis PB, Hayden JK: Arthroscopic rotator cuff repair: prospective functional outcome and repair integrity at minimum 2-year follow-up. *J Shoulder Elbow Surg* 2007; 16(5):579-585.

36. DeFranco MJ, Bershadsky B, Ciccone J, Yum JK, Iannotti JP: Functional outcome of arthroscopic rotator cuff repairs: A correlation of anatomic and clinical results. *J Shoulder Elbow Surg* 2007; 16(6):759-765.

37. Milano G, Grasso A, Salvatore M, Zarelli D, Deriu L, Fabbriciani C: Arthroscopic rotator cuff repair with and without subacromial decompression: A prospective randomized study. *Arthroscopy* 2007;23(1):81-88.

38. Hattrup SJ: Rotator cuff repair: Relevance of patient age. *J Shoulder Elbow Surg* 1995;4(2):95-100.

39. Boehm TD, Werner A, Radtke S, Mueller T, Kirschner S, Gohlke F: The effect of suture materials and techniques on the outcome of repair of the rotator cuff: A prospective, randomised study. *J Bone Joint Surg Br* 2005;87(6):819-823.

40. Murray TF Jr, Lajtai G, Mileski RM, Snyder SJ: Arthroscopic repair of medium to large full-thickness rotator cuff tears: Outcome at 2- to 6-year follow-up. *J Shoulder Elbow Surg* 2002; 11(1):19-24.

41. Rebuzzi E, Coletti N, Schiavetti S, Giusto F: Arthroscopic rotator cuff repair in patients older than 60 years. *Arthroscopy* 2005;21(1):48-54.

42. Pai VS, Lawson DA: Rotator cuff repair in a district hospital setting: Outcomes and analysis of prognostic factors. *J Shoulder Elbow Surg* 2001;10(3):236-241.

43. McKee MD, Yoo DJ: The effect of surgery for rotator cuff disease on general health status: Results of a prospective trial. *J Bone Joint Surg Am* 2000;82(7):970-979.

44. Worland RL, Arredondo J, Angles F, Lopez-Jimenez F: Repair of massive rotator cuff tears in patients older than 70 years. *J Shoulder Elbow Surg* 1999; 8(1):26-30.

45. Gartsman GM, Khan M, Hammerman SM: Arthroscopic repair of full-thickness tears of the rotator cuff. *J Bone Joint Surg Am* 1998;80(6):832-840.

46. Baysal D, Balyk R, Otto D, Luciak-Corea C, Beaupre L: Functional outcome and health-related quality of life after surgical repair of full-thickness rotator cuff tear using a mini-open technique. *Am J Sports Med* 2005;33(9):1346-1355.

47. Gazielly DF, Gleyze P, Montagnon C: Functional and anatomical results after rotator cuff repair. *Clin Orthop Relat Res* 1994;304:43-53.

48. Lähteenmäki HE, Hiltunen A, Virolainen P, Nelimarkka O: Repair of full-thickness rotator cuff tears is recommended regardless of tear size and age: A retrospective study of 218 patients. *J Shoulder Elbow Surg* 2007; 16(5):586-590.

49. Motycka T, Kriegleder B, Landsiedl F: Results of open repair of the rotator cuff: A long-term review of 79 shoulders. *Arch Orthop Trauma Surg* 2001;121(3): 148-151.

50. Nicholson GP: Arthroscopic acromioplasty: A comparison between workers' compensation and non-workers' compensation populations. *J Bone Joint Surg Am* 2003;85-A(4):682-689.

51. Lopez JG, Ernst MD, Wright TW: Acromioplasty: Comparison of outcome in patients with and without workers' compensation. *J South Orthop Assoc* 2000;9(4):262-266.

52. Misamore GW, Ziegler DW, Rushton JL II: Repair of the rotator cuff: A comparison of results in two populations of patients. *J Bone Joint Surg Am* 1995; 77(9):1335-1339.

53. Chen AL, Shapiro JA, Ahn AK, Zuckerman JD, Cuomo F: Rotator cuff repair in patients with type I diabetes mellitus. *J Shoulder Elbow Surg* 2003; 12(5):416-421.

54. Hsu SL, Ko JY, Chen SH, Wu RW, Chou WY, Wang CJ: Surgical results in rotator cuff tears with shoulder stiffness. *J Formos Med Assoc* 2007;106(6):452-461.

55. Celli A, Marongiu MC, Rovesta C, Celli L: Transplant of the teres major in the treatment of irreparable injuries of the rotator cuff (long-term analysis of results). *Chir Organi Mov* 2005;90(2): 121-132.

56. Burkhart SS, Tehrany AM: Arthroscopic subscapularis tendon repair: Technique and preliminary results. *Arthroscopy* 2002;18(5):454-463.

57. Guven O, Bezer M, Guven Z, Gokkus K, Tetik C: Surgical technique and functional results of irreparable cuff tears reconstructed with the long head of the biceps tendon. *Bull Hosp Jt Dis* 2001;60(1):13-17.

58. Klinger HM, Spahn G, Baums MH, Steckel H: Arthroscopic debridement of irreparable massive rotator cuff tears: A comparison of debridement alone and combined procedure with biceps tenotomy. *Acta Chir Belg* 2005;105(3): 297-301.

59. Klinger HM, Steckel H, Ernstberger T, Baums MH: Arthroscopic debridement of massive rotator cuff tears: Negative prognostic factors. *Arch Orthop Trauma Surg* 2005;125(4):261-266.

60. Charousset C, Grimberg J, Duranthon LD, Bellaiche L, Petrover D: Can a double-row anchorage technique improve tendon healing in arthroscopic rotator cuff repair? A prospective, nonrandomized, comparative study of double-row and single-row anchorage techniques with computed tomographic arthrography tendon healing assessment. *Am J Sports Med* 2007;35(8):1247-1253.

61. Anderson K, Boothby M, Aschenbrener D, van Holsbeeck M: Outcome and structural integrity after arthroscopic rotator cuff repair using 2 rows of fixation: Minimum 2-year follow-up. *Am J Sports Med* 2006;34(12):1899-1905.

62. 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(8):1254-1260.

63. Mohtadi NG, Hollinshead RM, Sasyniuk TM, Fletcher JA, Chan DS, Li FX: A randomized clinical trial comparing open to arthroscopic acromioplasty with mini-open rotator cuff repair for full-thickness rotator cuff tears: Disease-specific quality of life outcome at an average 2-year follow-up. *Am J Sports Med* 2008;36(6):1043-1051.

64. Ide J, Maeda S, Takagi K: A comparison of arthroscopic and open rotator cuff repair. *Arthroscopy* 2005;21(9):1090-1098.

65. Youm T, Murray DH, Kubiak EN, Rokito AS, Zuckerman JD: Arthroscopic versus mini-open rotator cuff repair: A comparison of clinical outcomes and patient satisfaction. *J Shoulder Elbow Surg* 2005;14(5):455-459.

66. Iannotti JP, Codsi MJ, Kwon YW, Derwin K, Ciccone J, Brems JJ: Porcine small intestine submucosa augmentation of surgical repair of chronic two-tendon rotator cuff tears: A randomized, controlled trial. *J Bone Joint Surg Am* 2006;88(6):1238-1244.

67. Walton JR, Bowman NK, Khatib Y, Linklater J, Murrell GA: Restore orthobiologic implant: Not recommended for augmentation of rotator cuff repairs. *J Bone Joint Surg Am* 2007;89(4):786-791.

68. 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(4):403-409, e1.

69. Badhe SP, Lawrence TM, Smith FD, Lunn PG: An assessment of porcine dermal xenograft as an augmentation graft in the treatment of extensive rotator cuff tears. *J Shoulder Elbow Surg* 2008;17(1 suppl):35S-39S.

70. Roddey TS: A comparison of two methods of home program instruction following arthroscopic full-thickness rotator cuff repair surgery. Texas Woman's University, 1999.

71. Hayes K, Ginn KA, Walton JR, Szomor ZL, Murrell GA: A randomised clinical trial evaluating the efficacy of physiotherapy after rotator cuff repair. *Aust J Physiother* 2004;50(2):77-83.

72. Cho NS, Ha JH, Rhee YG: Patient-controlled analgesia after arthroscopic rotator cuff repair: Subacromial catheter versus intravenous injection. *Am J Sports Med* 2007;35(1):75-79.