Effective Health Care Program

Future Research Needs Paper
Number 39

Nonoperative and Operative Treatments for Rotator Cuff Tears: Future Research Needs

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Number 39

Nonoperative and Operative Treatments for Rotator Cuff Tears: Future Research Needs

Identification of Future Research Needs From Comparative Effectiveness Review No. 22

Prepared for:
Agency for Healthcare Research and Quality
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The information in this report is intended to help health care researchers and funders of research make well-informed decisions in designing and funding research and thereby improve the quality of health care services. This report is not intended to be a substitute for the application of scientific judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical research and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances.

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None of the investigators have any affiliation or financial involvement that conflicts with the material presented in this report.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies and strategies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

An important part of evidence reports is to not only synthesize the evidence, but also to identify the gaps in evidence that limited the ability to answer the systematic review questions. AHRQ supports EPCs to work with various stakeholders to identify and prioritize the future research that is needed by decisionmakers. This information is provided for researchers and funders of research in these Future Research Needs papers. These papers are made available for public comment and use and may be revised.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality. The evidence reports undergo public comment prior to their release as a final report.

We welcome comments on this Future Research Needs document. They may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

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Executive Summary

Background

The systematic literature review, Comparative Effectiveness of Nonoperative and Operative Treatments for Rotator Cuff Tears,[1] was conducted by the University of Alberta Evidence-based Practice Center (EPC) in 2010 to examine the effectiveness of various nonoperative and operative treatments for adults with partial- or full-thickness rotator cuff tears. The review addressed six Key Questions (KQs) that compared patient outcomes after various operative approaches and techniques, early versus late surgical repair, operative versus nonoperative treatment and between various nonoperative therapies. The outcomes included health-related quality of life, return to work, pain, shoulder function, rotator cuff integrity, and complications. However, adverse treatment effects and the impact of baseline patient and injury characteristics on outcomes were also included.

The systematic review was unable to fully answer the KQs using the rotator cuff literature from 1990 through August 2009 because the literature was sparse and of low to moderate quality. Of the 137 studies included, less than one-fifth were clinical trials and more than half were uncontrolled studies. The literature limitations included low study quality, disparate treatments and outcomes, small sample sizes, incomplete followup, and a heavy focus on surgical technique or approach research over other aspects of rotator cuff treatment (82 percent of studies). The randomized clinical trial (RCT) literature was of particularly low quality with high risk of bias from the manner in which the studies had been conducted. The observational study literature was of moderate quality but often lacked control for the effects of potential confounding factors on outcomes.

For most rotator cuff interventions, only sparse data were available, which precluded firm conclusions about the value of any single approach in the optimal management of rotator cuff tears. Although most interventions showed positive effects, few improvements were of clinical importance. The paucity of evidence on early versus delayed surgery (one trial) was a noted concern because of the lack of evidence available for providers and patients on the important choice of initial nonoperative management or immediate surgical repair.

The review concluded that more research and higher quality research are needed to determine the relative effectiveness of rotator cuff treatments.

This Future Research Needs follow-on project used stakeholder feedback to identify and prioritize the current research knowledge gaps in rotator cuff treatment in order to improve outcomes after rotator cuff tears. The focus of this project was on treatment and post-treatment outcomes rather than complications, because the systematic review found that rotator cuff treatment complications were infrequent and often not clinically important.

This Executive Summary provides a brief synopsis of the project. Details can be found in the full report (www.effectivehealthcare.ahrq.gov).

Methods

We searched Medline from September 2009 through August 2011 for RCTs and observational studies with comparison groups to determine if new publications partially filled the previously-identified knowledge gaps. We searched ClinicalTrials.gov for relevant ongoing studies. Searches were conducted using simple search terms such as “rotator cuff tear.” Trial records were reviewed for relevance based on adults with acute or chronic partial- or full-

thickness rotator cuff tears. Publications and study protocols were assessed for relevance at the title and abstract level; applicable studies were retrieved, reviewed, and matched to one or more rotator cuff research gaps.

The Minnesota EPC team of researchers and orthopedic surgeons augmented the list of research gaps from the Rotator Cuff systematic review to include gaps that were identified before the literature and ongoing studies update. Additions were made to the Methods and Scientific lists of unresolved rotator cuff research issues.

We convened a 12-member stakeholder group with broad representation from orthopedic surgeon-researchers, nonoperative health care providers, nonoperative clinician-researchers, professional organization representatives, federal research funders, payers, and consumers. We sought stakeholders who were familiar with the current rotator cuff research and had knowledge of research designs since many research gaps were methodological in nature.

Between September and November 2011, stakeholders participated in at least one of four conference calls to discuss the state of rotator cuff research and provide feedback on the initial list of research gaps. Consumers were convened on a separate call to provide a relaxed atmosphere for open discussion and to minimize potential communication barriers due to medical terminology. All other calls involved stakeholders according to their scheduling convenience. Prior to the conference calls, stakeholders were provided a document on the background and purpose of the project, the original report's Executive Summary, the initial list of research gaps, a list of new publications and ongoing studies, the Effective Health Care Selection Criteria for New Research, and an agenda.

Email was used for all other contact. A combined conference call summary was sent to all stakeholders with a revised research gap list based on their input.

We subsequently conducted a prioritization activity with 10 stakeholders using Web-based ranking software developed by the Research Triangle Institute/University of North Carolina EPC. All ten stakeholders were provided a limited number of stars with which to indicate their selection of high priority issues or topics. Six stars were available to indicate priorities among the 17 methods issues. Nine stars were available for the 27 scientific questions. A stakeholder could assign up to three stars for an issue or item deemed highly important.

Priority scores were calculated by summing the stars assigned by all stakeholders to a methods or scientific topic. High priority was assigned to those items in the top quartile of scores. Weighted and unweighted scores were calculated.

Results

No rotator cuff research knowledge gap was adequately addressed with the recently published outcomes literature or ongoing studies identified through ClinicalTrials.gov

All professional stakeholders and one consumer completed the prioritization exercise for a 100 percent participation rate. Table A provides methods issues and scientific questions with priority rankings in the top quartile.

Table A. Stakeholder rankings of methods issues

Methods Issue Questions	Weighted Score	Related PICO Element
Measurement		
What is a minimal clinically important difference in key outcomes?	9	O
Which validated outcomes instruments should be used in all studies?	8	O
What diagnostic imaging (MRI, ultrasound, surgical inspection, arthrogram) best determines the extent of rotator cuff pathology at baseline, and when is it indicated?	5	
Which patient factors should be collected at baseline across all studies?	5	P
Which promising and/or controversial interventions should be studied?	4	I
What set of consistent definitions of rotator cuff pathology, including concomitant pathology, should be used across providers and imaging reports?	4	P
What imaging is best to evaluate cuff integrity post-surgery, and when is it indicated?	4	
Design and Reporting		
Identify additional outcomes data sources (health plan, CMS, VA, other) and develop guidelines for use and reporting (STROBE, other). Is a registry necessary to accrue sufficient patients to examine natural history, baseline factors, and outcomes?	4	
Scientific Research Questions		
Which patients do best with nonoperative treatment?	9	P
How should rehabilitation (operative and nonoperative) strategies, timing, and intensity, differ by the tear characteristics, patient age, mechanism of injury, type of repair and work issues/worker's compensation?	8	P
What is the natural history of rotator cuff tears? What variables (risk factors) are associated with progression of fatty atrophy and tear size?	7	P
Which tears require surgery?	6	P
Which patient and cuff tear factor(s) most strongly predict poor outcomes after surgery?	6	P
What is the effectiveness or comparative effectiveness of different surgical decisions, such as approach, technique, or associated procedures?	5	I/C

CMS = Centers for Medicare and Medicaid Services; MRI = magnetic resonance imaging; PICO = population, intervention, comparison, outcome; STROBE = strengthening the reporting of observational studies in epidemiology; VA = U.S. Department of Veterans Affairs

The highest priority methods issues in need of consensus were determining the amount of change in key outcomes that is clinically (rather than statistically) significant, and the selection of a set of outcomes assessment tools to be used in all studies. Ranking patterns were similar across types of stakeholders.

The highest priority scientific issues include understanding which patients do best with nonoperative treatment, determining the optimal rehabilitation strategies, understanding the natural history of rotator cuff tears, and distinguishing which rotator cuff tears require surgery. Here differences in scientific prioritization patterns were noted between categories of stakeholders. Orthopedic researchers/clinicians drove the high ranking of the question on the natural history of rotator cuff tears, whereas the physical therapy and massage therapy researcher/clinicians and the nonprovider stakeholders drove the high ranking for determining the optimal rehabilitation strategies. Neither the orthopedic researcher/clinicians nor the physical therapy or massage therapy researcher/clinicians ranked the surgical technique comparisons as high priority; nonprovider stakeholders assigned higher scores to surgical technique comparisons. The use of local biologic agents to improve healing after surgery was not deemed a priority research item.

Stakeholders did not define a priority patient population for rotator cuff studies, although subgroups such as older individuals with underlying degenerative changes in the shoulder and patients on workers compensation were identified during the calls. Rather, stakeholders recommended that all studies collect critical variables that define both the degree and age of rotator cuff injury and the patient in whom it occurred.

The highest consumer priority was full return to function after rotator cuff tears. Consumers recommended that patients seek initial evaluations from shoulder-specific providers to assure an accurate diagnosis because serial misdiagnoses are common and may delay appropriate treatment. Consumers lack knowledge about which rotator cuff injuries need surgery and how to find information on good shoulder providers who will provide a good clinical examination for a potential rotator cuff problem. Consumers suggested that the treatment options identified by providers may be limited to the preference of the specific provider (surgery versus other), rather than encompass the realm of suitable options. Consumers want information and education to enable them to make informed care choices in accordance with their values and care preferences.

Strategies to resolve rotator cuff knowledge gaps differ between methods and scientific issues. First, consensus must be reached within and across disciplines on the highest priorities in rotator cuff methods. Then, based on the consensus information, researchers should address the highest priority research gaps by designing and conducting focused, sufficiently-powered clinical studies that use a comparison or control group.

The top three methods issues could be resolved through a consensus conference. Since rotator cuff tears are treated by more than one provider group, a consensus conference would require multidisciplinary participation of surgical, nonoperative, and nonallopathic health care providers, radiologists, and researchers with expertise in clinical outcomes, epidemiology, biostatistics, and health services research.

Priority populations for the scientific questions could also be identified during a consensus conference. Stakeholders overwhelmingly agreed during the conference calls and in their ranking that to advance the field will require greater differentiation of baseline patient characteristics.

Since most rotator cuff treatment involves true professional equipoise with no one treatment clearly preferred to another, RCTs are the best research approach for resolving many rotator cuff questions. RCTs should compare: (1) strategies and timing for rehabilitation; (2) operative versus nonoperative treatment for patients with tears where there is true equipoise among types of providers; and (3) surgical techniques. However, RCT results may not be generalizable to the range of patients with rotator cuff tears. Rather, RCTs can offer important information about the relative merits of competing treatments within the same or similar patients in highly-controlled treatment settings.

Prospective cohort studies enroll and follow patients over time to assess outcomes. Patients are enrolled based on their condition and demographic factors, with treatment decisions made at the discretion of the providers. Cohort studies, often directed by epidemiologists, typically enroll more patients than orthopedic RCTs. The advantages of prospective cohort studies include having a comparison group without randomizing patients, having sufficient number and variety of patients to comment on outcomes differences within subgroups, and generally possessing greater similarity to real-world practice than RCTs. Cohort studies can also make comments about recovery trajectories and the natural history of rotator cuff tears. While cohort studies allow for comparison of outcomes in patients treated by varying regimens, caution must be exercised because of the inherent risk of bias in interpreting outcomes in nonrandomized studies.

Several stakeholders suggested a rotator cuff registry to follow patients over time. The data collected would provide insight into recovery trajectories and natural history studies. Registries follow a select subset of patients, often those who live near the high-volume health care sites involved. Such patients and their treatment results may not reflect the outcomes that could be obtained among rural or lower volume providers and settings.

Discussion

A select group of rotator cuff tear experts, professional organization representatives, funders, payers, and consumers, showed a high level of agreement in identifying the overarching question of "which treatment is best for which patients, and when." In the context of unresolved rotator cuff questions, surgical technique questions were superseded by questions about which patients actually require surgery. Consistent with conference call themes, stakeholder rankings emphasized that research undertaken to address the scientific questions should be conducted with an eye to moving the field forward.

Answers to the scientific questions will depend on resolving the methodological issues that have thus far plagued the literature. To improve the quality of rotator cuff research, and ultimately of patient care, consistent definitions and terms for rotator cuff pathology are essential across nonoperative, operative, and diagnostic/radiologic providers. Future clinical investigation should utilize comparison groups where possible. Additionally, multidisciplinary consensus on methods issues will enhance the comparability and utility of research findings so that the most successful treatments can be applied at the right time and in the right patients.

A primary concern of consumers across the spectrum of rotator cuff evaluation and treatment was the way in which provider specialization, or lack thereof, affected rotator cuff diagnoses and treatments. Although brief summary comments were made on provider effects in the systematic review, stakeholders in this project identified as issues potential provider quality and expertise differences in treatment and outcomes across the full range of diagnostic, nonoperative, and operative providers. Provider quality issues may emerge as the rotator cuff research foundation becomes more clearly established, particularly among patients with complex pathology.

This project's strength lies in the multidisciplinary perspective brought by the broad stakeholder participation. Stakeholders from orthopedic surgery, physical therapy, massage therapy, research program funders, provider organizations, and consumers, contributed insights toward a cohesive set of recommendations. Consumer input during and separate from the provider stakeholder calls illuminated the needs of consumers in rotator cuff research and care choices, and the impact of the current substandard rotator cuff tear research base on patient care. Even with 100 percent participation, the prioritization activity was limited to a small sample, and the results may not reflect the priorities of the general stakeholder populations.

Conclusions

This project engaged a broad array of stakeholders to identify and prioritize critical knowledge gaps regarding rotator cuff tear outcomes. Stakeholders identified "which treatment is best for which patient, and when" as the important overarching question.

Since patients with rotator cuff tears are treated by a broad range of health care providers, consensus on the minimum set of outcomes assessment tools to use in clinical studies would best be decided by a multidisciplinary consensus conference. Once consensus is attained on the highest priority methodological issues, scientific investigation in existing gap areas can progress towards resolution.

Using such consensus information, researchers are encouraged to design and conduct focused, sufficiently powered clinical studies that utilize a comparison or control group to address the highest priority research gaps. The ideal format is an RCT. However, the modest sample sizes of most rotator cuff RCTs does not allow for subgroup analyses. Consequently, a prospective cohort study may be the best way to determine the influence of a variety of patient factors on outcomes, examine the natural history of rotator cuff tears, or compare clinical recovery trajectories that account for baseline patient differences including the magnitude of rotator cuff pathology.

Hence, the systematic review findings along with the prioritized gaps lists provide a roadmap for focusing and advancing rotator cuff research in the United States toward improved patient care.

Background

Context

The 2010 systematic literature review, "Comparative Effectiveness of Nonoperative and Operative Treatments for Rotator Cuff Tears,"[1] was conducted by the University of Alberta Evidence-based Practice Center (EPC) to examine the comparative effectiveness of various nonoperative and operative treatments for adults with rotator cuff tears. The report was intended for a broad audience, including professional societies for the development of clinical practice guidelines, patients, health care providers, and researchers conducting studies on rotator cuff treatments. The review addressed six Key Questions (KQs) related to treatments for adults with partial- or full-thickness rotator cuff tears. Examined outcomes included health-related quality of life, return to work, pain, shoulder function, rotator cuff integrity, and complications. The review compared patient outcomes after various operative approaches and techniques, early versus late surgical repair, operative versus nonoperative treatment, and between various nonoperative therapies. Additionally, the adverse effects of any treatment approach and the impact of baseline demographic and injury characteristics on outcomes were included.

The six KQs in the 2010 rotator cuff systematic review were:

KQ 1: Does early surgical repair compared with late surgical repair (i.e., nonoperative intervention followed by surgery) lead to improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?

KQ 2: What is the comparative effectiveness of operative approaches (e.g., open surgery, mini-open surgery, and arthroscopy) and postoperative rehabilitation on improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?

- Which operative approach should be used for different types of tears (e.g., partial-thickness or full-thickness; small, medium, large, or massive; with or without fatty infiltration of muscle tissue)?

KQ 3: What is the comparative effectiveness of nonoperative interventions on improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength? Nonoperative interventions include, but are not limited to, exercise, manual therapy, cortisone injections, acupuncture, and treatments and modalities typically delivered by physical therapists, osteopaths, and chiropractors.

- Which nonoperative treatment approach should be used for different types of tears (e.g., partial-thickness, full-thickness; small, medium, large, or massive; with or without fatty infiltration of muscle tissue)?

KQ 4: Does operative repair compared with nonoperative treatment lead to improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?

KQ 5: What are the associated risks, adverse effects, and potential harms of nonoperative and operative therapies?

KQ 6: Which demographic (e.g., age, sex, ethnicity, comorbidities, workers' compensation claims) and clinical (e.g., size/severity of tear, duration of injury, fatty infiltration of muscle) prognostic factors predict better outcomes following nonoperative and operative treatment?

- Which (if any) demographic and clinical factors account for potential differences in surgical outcomes between patients who undergo early versus delayed surgical treatment?

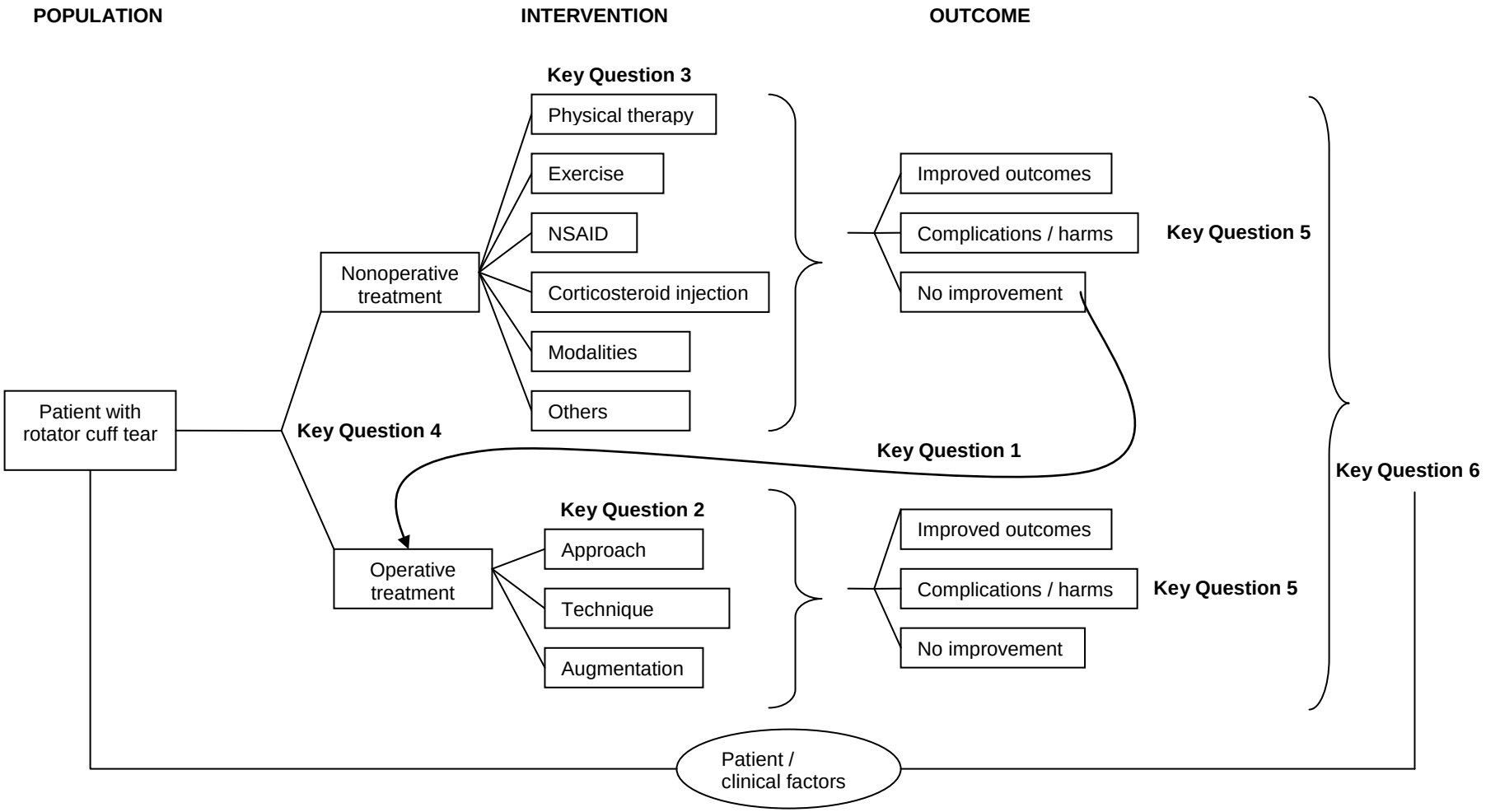
The systematic review was unable to fully answer the KQs using the rotator cuff literature from 1990 through August 2009 because the literature was sparse with low to moderate methodological quality. Of the 137 studies included in the systematic review, less than one-fifth were clinical trials and more than half were uncontrolled studies. The limitations of the literature included low overall quality of clinical research studies, wide variation in treatments and outcomes, small sample sizes, incomplete outcomes assessments, and a heavy focus on surgical approach or technique over research on other aspects of rotator cuff treatment (82 percent of studies). The randomized clinical trial (RCT) literature was found to be of particularly low quality with high risk of bias from the manner in which the studies had been conducted. The observational study literature was of moderate quality, but often lacked controls for the effects of potential confounding factors on outcomes.

For the overwhelming majority of rotator cuff interventions, only sparse data were available which precluded firm conclusions for any single approach and, more importantly, for the optimal overall management of rotator cuff tears. Although interventions appeared to positively impact clinical outcomes, in cases where interventions could be compared directly, few improvements were of clinical importance. The report found the paucity of evidence (one trial) related to early versus delayed surgery to be of particular concern, because patients and providers must decide whether to attempt initial nonoperative management or proceed immediately with surgical repair. The review concluded that more research and higher quality research is needed to determine the relative effectiveness of rotator cuff treatments.

Research Evidence Gaps

The report identified numerous comparators with only sparse evidence but for which future research is a priority. Figure 1 shows the analytic framework used for the systematic review, and the inter-relationship between the six KQs and the factors and interventions included in the systematic review.

Figure 1. Analytic framework



NSAID = nonsteriodal anti-inflammatory drug

The systematic review made a number of recommendations for improving future rotator cuff research quality and increasing comparability of results across studies. The goal of the recommendations was to increase the utility of research findings for providers, professional societies, and patients. Seven future research recommendations taken directly from the original rotator cuff systematic review are:

- Primary evidence is needed comparing the effectiveness of early versus delayed surgery, nonoperative versus operative interventions, and between nonoperative treatment options. Future research examining the comparative effectiveness of open, mini-open, or arthroscopic approaches is also a priority, as arthroscopic procedures are more costly and technically difficult.
- All future studies should employ a comparison or control group and should ensure comparability of treatment groups, optimally through the use of randomization.
- Future research should seek to minimize bias by blinding outcome assessors, using validated and standardized outcome assessment instruments, and ensuring adequate allocation concealment (where applicable) and the appropriate handling and reporting of missing data.
- Studies examining the long-term effectiveness of treatments over the course of several years are needed; at the very least, studies should follow patients for a minimum of 12 months.
- To avoid numerous studies on disparate interventions, the interventions and comparisons chosen for study should be guided by consensus regarding the most promising and/or controversial interventions.
- To ensure consistency and comparability across future studies, consensus is needed on outcomes that are important to both clinicians and patients. Moreover, consensus on minimal clinically important differences is needed to guide study design and interpretation of results.
- To permit the appropriate interpretation of results, Future Research Needs to be reported in a consistent and comprehensive manner.

Additionally, the report suggested improving cross-cutting research quality and comparability issues, including improving consistency in research reporting:

> "Future research should incorporate design elements to minimize bias in treatment effects including randomization where possible, blinding of outcome assessors, comparability of study groups, and appropriate handling and reporting of missing data. Consensus is needed on clinically and patient-important outcomes, as well as minimum clinically important differences. Consistency across studies is needed in choice of outcomes and measurement tools. Comprehensive and consistent reporting in future studies will allow for more accurate comparisons and the interpretation of findings across studies as well as greater understanding with respect to the applicability of the findings."

Future Research Needs for Rotator Cuff Tears

The goal of this project was to use stakeholder feedback to identify and prioritize the current research knowledge gaps in rotator cuff treatment in order to improve outcomes after rotator cuff tears. The project focused on treatment and post-treatment outcomes rather than complications,

because the systematic review found that rotator cuff treatment complications were infrequent and often not clinically important.

This project expands and builds on the recommendations of the Alberta EPC to provide further specification and focus for future rotator cuff research efforts. We utilized a health services research perspective throughout this project by augmenting the original list of rotator cuff knowledge gaps with factors that can impact rotator cuff treatment quality and outcomes that were not considered in the original systematic review, such as provider experience, degree of provider specialization and surgical quality.

Methods

Identification of Evidence Gaps

We searched Medline from September 16, 2009, through August 11, 2011, for RCTs and observational studies with comparison groups to determine if publications subsequent to the 2010 Alberta EPC systematic review partially filled the previously identified knowledge gaps. We replicated the search strategy used in the original report. The search included a list of terms intended to identify all research publications associated with rotator cuff tears in adults. We further limited searches for trials by terms to identify types of interventions that included a comparison group or included the term "minimally-important clinical difference." Full search algorithms are available in Appendix A. Publications were assessed for relevance at the title and abstract level; applicable studies were retrieved, reviewed, and matched to one or more existing rotator cuff research gaps.

We searched ClinicalTrials.gov (clinicaltrials.gov) for relevant ongoing studies; we used simple search terms such as "rotator cuff tear." Trial records were reviewed for relevance based on the patient population of adults with acute or chronic partial- or full-thickness rotator cuff tears. Applicable studies were reviewed and matched to one or more existing research gap area.

Health services and clinical outcomes researchers and orthopedic surgeons of the Minnesota EPC augmented the list of research gaps from the Rotator Cuff systematic review to include additional scientific or methodological knowledge gaps identified before or during the update of the literature and ongoing studies. Examples of some of the items added for stakeholder discussion were the impact of provider experience, degree of provider specialization and surgical quality on outcomes, as well as a clear definition of "rotator cuff integrity" for both nonoperative and postoperative patients.

Criteria for Prioritization

Stakeholders received the Agency for Healthcare Research and Quality's (AHRQ's) Selection Criteria for research topics prior to the conference calls. During each call, we asked stakeholders to identify the most salient criteria to use for rotator cuff research. The criteria did not have weights assigned to them; stakeholder responses were thus based on an inductive summary of the criteria. A comments area was made available for stakeholders to note whether particular criteria weighed more heavily in their decisions.

Engagement of Stakeholders

This section provides a brief overview of the methods used for this project. Please refer to Appendixes B through G for more detailed project methods.

We formed a 12-member stakeholder group with broad representation from orthopedic surgeon-researchers, nonoperative health care providers and nonoperative clinician-researchers, professional organizations, federal research funders, payers, and consumers. We particularly sought stakeholders who were familiar with current rotator cuff research practices and knowledge of research design since many research gaps were methodological in nature.

Between September and November 2011, stakeholders participated in at least one of four conference calls, during which they discussed the state of rotator cuff research and provided feedback on the initial list of research gaps. Consumers were convened on a separate call to assure that there was adequate time for discussion of research and care issues in less-technical

language than was standard on the professional stakeholder calls. All other calls involved stakeholders according to their scheduling convenience; stakeholders were not segregated by profession or perspective. Prior to the conference call, all stakeholders were provided a written memo on the background and purpose of the project, the original report's Executive Summary, the initial list of research gaps, a list of new publications and ongoing studies since the original report, the Effective Health Care Selection Criteria, and an agenda.

Email was used for all other stakeholder contact. All 12 stakeholders received a summary of the conference calls, and a revised research gap list based on stakeholder input. Stakeholders were asked to provide further comment or clarification if warranted. We conducted a prioritization activity with 10 of the stakeholders using web-based ranking software developed by the Research Triangle Institute/University of North Carolina EPC.

Handling Conflicts of Interest

Forms for disclosure of conflicts of interests were collected from all stakeholders. No one was prohibited from participating based on disclosures; however, the forms would have allowed us to temper any stakeholder's contributions if the conversation topic warranted attention.

Since the conference call discussions were focused on how the field needs to address the existing research gaps, rather than the development of specific research questions, it was unlikely that researchers would receive an unfair advantage for future research proposals. Stakeholders used web-based software to rank specific scientific topics during the prioritization exercise, thus researchers and funders were blind to the others' stated opinions.

Prioritizing Research

Ten stakeholders (nine nonfederal employees, including one consumer, and one federal employee) were asked to prioritize methods related issues separate from scientific research topics. All 10 stakeholders were provided a limited number of stars with which to indicate their selection of high priority issues or topics. Six stars were available to indicate priorities among the 17 methods issues. Nine stars were available for the 27 scientific questions. A stakeholder could assign up to three stars for an issue or item they deemed to be highly important.

Priority scores were calculated by summing the stars assigned by all stakeholders to a methods issue or scientific topic. We determined high priority as items in the top quartile of scores. Unweighted scores were also calculated based on the number of stakeholders voting for an issue or topic by collapsing multiple star assignments by any one stakeholder into a count of one for that item.

Results

Contribution of Recent Publications and Ongoing Studies

No rotator cuff research knowledge gap was adequately addressed with the recently published outcomes literature or ongoing studies identified through ClinicalTrails.gov (see Appendix B Table 1). As with the studies in the original systematic review, most recent publications covered surgical technique or surgical repair augmentation rather than the many other approaches to rotator cuff treatment. However, a small proportion of ongoing studies focus on the broader questions in rotator cuff treatment, such as rehabilitation timing and intensity, nonoperative versus operative care, and demographic factors in successful nonoperative care.

Research Needs

All professional stakeholders and one consumer completed the web-based prioritization exercise for a 100 percent participation rate.

Stakeholders identified, discussed, and prioritized the fundamental methodological and scientific issues that need to be investigated and resolved in order to meaningfully advance outcomes knowledge for patients with rotator cuff tears. Due to the breadth of unresolved research questions in rotator cuff outcomes, the prioritized lists of Methods and Scientific Issues identify both unresolved thematic areas within the domains of rotator cuff diagnosis and treatment as well as several specific research questions.

Methods Issues

The methods issues in rotator cuff outcomes are aimed at improving consistency in the conduct of clinical trials, estimating treatment effects in terms of clinically important differences in outcomes, and reliably assessing the magnitude of rotator cuff pathology. These issues were considered by stakeholders as fundamental to enable future research to adequately address scientific rotator cuff tear research questions. To accomplish that aim, the suggested mechanism to resolve Methods issues was a consensus conference.

Table 1 provides a summary of stakeholder rankings for methods issues. Issues that scored above 4 for both weighted and unweighted scores are considered high priority. Based on ranking, the highest ranked issues stakeholders identified in need of consensus were determining the amount of change in key outcomes that is clinically (as opposed to statistically) significant for patients (weighted score = 9), and the selection of a set of outcomes assessment tools to be used in all studies (weighted score = 8). At the other end of the range, issues given a score of 0 related to measuring provider-related factors that may contribute to patient outcomes.

Stakeholder prioritization generally agreed, whether using weighted scores (total number of assigned stars per item) or unweighted scores (the number of stakeholders assigning at least one star). No noticeable differences in ranking patterns were discerned across type of stakeholder. (See Appendix B Table 2 for detailed ranking scores.)

Table 1. Stakeholder ranking of methods issues

Methods Issue Question	Weighted	Unweighted	Related PICO Element
Measurement			
Which validated outcomes instruments should be used in all studies?	8 †	7 †	O
What is a minimal clinically important difference in key outcomes?	9 †	7 †	O
Which promising and/or controversial interventions should be studied?	4 †	4 †	I
What set of consistent definitions of rotator cuff pathology, including concomitant pathology, should be used across providers and imaging reports?	4 †	4 †	P
What diagnostic imaging (MRI, ultrasound, surgical inspection, arthrogram) best determines the extent of rotator cuff pathology at baseline, and when is it indicated?	5 †	5 †	
What imaging is best to evaluate cuff integrity post-surgery, and when is it indicated?	4 †	4 †	
Which imaging is best for cuff tears superimposed on pre-existing pathology?	1	1	
What provider training and experience thresholds are required for accurate imaging interpretation (tear classification) for rotator cuff for pathology?	0	0	
How should 'cuff integrity' be defined for (1) nonoperative/preoperative and (2) postoperative patients?	3	3	
What constitutes a good or acceptable repair?	3	3	
What surgeon factors are associated with better operative repair and/or better outcomes?	0	0	
Should minimum thresholds, such as number of cases or training, be required for complex repairs or revisions?	0	0	
Which patient factors should be collected at baseline across all studies?	5†	5 †	P
Design and Reporting			
Should classification of study participants be pathology based or impairment based?	3	3	
Which patient groups (for example, acute/chronic, older active/inactive, worker's compensation) should special care be given to assure representation in research samples?	2	2	
What should the minimum followup duration be? Define "long-term."	2	2	
Identify additional outcomes data sources (health plan, CMS, VA, other) and develop guidelines for use and reporting (STROBE, other). Is a registry necessary to accrue sufficient patients to examine natural history, baseline factors, and outcomes?	4 †	3	

CMS = Centers for Medicare and Medicaid Services; MRI = magnetic resonance imaging; PICO = population, intervention, comparison, outcome; STROBE = strengthening the reporting of observational studies in epidemiology; VA = U.S. Department of Veterans Affairs

†Item was ranked in the top quartile. Each stakeholder had six stars to assign to issues deemed high priority. Up to three stars could be assigned to any one issue.

Stakeholders did not define a single patient population as priority for studies of rotator cuff treatments, although subgroups such as older individuals with underlying degenerative changes in the shoulder and patients on Workman's Compensation were mentioned in discussions. Instead, stakeholders recommended that all studies collect critical variables that define both the degree and age of rotator cuff injury and the patient in whom it occurred.

Scientific Research Questions

Table 2 provides a summary of the prioritized stakeholder rankings for unresolved scientific issues. Most of the scientific gaps reflect focused theme areas rather than specific research questions. The quality and quantity of the literature to date is thin, and the research gaps are

broad. Therefore, stakeholder discussions often focused on areas of knowledge gaps as opposed to specific research questions.

High-priority areas are those that scored in the top quartile, 4.75 for weighted scores and 4 for unweighted scores. The highest priority scientific issues include understanding which patients do best with nonoperative treatment (weighted score = 9), determining the optimal rehabilitation strategies (weighted score = 8), understanding the natural history of rotator cuff tears (weighted score = 7), and distinguishing which rotator cuff tears require surgery and which factors predict poor recovery after surgery (weighted score = 6).

Table 2. Stakeholder ranking of scientific research questions

Scientific Research Question	Weighted	Unweighted	Related PICO Elements
Overarching Questions			
Which patients do best with nonoperative treatment?	9 †	7 †	P
Which tears require surgery?	6 †	5 †	P
What is the threshold for surgery, given the rotator cuff tear severity/grade?	2	2	
How does concomitant pathology or patient age modify a surgical threshold?	5 †	3	
How long should a good outcome persist after operative or nonoperative intervention and should these recovery duration expectations differ by treatment approach?	1	1	
How should recovery duration expectations differ in older patients?	0	0	
What is the overall value of rehabilitation/adjunctive care?	4	3	
How should rehabilitation (operative and nonoperative) strategies, timing, and intensity, differ by the tear characteristics, patient age, mechanism of injury, type of repair and work issues/worker's compensation?	8 †	6 †	P
How does the timing of passive/active/resistive exercise impact tissue healing in post-operative rehabilitation?	4	4 †	
What is the impact of range of motion and strength on outcomes?	1	1	
What is the natural history of rotator cuff tears? What variables (risk factors) are associated with progression of fatty atrophy and tear size?	7 †	5 †	P
Which patient and cuff tear factor(s) most strongly predict poor outcomes after surgery?	6 †	5 †	P
Which patient subgroups (age, tear-based, functional limitation-based) should be identified in RCTs/clinical studies, and which are too heterogeneous to combine for outcomes comparisons?	0	0	
What patient demographics and clinical profiles are important? (Age, health habits/smoking, hand dominance, worker's compensation, specific comorbidities).	3	3	
How do tear characteristics affect outcomes: size, age/duration of pathology, pre-existing/chronic changes, mechanism of injury?	4	4 †	
How do psychosocial factors such as depression, socioeconomic status, motivation/self-efficacy, fear-avoidance, and coping mechanisms modify outcomes?	4	4 †	
Nonoperative Questions			
Which nonoperative interventions and which comparisons should be studied? (Physical therapy, exercise (supervised vs. home-based), cortisone injections, massage therapy, acupuncture, other).	4	4 †	
Nonoperative vs. Operative Questions			
Which nonoperative vs. operative treatment comparisons are most important among patients whose condition may benefit from either approach? (Which patients do equally well when treated nonoperatively or operatively?)	2	1	

Table 2. Stakeholder ranking of scientific research questions (continued)

Scientific Research Question	Weighted	Unweighted	Related PICO Elements
Operative Questions			
Given surgery is indicated, when is early (vs. delayed) surgery indicated?	2	2	
Does cuff integrity predict patient-centered outcomes? Is a "successful" (intact) rotator cuff repair necessary?	2	2	
Why does surgery often result in improved outcomes, even with evidence of repair failure?	0	0	
What is the effectiveness or comparative effectiveness of different surgical decisions, such as approach, technique, or associated procedures?	5 †	4 †	I/C
Who benefits from repeat procedures and when should revision repair be attempted?	1	1	
What is the effectiveness of adjunctive/biologic technologies such as protein-rich plasma, growth factors, stem cells, reinforcement meshes or patches?	3	3	
Which surgical procedures (tenotomy, muscle transfer, reverse total shoulder replacement, other) should be considered for irreparable rotator cuff tears?	3	3	
What information will best help a patient choose a provider and treatment path?	4	3	

PICO = population, intervention, comparison, outcome; RCT = randomized controlled trial
†Item was ranked in the top quartile. Each stakeholder had 9 stars to assign to questions deemed high priority. Up to 3 stars could be assigned to any one issue.

A greater number of stakeholders assigned multiple stars to scientific questions than methods issues, so more differences are seen between the weighted and unweighted rankings. This accounts for the differences in the quartile statistics, and the addition of the patient age or concomitant pathology as modifier for a surgical threshold.

There were also discernable differences in the prioritization patterns between the categories of stakeholders. Orthopedic researchers/clinicians drove the high ranking of the question on the natural history of rotator cuff tears, while the physical therapy and massage therapy researcher/clinicians and the nonclinician stakeholders drove the high ranking for determining the optimal rehabilitation strategies. While the term "natural history" typically refers to what happens over time to the rotator cuff and surrounding structures and pain *without* treatment, stakeholders agreed that the natural history questions for rotator cuff tears should also encompass what happens over time *with* or *in spite of* treatment. In either case, studies of the progression of rotator cuff pathology over time are extremely limited and much remains unknown.

Interestingly, nonclinician stakeholders drove the appearance of the question on the effectiveness of different surgical techniques. Neither the orthopedic researcher/clinicians nor the physical therapy or massage therapy researcher/clinicians ranked surgical technique studies as high priority. (See Appendix B Table 3 for more detail.)

The highest priority scientific question of when to utilize a nonoperative versus operative treatment approach is notable. It suggests a great deal of provider uncertainty in the treatment of patients with tears that fall in the mid-range of the spectrum of rotator cuff pathology. In general, stakeholders suggested that among patients with extreme or minor pathology, there is less variability in the choice of a class of health care (nonoperative vs. operative) because providers may better agree on which general class of treatment to pursue initially. However, a large proportion of patients with rotator cuff tears could potentially be treated nonoperatively or

operatively, and the current literature lacks sufficient information for helping health care providers make those decisions.

Stakeholders noted that despite great pressure in orthopedics to evaluate new, controversial, or promising interventions such as the use of local biologic agents to improve healing after surgery (as evidenced by the quantity of ongoing studies in this area), such therapies are not top priority research agenda items.

Consumer Priorities

Consumers' main goal was for rotator cuff treatment to return patients to full physical function. Consumers suggested that patients should be evaluated initially by shoulder-specific providers and specialists to assure that patients receive an accurate clinical diagnosis and plan of care. Serial misdiagnoses delay appropriate treatment and delays may limit some treatment options altogether.

Similar to providers, consumers indicated during conference calls that they lack knowledge about which rotator cuff injuries need surgery, how to find information on highly qualified shoulder providers, and where to get a good initial examination for a potential rotator cuff problem. More importantly, consumers suggested that providers may limit the treatment options they identify for consumers to their own specific preferences (surgery versus other), rather than informing patients of the realm of treatment options for a given pathology and patient situation. Consumers want access to the necessary information to make choices appropriate to their condition and in accordance with their values and care preferences.

Research Approach Considerations

Strategies to resolve rotator cuff knowledge gaps differ between methods and scientific issues. First, consensus must be reached within and across disciplines on the highest priorities in rotator cuff methods. Then, based on the consensus information, researchers can address the highest priority scientific research gaps by designing and conducting focused, sufficiently-powered clinical studies that use a comparison or control group.

The top three methods issues could be resolved through a consensus conference. Since rotator cuff tears are treated by more than one provider group, a consensus conference ideally would be multidisciplinary with participants to include surgical, nonoperative, and nonallopathic health care providers, radiologists, and researchers with expertise in clinical outcomes, epidemiology, biostatistics, and health services research.

Priority populations for the top scientific questions could also be clarified during a consensus conference. Although stakeholders did identify populations whose outcomes could differ within given treatment approaches, the current research gaps were too broad to focus exclusively on patient subgroups. Still, stakeholders overwhelmingly agreed during the conference calls and in their ranking that greater differentiation of baseline patient characteristics is required to advance the field. This was reflected in six of the seven top-ranked scientific questions pertaining to understanding patient populations.

Since most rotator cuff treatment involves true professional equipoise with no one treatment clearly preferred to another, RCTs are the best research approach for resolving many rotator cuff tear questions related to specific treatments and techniques. RCTs with sufficient sample sizes are able to detect small treatment effects or differences in rotator cuff treatment outcomes because randomization minimizes bias from both observed and unobserved (or unmeasured) variables, giving a clear picture of treatment effects in specific populations. RCTs can be used to

compare: (1) strategies and timing for rehabilitation; (2) operative versus nonoperative treatment for patients with rotator cuff tears where there is true equipoise among both types of providers; and (3) surgical techniques. RCTs most often produce valid conclusions and can offer important information about the relative merits of competing treatments within the same or similar rotator cuff patients in highly-controlled treatment settings. However, RCTs can be relatively costly due to study personnel and data collection costs including staff time and patient travel. A second drawback, as with most RCTs, is that results may not be generalizable to the range of patients with rotator cuff tears.

Operative rotator cuff treatment studies may be subject to fewer ethical concerns than investigations of other operative conditions, such as hip fracture, for two reasons. First, the original systematic review found that treatment complications are uncommon, relatively mild and usually not life-threatening. Second, potential ethical dilemmas related to vulnerable patient populations may be less prominent in the rotator cuff investigations suggested in the original systematic review. While rotator cuff problems are common in a wide array of individuals, the prioritized unresolved rotator cuff treatment questions apply to a population of relatively healthy adults, rather than particularly impaired or otherwise unhealthy or frail individuals. However, the use of local, novel biologics and other healing agents may require special consideration depending on the stage of product development and regulatory approval.

The most important question in rotator cuff treatment is “what to do and for whom?” There is great variability in patient characteristics, rotator cuff tear characteristics, pre-existing degenerative changes about the shoulder, the condition of the surrounding tissues to provide shoulder stability, and categories of surgical and nonsurgical treatments including specifics within those categories. The number of RCTs required to meet all of those needs with sufficient patient samples could be staggering. Therefore, focused observational research studies within the topic of “what for whom” that are sufficiently powered and meticulously conducted can incrementally advance the field.

For rotator cuff tear studies, cohort studies can offer more generalizable information than results from most RCTs. Prospective cohort studies enroll and follow patients over time to assess outcomes. The advantages of cohort studies include having a comparison group without randomizing patients, having a sufficient number and variety of patients, such as patient demographics and tear characteristics, to comment on outcomes differences within subgroups, and generally possessing greater similarity to real-world practice than RCTs. Cohort studies are also better suited to make comments about recovery trajectories and the natural history of rotator cuff tears. These studies compare one or more groups of individuals who have a risk factor or treatment to “control” individuals who lack “exposure” to that risk factor treatment.

While cohort studies allow for comparisons of outcomes in rotator cuff patients treated by varying regimens, caution must be exercised because of inherent risk of bias in interpreting outcomes in nonrandomized studies. Typically, unmeasured variables account for what treatments the patients received, which may also be responsible for any differences in outcomes, rather than the treatments themselves. Controlling for the effects of unmeasured variables is harder to accomplish through statistical techniques. While cohort studies allow for comparison of outcomes in patients treated by varying regimens, caution must be exercised because of the inherent risk of bias in interpreting outcomes in nonrandomized studies. Treatment selection biases can come from patient and provider factors and need to be considered in the selection of variables to collect and use for analyses. For example, some surgeons may choose one rotator cuff procedure over another because of personal preference or familiarity, rather than based on

patient factors. Cohort studies also include disadvantages similar to RCTs, such as high costs of following patients over time and dealing with attrition. Similar to RCTs, recruitment of large numbers of patients (at least hundreds) are needed to examine effects in patient subgroups.

Several stakeholders suggested a rotator cuff registry, which would make it possible to follow patients over time and collect a large number of variables at baseline and over time. In order to track subjects over time, treating practitioners need to be involved in recruiting patients into the effort. Additionally, resources must be dedicated to tracking and contacting subjects using internet-based techniques in order to optimize followup information contained in the registry. Though no control group is utilized with a registry, the data collected would provide insight into recovery trajectories and natural history studies. However, the outcomes collected may be limited and based on funding and other important limitations, such as the number of participating health care sites and the research focus of the main investigators. Further, registries follow a select subset of patients, often those who live near the high-volume health care sites involved. Such patients and their treatment results may not reflect the outcomes that could be obtained among rural or lower volume providers and settings.

Discussion

A select group of rotator cuff tear experts, professional organization representatives, funders payers, and consumers showed a high level of agreement in identifying the overarching question of, "which treatment is best for which patients, and when." A large proportion of patients with rotator cuff tears could potentially be treated nonoperatively or operatively. In the context of unresolved rotator cuff questions, surgical technique questions were superseded by questions about which patients actually require surgery. However, much of the current rotator cuff research (Appendix B Table 1) focuses not on areas of top priority for stakeholders, but instead on aspects of rotator cuff care that can be more quickly or easily evaluated. For example, studies have tended to be short-term examinations of technique or surgical augmentation rather than more difficult-to-conduct RCTs or prospective cohort studies. Consistent with conference call themes, stakeholder rankings emphasized that any research undertaken to address the scientific questions should be conducted with an eye to moving the field forward. That is, it must address the overarching question of best treatment choice and timing for specific patients.

Answers to the scientific questions listed by the stakeholders will depend on resolving the methodological issues that have thus far plagued the literature. Inconsistencies in the use of outcomes tools and terms, along with study conduct flaws, have resulted in excessive variability in treatment results. This variability makes it difficult to determine the true results "signal" from other research "noise." Meticulously following the Consolidated Standards of Reporting Trials (CONSORT) recommendations[2] and improving inconsistencies in reporting would improve the quality of future rotator cuff studies. As recommended in the original systematic review, future clinical investigation should utilize comparison groups where possible. The usefulness of future rotator cuff research efforts will be dramatically advanced by consistent improvements in the conduct and reporting of clinical studies that include clear definitions of pathology, use consistent outcomes tools, and include ample baseline information on patients and pathology.

The successful treatment of rotator cuff tears often requires multispecialty professional efforts. Therefore, removing methodological roadblocks to advancing the research will require multidisciplinary consensus to improve the comparability and utility of rotator cuff clinical research findings for providers and patients. No single study will answer the broader rotator cuff treatment questions. Multicenter, even multinational, efforts are imperative to improve the clinical utility of the information produced by these studies. However, consensus on methods issues and adoption of the consensus recommendations across health care disciplines will create a solid foundation from which higher comparability investigations can emerge.

In order for valid conclusions about which treatments work best in defined patient subgroups, future studies should use outcomes assessment tools and a reliable set of baseline patient variables. This would lead to greater comparability of populations and outcomes across studies. Establishing minimum clinical differences for outcomes will ensure that researchers can accurately determine whether statistically significant differences are clinically meaningful. At a minimum, researchers should use agreed-upon outcomes tools and the full set of recommended baseline variables so that outcomes from small rotator cuff studies can be pooled, allowing for systematic reviews and meta-analyses to identify overarching effects.

To improve the quality of rotator cuff research, and ultimately of patient care, consistent definitions and terms for rotator cuff pathology are essential across nonoperative, operative, and diagnostic/radiologic providers. Additionally, the selection of a consistent set of outcomes assessment tools for use across multiple categories of providers will enhance the comparability

and utility of research findings so that the most successful treatments can be applied at the right time and in the right patients.

A primary concern of consumers across the spectrum of rotator cuff evaluation and treatment was the way in which provider specialization, or lack thereof, affected rotator cuff diagnoses and treatments. Although brief summary comments were made on provider effects in the systematic review, stakeholders in this project identified potential provider quality and expertise differences in treatment and outcomes across the full range of diagnostic, nonoperative, and operative providers. Provider quality issues may emerge as the rotator cuff research foundation becomes more clearly established, particularly among patients with complex pathology.

This project's strengths lie in the multidisciplinary perspective brought by the broad stakeholder participation. Stakeholders from orthopedic surgery, physical therapy, massage therapy, research program funders, provider organizations, and consumers, contributed insights toward a cohesive set of recommendations. Consumer input illuminated the needs and priorities of consumers in rotator cuff research and treatment choices, and the impact of the current substandard rotator cuff tear research base on patient care.

Although the experts who participated in this project were selected as representative of broader professional and research groups with rotator cuff tear interests, the prioritization activity was limited to a small sample, and the results may not reflect the priorities of the general stakeholder populations. The sample size was limited by the Paperwork Reduction Act and Information Collections Policy (44 USC 3501-3520), administered by the Office of Management and Budget.[3] The Act was designed to minimize the paperwork burden on the public, assure that high quality data are obtained, and minimize costs. However, the approval process to allow greater than nine nongovernment participants exceeded the length of time available to complete the project.

Conclusion

This project engaged a broad array of stakeholders to identify and prioritize critical knowledge gaps regarding rotator cuff tear outcomes. Stakeholders identified “which treatment is best for which patient, and when?” as the important overarching question.

Since patients with rotator cuff tears are treated by a broad range of health care providers, consensus on the minimum set of outcomes assessment tools to use in clinical studies would best be decided by a multidisciplinary consensus conference. Once consensus is attained on the highest priority methodological issues, scientific investigation in existing gap areas can progress towards resolution.

Using such consensus information, researchers are encouraged to design and conduct focused, sufficiently powered clinical studies that utilize a comparison or control group to address the highest priority research gaps. The ideal format is an RCT. However, the modest sample sizes of most rotator cuff RCTs does not allow for subgroup analyses. Rather, a prospective cohort study may be the best way to determine the influence of a variety of patient factors on outcomes, examine the natural history of rotator cuff tears, or compare clinical recovery trajectories that account for baseline patient differences, including the magnitude of rotator cuff pathology.

Hence, the systematic review findings along with the prioritized gaps lists provide a roadmap for focusing and advancing rotator cuff research in the United States toward improved care.

References

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2. Moher D, Schulz K, Altman D. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. Annals of Internal Medicine 2001 April 17; 134(8):657-62. PMID: 11304106.

3. Department of Commerce. Office of the Chief Information Officer WebPage. The Paperwork Reduction Act and Information Collections Policy. www.whitehouse.gov/sites/default/files/omb/inforeg/statpolicy/standards_stat_surveys.pdf. Accessed August 31, 2010.

Acronyms and Abbreviations

AHRQ	Agency for Healthcare Research and Quality
EPC	Evidence-based Practice Center
KQ	Key Question
RCT	Randomized controlled trials

Appendix A. Search Strategy for Recently Published and Ongoing Studies

Medline was searched from September 16, 2009, through August 11, 2011, for randomized clinical trials and observational studies with comparison groups to determine if publications subsequent to the 2010 Alberta EPC systematic review partially filled the previously-identified knowledge gaps. The search strategy used in the original report was replicated. The search included a list of terms intended to identify all research publications associated with rotator cuff tears in adults. Searches for trials were further limited by terms to identify types of interventions that included a comparison group or included the term minimally-important clinical difference (MCID). Publications were assessed for relevance at the title and abstract level; applicable studies were retrieved, reviewed, and matched to one or more existing rotator cuff research gap areas.

We searched ClinicalTrials.gov (clinicaltrials.gov) for relevant ongoing studies. Searches were conducted using simple search terms such as “rotator cuff tear.” Trial records were reviewed for relevance based on the patient population of adults with acute or chronic partial- or full-thickness rotator cuff tears. Applicable studies were reviewed and matched to one or more existing research gap area.

Search Algorithm

Ovid Technologies, Inc. Email Service----------

Search for: limit 55 to yr="2009 - 2011"Results: 500

Database: Ovid MEDLINE(R) 1948 to Present with Daily Update Search Strategy:

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1 Rotator Cuff/ (3637)
2 ((rotator cuff* or rotator interval* or supraspin?tus or infraspin?tus or infraspin?teres minor or subscapularis or anterosuperior or posterosuperior) adj5 (tear or tears or tore or torn or lesion* or rupture* or avuls* or injur* or repair* or debride*)).mp. (3573)
3 exp tendon injuries/ (11739)
4 exp muscles/ (517043)
5 ((tendon or tendons or muscle* or muscular) adj5 (tear or tears or tore or torn or lesion* or rupture* or avuls* or injur* or repair* or debrid*)).mp. (24472)
6 ((ful or partial) adj4 (thick$ or tear or tears)).ti,ab. (2755)
7 3 or 4 or 5 or 6 (536343)
8 exp shoulder/ or exp shoulder joint/ (19030)
9 (shoulder or glenohumeral).mp. (39003)
10 (rotator cuff* or rotator interval* or supraspin?tus or infraspin?tus or infraspin?teres minor or subscapularis or anterosuperior or posterosuperior).mp. (7496)
11 8 or 9 or 10 (41011)
12 7 and 11 (9334)
13 1 or 2 or 12 (9930)
14 1 and 2 and 12 (2392)
15 randomized controlled trial.pt. (302309)
16 controlled clinical trial.pt. (82015)
17 exp randomized controlled trials/ (71901)
18 exp Random Allocation/ (70749)

19 exp double-blind method/ (108914)
20 exp single-blind method/ (14735)
21 clinical trial.pt. (460613)
22 (clin$ adj25 (trial$ or study or studies or design)).ti,ab. (620304)
23 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab. (109597)
24 exp placebos/ (29389)
25 placebo$.ti,ab. (127069)
26 random$.ti,ab. (507709)
27 exp research design/ (280789)
28 comparative study/ (1511948)
29 exp evaluation studies/ (146445)
30 exp follow-up studies/ (417212)
31 ((follow$ or observational or compar$) adj3 (trial$ or study or studies or design)).ti,ab. (310637)
32 exp prospective studies/ (291499)
33 exp epidemiologic studies/ (1289235)
34 exp causality/ (447500)
35 epidemiological factors.mp. (650)
36 (effect$ or outcome$ or allocat$ or control$ or assign$ or compar$ or experiment$ or analys$ or analyz$).mp. (8946248)
37 ((control$ or prospectiv$ or volunteer$ or participant$) adj5 (trial$ or study or studies or design)).mp. (989709)
38 (group or groups).ti,ab. (1863175)
39 cohort$.ti,ab. (167826)
40 case-control$.ti,ab. (55206)
41 cross sectional.ti,ab. (105853)
42 (case adj (comparison or referent$ or series)).ti,ab. (22211)
43 longitudinal.ti,ab. (98145)
44 (causation or causal$).ti,ab. (52896)
45 (analytic adj (study or studies)).mp. (1362)
46 single subject.ti,ab. (1502)
47 ssrd.ti,ab. (8)
48 n of 1.ti,ab. (33152)
49 baseline.ti,ab. (231517)
50 before after.ti,ab. (1886)
51 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 (9910805)
52 animals/ not humans/ (3472944)
53 51 not 52 (7525614)
54 13 and 53 (6253)
55 limit 54 to ("all adult (19 plus years)" or "adult (19 to 44 years)" or "middle age (45 to 64 years)" or "middle aged (45 plus years)" or "all aged (65 and over)" or "aged (80 and over)") (4789)
56 limit 55 to yr="2009 - 2011" (772)
57 14 and 53 (1753)

58 limit 57 to ("all adult (19 plus years)" or "adult (19 to 44 years)" or "middle age (45 to 64 years)" or "middle aged (45 plus years)" or "all aged (65 and over)" or "aged (80 and over)") (1385)
59 limit 58 to yr="2009 - 2011" (265)
60 59 not 56 (0)
61 56 not 59 (507)

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Appendix B. Prioritization Methods and Tools

Specific Methods

1. We formed stakeholder groups with representation from orthopedic surgeon-researchers, nonoperative health care providers and clinician-researchers, professional organizations, federal research funders, payers, and consumers.

We formed stakeholder groups from the provider/payer/researcher perspectives as well as consumer representatives. Since the rotator cuff research gaps were both topic-specific and methodological in nature, we sought expert stakeholders who were familiar with the current rotator cuff research and had a working knowledge of research design. We first constructed a general list of the types of health care providers, clinician and basic science researchers, funders and payers that represent various stakeholder groups and perspectives with an interest in rotator cuff outcomes across the spectrum of adult care (acute to chronic, all ages). A list of potential stakeholders was then constructed by the Minnesota Evidence-based Practice Center (EPC) faculty (health services and clinical outcomes researchers, orthopedic surgeon-researchers including an orthopedic shoulder surgeon and multidisciplinary nonoperative physicians). The Technical Expert Panel (TEP) members from the 2010 Alberta EPC rotator cuff systematic review were considered. Two representatives from the American Academy of Orthopedic Surgeons (AAOS) Rotator Cuff Guidelines Work Group were invited. Additional clinicians or clinician-researchers with broad rotator cuff treatment, outcomes and rehabilitation interests were added to include orthopedic shoulder surgery, physical therapy, massage therapy, and a family practice/nonoperative sports medicine physician. We included representatives from the major orthopedic funding agencies (government, orthopedic associations and foundations). In addition to the AAOS, we invited representatives from related professional organizations including the American Shoulder and Elbow Surgeons (ASES), the American Orthopaedic Society for Sports Medicine (AOSSM) and the American Academy of Physical Medicine and Rehabilitation (AAPM&R) the American Massage Therapy Association (AMTA), and the American Physical Therapy Association (APTA). We listed large payers of rotator cuff operative and nonoperative care and industry representatives. Consumers were identified by the Minnesota EPC to represent three varying perspectives on rotator cuff treatment in the United States. This process resulted in a 12- member stakeholder group including orthopedic surgeon-researchers, basic science and clinical outcomes researchers, nonoperative health care providers, professional organizations, federal research funders, health care payers, and consumers.

2. We simultaneously performed a search to locate relevant, recently-completed and currently on-going rotator cuff outcomes studies that potentially addressed existing knowledge gaps. The results of this search informed the preliminary list of identified research gaps to which the stakeholders would respond.

Search results were combined with the list of identified research gaps from the original systematic review plus Minnesota EPC faculty input in knowledge gap areas that are common to most orthopedic treatments (such as the effects of provider experience or surgical quality on outcomes) to generate a list of specific rotator cuff knowledge gaps. See Appendix A for more search details.

Appendix B Table 1 provides a summary table of the Key Questions (KQs), literature update and ongoing clinical trials list. The list of research gaps identified in the July 2010 systematic review served as the starting point for this project based on the six KQs that were the focus of that

report. Column 1 of Appendix B Table 1 lists the KQs (1-6) from the 2010 rotator cuff systematic review. Column 2 provides a short summary of the issue each KQ is aimed at addressing plus a list of "Other knowledge gaps" that were not specifically identified within the KQs but were identified by the Minnesota EPC faculty. Column 3 lists the title, primary author, journal, year and PubMed abstract link for randomized trials that were published after the 2010 systematic review search ended, or that covered minimally-clinically important differences in rotator cuff outcomes from other clinical studies. Column 4 lists ongoing clinical studies listed in clinicaltrials.gov limited to randomized trials, treatments used in the United States or those that used a comparison group or addressed a research gap area with modest methodology rigor.
An augmented, detailed list of rotator cuff research gaps was constructed by the Minnesota EPC project faculty to include additional gaps that were identified before or during the literature and ongoing studies update (Appendix C). Examples of some of the items added for stakeholder discussion and prioritization were the impact of provider experience, degree of provider specialization and surgical quality on outcomes, as well as a clear definition of "rotator cuff integrity" for both nonoperative and postoperative patients. The initial set of research gaps for the stakeholder engagement process is provided below. It includes two theme areas: Methodological Issues that include items related to measurement and study design, and Scientific Issues.

3. Three conference calls with stakeholders were held to solicit feedback on the consolidated list of research gap areas and discuss criteria for prioritization.
Preparatory materials, including a 2-page Stakeholder Call Information document (Appendix D), the list of Rotator Cuff Research Knowledge Gaps from the original report augmented by the Minnesota EPC researchers (Appendix C), the Executive Summary from the rotator cuff systematic review, Appendix B Table 1, a list of AHRQ's Topic Selection Criteria (Appendix E), and an agenda were distributed to all 12 stakeholders prior to the conference calls. Ten stakeholders, representing most major types of stakeholders were available and participated in the conference calls. The calls were convened by the Minnesota EPC and ranged from 40-60 minutes in length. A separate call was held for three consumer representatives. One consumer also participated in a provider/researcher/funder call. Information from the conference calls was used to edit the list of research knowledge gaps and generate the **Revised Rotator Cuff Research Gaps** list below. A summary of the call (Appendix F) was sent out to all 12 stakeholders for comment along with the list of Revised Rotator Cuff Research Knowledge Gaps (Appendix G). Only minor additions were made to the list of research gaps during the conference calls; stakeholders indicated that the original gap list was comprehensive. Three items that require consensus but did not fit under methodological or scientific issues exclusively follow the gaps list:

4. Stakeholders' comments and the Revised Rotator Cuff Research Gaps list were used to develop a two-part prioritization activity for stakeholders to rate and rank unresolved rotator cuff research areas: (1) rotator cuff methods issues and (2), unresolved scientific questions in rotator cuff treatment.
We conducted a prioritization activity with 10 of the stakeholders, nine nongovernmental responders and one government employee, using web-based ranking software developed by RTI. Two consumer stakeholders were not invited to participate in the prioritization activity. Stakeholders were asked to prioritize methods related issues separate from scientific research topics. All stakeholders were provided six stars with which to indicate high priority methods

issues and nine stars for scientific topics. A stakeholder could assign up to three stars for an issue or item if the stakeholder deemed it highly important.
An initial email invitation with links to the web-based software and instructions to complete the prioritization exercise was sent December 6, 2011, to all 10 stakeholders. A general reminder email with instructions was sent to all stakeholders on December 13, 2011. Personal emails asking the stakeholder to complete the exercise were sent to nonresponders December 20, 2011, and January 3, 2012. All invited stakeholders completed the exercise, a 100 percent participation rate.

5. Activity results were tabulated.

Prioritization activity results were tabulated and rank was calculated based on 3rd quartile scores. Scores were calculated as both weighted and nonweighted scores. Weighted scores totaled the number of stars stakeholders assigned to an individual issue or question. Unweighted scores totaled the number of stakeholders who voted for an individual issue or question. Weighted scores were also calculated by stakeholder category. Stakeholders were assigned to an MD researcher/clinician (three stakeholders), Physical Therapy/Massage Therapy researcher/clinician (three stakeholders), or Non-provider (four stakeholders comprised of medical directors, a funder, and a consumer). Ties in rankings were allowed. Appendix B Tables 2 and 3 provide ranking calculation detailed results.

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
1. Does early vs. late surgical repair (i.e. nonoperative care then surgery) lead to improved HRQoL, less disability, earlier return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased ROM and/or strength?	Effect of surgical timing on outcomes		
2. What is the comparative effectiveness of operative approaches (e.g., open, mini-open and arthroscopy) and postoperative rehabilitation on improved HRQoL, less disability, earlier return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased ROM and/or strength? Which operative approach should be used for different types of tears (partial- or full-thickness; small to massive; with/without fatty infiltration of muscle tissue)? **Recent literature and clinical trials (cols. 3 & 4) include all aspects of surgical treatment, not just approach*	Effectiveness of surgical approach and associated rehabilitation protocol on outcomes Which operative approach works best, given RC tear magnitude and duration? **Key Question includes rehabilitation but subaim (i) is surgical only*	Articles by various aspects of surgical care: Surgical approach	Trials by various aspects of surgical care: Surgical approach NCT00128076: all arthroscopic vs. mini-open, multicenter national RCT NCT00251147: open acromioplasty with RC repair vs. arthroscopic acromioplasty with mini-open repair NCT01140230: outcomes after repair of acute rotator cuff tears NCT00260949: arthroscopic repair outcomes and retears
2 (continued)		Surgical technique/procedure Arthroscopic rotator cuff repair with metal and biodegradable suture anchors: a prospective randomized study.[1] Milano et al., Arthroscopy, 2010: www.ncbi.nlm.nih.gov/pubmed?term=Milano%20G%2C%202010%2C%20cuff Prospective randomized clinical trial of single- versus double-row suture anchor repair in 2- to 4-cm rotator cuff tears: clinical and magnetic	Surgical technique/procedure NCT01039571: arthroscopic single vs. double row suture anchor repair for medium to large RC tears NCT00508183: quality of life after single vs. double row fixation for full-thickness RC tears NCT00739947: arthroscopic double row repair in full-thickness tears

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
		resonance imaging results.[2] Koh et al. Arthroscopy, 2011: www.ncbi.nlm.nih.gov/pubmed/21444007 Single-row vs. double-row arthroscopic rotator cuff repair in small- to medium-sized tears.[3] Aydin et al., J Shoulder Elbow Sur, 2010: www.ncbi.nlm.nih.gov/pubmed/20303287 Asymptomatic acromioclavicular joint arthritis in arthroscopic rotator cuff tendon repair: a prospective randomized comparison study.[4] Kim et al. Arch Orthop Trauma Surg, 2011 (RC repair vs. RC repair with distal clavicle resection): www.ncbi.nlm.nih.gov/pubmed/21161250 Massive rotator cuff tears: functional outcome after debridement or arthroscopic partial repair.[5] Berth et al., J Orthop Traumato, 2010: www.ncbi.nlm.nih.gov/pubmed/20198404	NCT00290888: arthroscopic RC repair with/without acromioplasty for full-thickness RC tears NCT00664794: arthroscopic RC repair with vs. without acromioplasty for full-thickness RC tears *NCT01116518: PT vs. (arthroscopic acromioplasty with debridement) vs. (arthroscopic RC repair with acromioplasty) for degenerative, atraumatic RC rupture (elderly) NCT01430598: does timing of arthroscopic subacromial decompression (before or after) RC repair during same surgery for complete tear has any clinical significance
2 (continued)		Augmentation/ biologics: repair healing Platelet-rich plasma augmentation for arthroscopic rotator cuff repair: a randomized controlled trial.[6] Castricini et al. Am J Sports Med, 2011: www.ncbi.nlm.nih.gov/pubmed/21160018	Augmentation/ biologics: repair healing NCT01170312: arthroscopic RC repair with autologous conditioned plasma (ACP) vs. normal saline NCT01238302: arthroscopic repair with/without PRP NCT01025037: outcomes after RC repair using graft reinforcement (Conexa Reconstructive Tissue Matrix) NCT01000935: autologous platelet rich plasma (PRP) vs. nothing (standard surgery) on healing after arthroscopic RC repair NCT01266226: arthroscopic RC repair with ACP vs. placebo NCT01256242: pilot: (rhPDGF-BB and bovine collagen matrix) vs. standard suture repair

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
			NCT01122498: safety and tolerability of 3 concentrations of BMP-655/ACS in full-thickness RC tears (open repair) NCT00208338 Pilot RCT of standard surgery with/without porcine small intestine submucosa patch for full-thickness RC tear NCT01414764: ACP vs. placebo injected to repair site 10 and 21 days post-surgery (?type) for full-thickness supraspinatus tear NCT01029574: PRP vs. placebo on re-tears after arthroscopic repair of complete RC tear
2 (continued)		Postoperative Rehabilitation Effects of one-month continuous passive motion after arthroscopic rotator cuff repair: results at 1-year follow-up of a prospective randomized study.[7] Garofalo et al., Musculoskelet Surg, 2010: www.ncbi.nlm.nih.gov/pubmed/20383685	Postoperative Rehabilitation NCT01383239: pilot RCT of early vs. delayed PT program for isolated supraspinatus tears after standard surgical repair NCT00891566 4 vs. 8 wks immobilization after arthroscopic repair for medium-large RC tears NCT01333527: sling (6 wks) vs. sling (as needed) after arthroscopic RC repair NCT00624117: progressive exercise (vs. home-based progressive exercise program?) after RC repair and anterior labrum rupture (RCT: comparator unclear) NCT00756015: early motion protocol (self and PT) vs. immobilization (6 wks) on tendon healing and clinical outcomes after arthroscopic RC repair NCT00275366: VA pilot: 8 wks of robotic rehabilitation vs. PT protocol on the rate and quality of recovery (ROM, strength, function) following arthroscopic RC repair

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
3. What is the comparative effectiveness of nonoperative interventions on improved HRQoL, less disability, earlier return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased ROM and/or strength? Treatments include but are not limited to: exercise, manual therapy, cortisone injections, acupuncture, other treatments/modalities Typically delivered by: physical therapists, osteopaths, chiro-practors Which non operative approach should be used for different types of tears (partial- or full-thickness; small to massive; with/without fatty infiltration of muscle tissue)?	Effectiveness of various nonoperative treatments on outcomes Which nonoperative treatment works best, given RC tear magnitude and duration?	Effect of sodium hyaluronate treatment on rotator cuff lesions without complete tears: a randomized, double-blind, placebo-controlled study.[8] Chou et al., J Shoulder Elbow Surg,2010: www.ncbi.nlm.nih.gov/pubmed/19963403	NCT01123889: subacromial injection with PRP or cortisone (pilot) NCT01152658: partial tear of supraspinatus treated (injected) with plasma-rich in growth factors (PRGF) (PrgfRC001IL) vs. saline NCT01355549: pilot: feasibility of platelet-rich plasma therapy for chronic shoulder pain due to RC disease in persons with spinal cord injury (nonoperative: inject PRP vs. autologous blood)
4. Does operative repair compared with nonoperative treatment lead to improved HRQoL, less disability, earlier return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased ROM and/or strength?	Effectiveness of operative vs. nonoperative treatment on outcomes	Comparison between surgery and physiotherapy in the treatment of small and medium-sized tears of the rotator cuff: A randomised controlled study of 103 patients with one-year follow-up.[9] Moosmayer et al., JBJS-Br, 2010: www.ncbi.nlm.nih.gov/pubmed/20044684	NCT00695981:(arthroscopic or open) surgery vs. nonoperative (PT protocol) NCT00852657: Open or mini-open RC tendon repair with acromioplasty vs. physiotherapy rehabilitation program *NCT01116518: physiotherapy vs. (arthroscopic acromioplasty) vs. (arthroscopic acromioplasty with RC reconstruction) for atraumatic RC rupture in age 55+ patients
5. What are the associated risks, adverse effects, and potential harms of nonoperative and operative therapies?	Adverse effects of operative and nonoperative treatments		Listed within respective Key Questions (2, 3, 4) above

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
6. Which demographic (e.g., age, gender, ethnicity, comorbidities, workers' compensation claims) and clinical (e.g. size/severity of tear, duration of injury, fatty infiltration) prognostic factors predict better outcomes following nonoperative and operative treatment? Which (if any) demographic and clinical factors account for potential differences in surgical outcomes between patients who undergo early vs. delayed surgical treatment?	Which demographic and RC tear factors predict better outcomes after any treatment (operative or nonoperative)? i. Which demographic and tear factors account for outcome differences between early vs. delayed surgery patients?		NCT00762580: factors that predict success with nonoperative care (PT only, n=380) NCT00253864: initiate prospective database for data collection on patients undergoing surgery of the shoulder (including RC tears)
Other knowledge gaps:			
	Imaging : Determine best means to image/detect/assess rotator cuff status		NCT01242761: accuracy of ultrasound diagnosis by community or specialist vs. surgical findings NCT00925366:optimal preoperative imaging for RC tears: MRI vs. MR-arthrography vs. CT-arthrography
	Natural history, biology, genetics		NCT00923858: natural history of asymptomatic RC tears (Yamaguchi PI: NIH 5R01AR05102602) NCT01069224: proinflammatory factors in synovial fluid of patients with RC disease: vs. control group (shoulder instability scheduled for elective surgery) NCT01193647: genetic factors affecting risks for RC disease (serum and DNA, prospective database, Utah)
	Irreparable rotator cuff		

Appendix B Table 1. Rotator cuff research gaps by Key Question and list of recent studies: for stakeholder conference call discussions

Key Question	Research Knowledge Gap	RCT/Other Clinical Studies Published Since 9/16/2009	Ongoing Studies that May Address Knowledge Gaps www.clinicaltrials.gov
	Outcomes assessment	Minimal clinically important differences in ASES and simple shoulder test scores after nonoperative treatment of rotator cuff disease.[10] Tashjian et al. JBJS-Am, 2010: www.ncbi.nlm.nih.gov/pubmed/20124055 Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease.[11] Tashjian et al. J Shoulder Elbow Surg, 2009: www.ncbi.nlm.nih.gov/pubmed/19535272	
	Postoperative pain management		NCT01204606: intraoperative periarticular injection (ropivacaine, morphine, epinephrine, cefotetan, and hyaluronic acid) vs. placebo (isotonic saline) on pain and narcotic use after arthroscopic RC repair. NCT01126593: postoperative subacromial continuous infusion bupivacaine catheters vs. placebo (normal saline) infusion after arthroscopic RC repair NCT00814580: RCT of Tapentadol (IR) vs. Oxycodone IR for acute postoperative pain after elective arthroscopic shoulder surgery (repairs of RC, labral tear, or Bankart)
	Miscellaneous		NCT00998868: prevalence of RC tears in hemiplegic shoulder

HRQoL=health-related quality of life ; RC=rotator cuff ; ROM; range of motion.
*Clinical studies with 3 distinct comparison groups (2 operative, 1 nonoperative) are listed twice, within Key Question 2 (operative comparisons) and Key Question 3 (operative vs. nonoperative comparisons).

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Appendix B Table 2. Stakeholder ranking of methods issues

Methods Issue Question	Unweighted	Weighted	MD Research/ Clinician	PT/MT Research/ Clinician	Nonclinicians
Measurement					
Which validated outcomes instruments should be used in all studies?	7	8	3	3	2
What is a minimal clinically important difference in key outcomes?	7	9	5	2	2
Which promising and/or controversial interventions should be studied?	4	4	2	1	1
What set of consistent definitions of rotator cuff pathology, including concomitant pathology, should be used across providers and imaging reports?	4	4	0	1	3
What diagnostic imaging (MRI, ultrasound, surgical inspection, arthrogram) best determines the extent of rotator cuff pathology at baseline, and when is it indicated?	5	5	1	1	3
What imaging is best to evaluate cuff integrity post-surgery, and when is it indicated?	4	4	2	2	0
Which imaging is best for cuff tears superimposed on pre-existing pathology?	1	1	0	1	0
What provider training and experience thresholds are required for accurate imaging interpretation (tear classification) for rotator cuff for pathology?	0	0	0	0	0
How should ‘cuff integrity’ be defined for (1) nonoperative/pre-operative and (2) postoperative patients?	3	3	1	0	2
What constitutes a good or acceptable repair?	3	3	0	2	1
What surgeon factors are associated with better operative repair and/or better outcomes?	0	0	0	0	0
Should minimum thresholds, such as number of cases or training, be required for complex repairs or revisions?	0	0	0	0	0
Which patient factors should be collected at baseline across all studies?	5	5	1	2	2
Design and Reporting					
Should classification of study participants be pathology-based or impairment-based?	3	3	0	1	2
Which patient groups (for example, acute/chronic, older active/inactive, worker’s compensation) should special care be given to assure representation in research samples?	2	2	1	1	0
What should the minimum followup duration be? Define ‘long-term’.	2	2	0	1	1
Identify additional outcomes data sources (health plan, CMS, VA, other) and develop guidelines for use and reporting (STROBE, other). Is a registry necessary to accrue sufficient patients to examine natural history, baseline factors, and outcomes?	3	4	2	0	2

Appendix B Table 3. Stakeholder ranking of scientific questions

Scientific Research Question	Unweighted	Weighted	MD Research/ Clinician	PT/MT Research/ Clinician	Nonclinicians
Overarching Questions					
Which patients do best with nonoperative treatment?	7	9	1	4	4
Which tears require surgery?	5	6	3	1	2
What is the threshold for surgery, given the rotator cuff tear severity/grade?	2	2	0	1	1
How does concomitant pathology or patient age modify a surgical threshold?	3	5	2	0	3
How long should a good outcome persist after operative or nonoperative intervention and should these recovery duration expectations differ by treatment approach?	1	1	1	0	0
How should recovery duration expectations differ in older patients?	0	0	0	0	0
What is the overall value of rehabilitation/adjunctive care?	3	4	1	3	0
How should rehabilitation (operative and nonoperative) strategies, timing, and intensity, differ by the tear characteristics, patient age, mechanism of injury, type of repair and work issues/worker's compensation?	6	8	0	4	4
How does the timing of passive/active/resistive exercise impact tissue healing in post-operative rehabilitation?	4	4	0	3	1
What is the impact of range of motion (ROM) and strength on outcomes?	1	1	0	1	0
What is the natural history of rotator cuff tears? What variables (risk factors) are associated with progression of fatty atrophy and tear size?	5	7	5	1	1
Which patient and cuff tear factor(s) most strongly predict poor outcomes after surgery?	5	6	1	1	4
Which patient subgroups (age, tear-based, functional limitation-based) should be identified in RCTs/clinical studies, and which are too heterogeneous to combine for outcomes comparisons?	0	0	0	0	0
What patient demographics and clinical profiles are important? (age, health habits/smoking, hand dominance, worker's compensation, specific comorbidities)	3	3	1	1	1
How do tear characteristics affect outcomes: size, age/duration of pathology, pre-existing/chronic changes, mechanism of injury?	4	4	1	1	2
How do psychosocial factors such as depression, socioeconomic status, motivation/self-efficacy, fear-avoidance, and coping mechanisms modify outcomes?	4	4	2	2	0
Nonoperative Questions					
Which nonoperative interventions and which comparisons should be studied (PT, exercise (supervised vs. home-based), cortisone injections, massage therapy, acupuncture, other)?	4	4	0	1	3
Nonoperative Vs. Operative Questions					
Which nonoperative vs. operative treatment comparisons are most important among patients whose condition may benefit from either approach? (Which patients do equally well when treated nonoperatively or operatively?)	1	2	2	0	0

Appendix B Table 3. Stakeholder ranking of scientific questions

Scientific Research Question	Unweighted	Weighted	MD Research/ Clinician	PT/MT Research/ Clinician	Nonclinicians
Operative Questions					
Given surgery is indicated, when is early (vs. delayed) surgery indicated?	2	2	1	0	1
Does cuff integrity predict patient-centered outcomes? Is a "successful" (intact) rotator cuff repair necessary?	2	2	2	0	0
Why does surgery often result in improved outcomes, even with evidence of repair failure?	0	0	0	0	0
What is the effectiveness or comparative effectiveness of different surgical decisions, such as approach, technique, or associated procedures?	4	5	1	0	4
Who benefits from repeat procedures and when should revision repair be attempted?	1	1	0	1	0
What is the effectiveness of adjunctive/biologic technologies such as protein-rich plasma (PRP), growth factors, stem cells, reinforcement meshes or patches?	3	3	2	1	0
Which surgical procedures (tenotomy, muscle transfer, reverse total shoulder replacement, other) should be considered for irreparable rotator cuff tears?	3	3	1	0	2
What information will best help a patient choose a provider and treatment path?	3	4	0	1	3

Appendix C. Initial List of Rotator Cuff Research Knowledge Gaps

The rotator cuff research recommendations that were made in the original report are organized below in two categories: ***methodological issues*** that limit the usefulness of current and future research, and ***scientific issues*** that have not been addressed within the literature. Within each subsection, we expanded the original gap list using Minnesota EPC team member expertise, and have labeled those additions by subheading as *Additional-(MN EPC)*.

1. Gaps Related to Methodological Issues

a. Measurement Issues

Recommendations from original report

- ***Outcomes*:** There is inconsistency in measures and a lack of comparability across studies regarding:
  - *Which measures to use:* consensus is needed on outcomes measures that are most important both to clinicians and patients. Validated and standardized outcome assessment instruments should be used where possible.
  - *What is a minimal clinically-important difference (MCID) in key outcomes:* Consensus will assist sample size calculations for future studies.
- ***Interventions***: to avoid numerous studies on disparate interventions, the interventions and comparisons chosen for a study should be guided by consensus regarding the most promising and/or controversial interventions.

Additional measurement gaps (MN EPC)

- ***Classification of rotator cuff pathology****:* Clinical examination is often unreliable.
  - What diagnostic imaging best determines the extent of rotator cuff pathology at baseline (MRI, ultrasound, surgical inspection, arthrogram) and is consensus needed?
  - What imaging should be used to evaluate cuff integrity post-surgery for outcomes comparison?
  - Does either of these recommendations differ with patient age? (Are tears harder to detect in patients with pre-existing advanced degenerative changes in/about the shoulder?)
- ***Cuff integrity****:* cuff integrity should be defined and operationalized. How does this definition differ among pre- and postoperative patients?
- ***Surgical quality***: Consensus should be reached on what constitutes a good or acceptable repair.
- ***Surgeon factors****:* What surgeon factors are associated with better operative repair and/or better outcomes? Possible examples include rotator cuff operative case volume (total career or annual), fellowship training, experience per approach, years of general surgical experience, and complication rates. Should repeat rotator cuff repairs and complex procedures be limited to a subset of shoulder surgeons?
- ***Patient factors****:* Which factors should be collected at baseline across all studies?

b. Design and Reporting Issues

Recommendations from original report

- ***Study design****:* Future studies should employ a comparison or control group and should ensure comparability of treatment groups, optimally through the use of randomization.

- ***Study conduct*** *(internal validity):* Future research should seek to minimize bias by blinding outcome assessors, using validated and standardized outcome assessment instruments, and ensuring adequate allocation concealment (where applicable) and the appropriate handling and reporting of missing data.
- ***Reporting****:* Results and study quality are often difficult to interpret due to inconsistent or incomplete results reporting. CONSORT and STROBE are suggestions for quality research reporting. Reporting study results in a consistent and comprehensive manner permits appropriate interpretation of results.

Additional design and reporting issues (MN EPC)

- ***Omission of conceptual models****:* Failure to control for the influence of multiple predictors on outcomes (baseline demographic and comorbidity information, cuff/tear-specifics, intervention, surgeon and rehabilitation, etc.) can lead to inaccurate (biased) conclusions about the effect of specific interventions on outcomes.
- ***Sampling issues****:*
  - Small sample sizes (MCID consensus is needed).
  - Representativeness: acute versus chronic patients, understudied populations (older active, older inactive, others).
- ***Clinical trajectories***: How long should good outcome persist, especially in older patients where rotator cuff tear incidence increases over time? Should expectations differ for operative versus nonoperative interventions?
- ***Data sources***: Are there additional outcomes data sources (large health plan, CMS, VA, other)?
- ***Administrative databases****:* Develop guidelines for use and reporting (STROBE, other).

2. Gaps Related to Scientific Issues

Recommendations from original report

- ***Operative timing***: Primary evidence is needed comparing the effectiveness of early versus delayed surgery.
- ***Nonoperative and operative interventions***: Primary evidence is needed comparing nonoperative and operative interventions.
- ***Nonoperative treatments***: Primary evidence is needed comparing different nonoperative treatments.
- ***Surgical approach****:* Future research examining the comparative effectiveness of open, mini-open, or arthroscopic approaches is also important, as arthroscopic procedures are more costly and technically difficult.
- ***Long-term outcomes***: Studies examining the long-term effectiveness of treatments over the course of several years are needed; at the very least, studies should follow patients for a minimum of 12 months.
- ***Rehabilitation***: Research is needed to determine optimal post-operative rehabilitation protocol.

Additional scientific issues *(MN EPC)*

Operative

- ***Surgical technique***: What, if any, technique-specific comparisons are warranted, regardless of surgical approach?
- ***Post-operative Rehabilitation***: How should rehabilitation strategies differ by the size of the cuff tear, type of repair, patient age, mechanism of injury etc.?

- ***Operative timing***: Primary evidence is needed on comparing early versus delayed surgery.
- ***Operative interventions***: Is a "successful" (intact) rotator cuff repair necessary? If a large proportion of rotator cuff repairs fail early (i.e., en route from the operating room to recovery), why does surgery sometimes result in improved outcomes, even with evidence of repair failure? ***Repeat procedures:*** Who benefits from repeat repair attempts and when should a repair revision be considered? The impact of this question will grow due to the aging population and the increase in "working retired" population.
- ***Intraoperative cuff repair adjunctive technology***: What is the effectiveness of protein-rich plasma, growth factors, stem cells, reinforcement meshes or patches, or other adjunctive technologies?
- **Irreparable rotator cuff tears**: Which surgical procedures (muscle transfer, reverse total shoulder replacement, other) should be considered? When should associated procedures be performed (distal clavicle excision, biceps tenodesis or tenotomy, SLAP repair, subacromial decompression [acromioplasty])?

Nonoperative

- ***Nonoperative treatments*:** Which interventions, and comparisons of interventions, are important to study (PT, cortisone injections, acupuncture, massage therapy, other)?
- ***Risk Factors:*** What variables are associated with risk of progression of fatty atrophy and tear size?

Overarching Questions

- ***Longer-term outcomes***: What followup duration should be considered minimum? (24 months?)
- ***Patient age****:* If differences exist in the types of pathology by age, then age distinctions for Future Research Needs, such as young, middle-age, young-old, and old-old, are important to consider. Applicability of findings for treatment or recovery trajectories for the elderly population is of particular interest.
- ***Predictors of outcomes/covariates***: Further information for applicability would be useful.
  - Which patient and rotator cuff tear factor(s) most strongly predict poor outcome after rotator cuff repair?
  - Which patient subgroups (age or tear-based) should be identified in RCTs/clinical studies, and which are too heterogeneous to combine for outcomes comparisons?
  - What patient demographics and clinical profiles are important: age, health habits, smoking, hand dominance, specific comorbidities?
  - How do tear characteristics affect outcomes: size, age/duration of pathology, pre-existing/chronic changes, mechanism of injury?
- ***Rehabilitation***: Controversies continue regarding timing and intensity. How should rehabilitation differ by age of patient, tear characteristics, return to work or other factors?
- ***Psychosocial factors***: How do factors such as depression, socioeconomic status, motivation/self-efficacy, modify outcomes?

Appendix D. Minnesota Evidence-based Practice Center Rotator Cuff Research Needs Project: Stakeholder Conference Call Information

This memo outlines specific areas where your expert feedback is requested for this AHRQ-funded project. The attached information forms the basis of your upcoming conference call with us, so please review it prior to our call. We are specifically interested in any additions, modifications, or deletions to the list of research knowledge gaps that you would suggest, especially if you believe that the list does not include pressing research issues that hinder the field's ability to address rotator cuff research questions adequately.

Background: The 2010 University of Alberta EPC report, "Comparative Effectiveness of Nonoperative and Operative Treatments for Rotator Cuff Tears," summarized the rotator cuff outcomes literature from 1990 through 2009, and focused on six Key Questions (KQs) related to rotator cuff treatment options in adults. The KQs are listed on page 2 of this document. The outcomes examined were health-related quality of life, return to work, pain, shoulder function, cuff integrity and complications. Broadly, the review compared outcomes following various operative approaches, after early versus late surgical repair, after operative versus nonoperative treatment and between various nonoperative therapies. It also included adverse effects or harms of any approach, and the impact of baseline demographic and injury characteristics on outcomes. The review found the existing literature to be sparse and of low to moderate quality, rendering many outcomes questions unanswerable. Seven recommendations were made for further research.

This project will expand and build on those recommendations to provide further specification and focus for future research endeavors. The initial report recommendations are listed in the *Rotator Cuff Research Knowledge Gaps* list.

Project objective: The goal of this project is to use expert/stakeholder feedback to identify and prioritize the current research knowledge gaps in rotator cuff treatment, and recommend the optimal research approaches to best fill those knowledge gaps to improve patient care. The main focus of this project is on treatment and post-treatment outcomes, rather than complications.

What we need from you during the conference call: Please review the attached document, *Rotator Cuff Research Knowledge Gaps*. The document was generated by content and methodological experts at the MN EPC to summarize the rotator cuff knowledge gaps identified in the 2010 report. The MN EPC expanded the list with additional items identified as issues from a broader health services research perspective. The list is extensive and will need to be reduced to a reasonable number before the prioritization exercise. The *Ongoing or Recently Completed Studies* document provides information that may or may not help you determine whether a research gap should advance to the prioritization stage. During the call we will discuss:

- What gaps you feel should be added or clarified.
- Which gaps should be excluded from the list due to not meeting a minimum importance threshold?

- If the Ongoing or Recently Completed Studies list complete or if it is missing important studies.

Timeline and Plan: The conference call is scheduled for **September 23, 1:00 CDT**. A summary of the conference call will be emailed to stakeholders within one week, where you will be given the opportunity to provide any additional comments or clarification. The MN EPC will then draft a final list of research gaps with suggested conference projects, goals, or research designs to address those gaps. Stakeholders will then engage in a ranking procedure by using a web-based prioritization software through which a suggested prioritization list will be generated. A final report will be generated by the MN EPC in September, which will later be posted on AHRQ's Effective Health Care Web site.

We welcome your participation in this AHRQ-sponsored project, and look forward to working with you. If you have any questions, please feel free to contact Robert Kane or Mary Butler.

Comparative Effectiveness of Nonoperative and Operative Treatments for Rotator Cuff Tears*

AHRQ Pub. No. 10-EHC050-EF, July 2010

The following Key Questions (KQs) were investigated for a population of adult patients with partial- and full thickness rotator cuff (RC) tears:

1. Does early surgical repair compared with late surgical repair (i.e., nonoperative intervention followed by surgery) lead to improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?

2. What is the comparative effectiveness of operative approaches (e.g., open surgery, mini-open surgery, and arthroscopy) and postoperative rehabilitation on improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?
- Which operative approach should be used for different types of tears (e.g., partial-thickness or full-thickness; small, medium, large, or massive; with or without fatty infiltration of muscle tissue)?

3. What is the comparative effectiveness of nonoperative interventions on improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength? Nonoperative interventions include, but are not limited to, exercise, manual therapy, cortisone injections, acupuncture, and treatments and modalities typically delivered by physical therapists, osteopaths, and chiropractors.
- Which nonoperative treatment approach should be used for different types of tears (e.g., partial-thickness, full-thickness; small, medium, large, or massive; with or without fatty infiltration of muscle tissue)?

4. Does operative repair compared with nonoperative treatment lead to improved health-related quality of life, decreased disability, reduced time to return to work/activities, higher rate of cuff integrity, less shoulder pain, and increased range of motion and/or strength?

5. What are the associated risks, adverse effects, and potential harms of nonoperative and operative therapies?

6. Which demographic (e.g., age, gender, ethnicity, comorbidities, workers' compensation claims) and clinical (e.g., size/severity of tear, duration of injury, fatty infiltration of muscle) prognostic factors predict better outcomes following nonoperative and operative treatment?
- Which (if any) demographic and clinical factors account for potential differences in surgical outcomes between patients who undergo early versus delayed surgical treatment?

*The full report is available at: www.effectivehealthcare.ahrq.gov/ehc/products/67/467/CER22_RotatorCuff1.pdf.

Appendix E. Prioritization Criteria for Rotator Cuff Future Research Needs

Based on stakeholder input, a set of prioritization criteria was determined based on a modified set of the Agency for Healthcare Research and Quality's (AHRQ's) Effective Health Care Program's Topic Selection Criteria. (Numbering was not altered to facilitate comparison to the original criteria set.) The Importance criteria should include considerations such as uncertainty for decisionmakers, important variation in clinical care, clinical benefits and harms, and high costs. Potential Impact includes the potential for new knowledge and the likelihood the study will inform clinical practice, whether the research addresses inequities, vulnerable and diverse populations, or ethical, legal, and social issues pertaining to the condition. Capacity includes considerations regarding the feasibility of the suggested methods or research question potential success based on possible conference proceedings or study designs.

2. Importance	**2a.** Represents a significant disease burden; large proportion or priority population
	2b. Is of high public interest; affects health care decision-making, outcomes, or costs for a large proportion of the U.S. population or for a priority population in particular
	2c. Was nominated/strongly supported by one or more stakeholder groups
	2d. Represents important uncertainty for decisionmakers
	2e. Incorporates issues around both clinical benefits and potential clinical harms
	2f. Represents important variation in clinical care, or controversy in what constitutes appropriate clinical care
	2g. Represents high costs due to common use, to high unit costs, or to high associated costs to consumers, to patients, to health care systems, or to payers
4. Potential Impact	**4a.** Potential for significant health impact: - To improve health outcomes - To reduce significant variation in clinical practices known to be related to quality of care - To reduce unnecessary burden on those with health care problems
	4b. Potential for significant economic impact: - To reduce unnecessary or excessive costs
	4c. Potential for change: - The proposed topic exists within a clinical, consumer, or policymaking context that is amenable to evidence-based change - A product from the EHC program could be an appropriate vehicle
	4d. Potential risk from inaction: - Unintended harms from lack of prioritization of a nominated topic
	4e. Addresses inequities, vulnerable populations (including issues for patient subgroups)
	4f. Addresses a topic that has clear implications for resolving important dilemmas in health and health care decisions made by one or more stakeholder groups
5. Capacity	**5a**. Efficiency (i.e., considering the timing of the need for new evidence, it is likely that a result could be produced in a timely manner)
	5b. Utilizes existing AHRQ resources or builds desired additional research capacity or decisional support for the EHC Program
	5c. Costs associated with the likely study design are reasonable considering limited program resources

Adapted from www.ncbi.nlm.nih.gov/books/NBK51239/ Appendix F in Carey TS, Crotty KA, Morrissey JP, et al. Future Research Needs for the Integration of Mental Health/Substance Abuse and Primary Care: Identification of Future Research Needs from Evidence Report/Technology Assessment No. 173 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (U.S.); 2010 Sep. (Future Research Needs Papers, No. 3.)

Appendix F. Minnesota Evidence-based Practice Center Rotator Cuff Research Needs Project: Stakeholder Conference Call Summary, September 23 to October 24, 2011

Purpose of the Meetings

- To solicit feedback from stakeholders on a list of research knowledge gaps in rotator cuff tear outcomes which need to be addressed in order to fully answer the key research questions posed in the EPC report "Comparative Effectiveness of Nonoperative and Operative Treatments for Rotator Cuff Tears."

Research Knowledge Gaps to add or differentiate in the MN EPC list

The discussion was initially guided by the research gaps identified in the EPC report and the list provided by the MN EPC. Some points were elaborations of gaps already noted. Others are new gaps.

Methodological questions

Measurement:

- Need clear and consistent definitions (terms) for rotator cuff pathology across providers and imaging reports, including terms for concomitant pathology. Clinicians need to know what is being treated before choosing or comparing treatments.
- Define "cuff integrity" for pre/nonoperative and postoperative patients
- Diagnostic imaging (ultrasound, MRI, CT arthrogram)
  - Tear classification/ cuff integrity: which modality and who should interpret it?
  - As outcome measure: what is reliable in the postoperative setting?
- Need agreement on core toolkit of outcomes measures to use across studies with the ability to add additional measures based on specific patient populations and research questions.

Design and Reporting

- Clear description of treatments.
- Baseline patient differences need better identification/differentiation in studies
- Clinical trial design issues:
  - Questions related to prognosis are best addressed with prospective observational studies; need sufficient sample size for subgroup analysis
  - Patient classification: should it be pathology or functional limitation/impairment based? Tear age considerations?
- Registry needed to accrue large number of patients: baseline factors, natural history, outcomes
- Design should be geared toward generalizability: pre/post treatment with concurrent controls, 10-15 year followup

- Reporting: What pathology is being treated with specific therapies or intraoperative procedures (such as intra-articular hyaluronic acid; stem cells, electrocautery of the joint capsule, etc.)

Scientific questions
The major questions/areas of stakeholder interest that motivated the majority of the discussions were:

- Who needs surgery?
- What treatments help, and in what order? (nonoperative, operative)
- What are the predictive factors - patient, pathology, treatment goals that should guide treatment decisions?
- What is the natural history of rotator cuff tears?
- What is the value of adjunctive care (e.g., rehabilitation)?

Additional scientific questions included:

- (Once pathology definitions are clear), what is the benchmark or threshold for surgery, given the rotator cuff tear severity/grade? How does concomitant pathology or patient age modify a surgical threshold? Who does best non-operatively?
- Identify optimal nonoperative rehabilitative protocol(s) for stabilization around rotator cuff tear.
- Worker's compensation patients: What treatment/rehabilitation and when?
- Operative decision timing: What needs to be repaired right away?
- Nonoperative treatment comparisons, including:
    - supervised versus home program
    - impact of range of motion (ROM) and strength on outcomes
- Post-operative rehabilitation:
    - What to do and when to do it
    - What is the role of CPM (continuous passive motion)?
    - How does the timing of passive→active→resistive exercise impact tissue healing?
- Impact of psychological factors on outcomes: fear-avoidance, coping mechanisms
- Does *cuff integrity* (yet to be defined) predict patient-centered outcomes (often 'good outcome' but poor strength)?
- Natural history studies of (nonoperative) rotator cuff tears, given patient and tear factors.
- Patient populations differ: sports, worker's compensation, elderly.

Items needing consensus (not classified above):

- Indications for imaging of the rotator cuff (initial)
- Post-operative imaging: When is it indicated and which imaging?
- Is a multidisciplinary guideline or standard of care attainable?
    - No standard of care for rotator cuff tears; therefore, patients don't know which provider to see first. Treatment (and imaging) track is determined by the type of provider a patient sees first and individual provider preferences (conservative versus other).

What Gaps could be culled prior to ranking process

- Surgical technique comparisons: Not as important as understanding which patients should receive which treatment within broad classifications (surgery or nonoperative).
- Biologics/PRP: not ready to be studied yet. The bigger issue is when surgery is indicated. Perhaps the "additional databases," last item under design and reporting issues.
- Massage therapy? Unclear on the role of massage therapy in rotator cuff recovery.

Consumer points:

- The primary outcome interest is in restoration of full function.
- Like other conditions, provider training, perspective and location are what determine which treatment a patient will receive, especially for conditions like rotator cuff where there is uncertainty among providers about which treatment is best under what circumstances. Therefore, who (which provider) a patient sees first will determine which course of treatment and/or diagnostic imaging a patient will receive. How does a patient determine who to see first? Most consumers don't know where to start.
- Consumers want to know treatment options based on their condition, not solely based on what providers want to do. If both nonsurgical and surgical options are practical, consumers want to know them so they can make a choice. Consumers suggest that patients may not be given choices because of provider preferences.
- There is great variability in diagnoses and care of rotator cuff problems.
- Shoulders are complex. Misdiagnoses are common across many types of providers: (primary care, physical therapy, radiology (misreads) and orthopedic surgeons (general). Serial misdiagnoses occur.
- Improper therapy (after misdiagnosis or accurate diagnosis) can cause patients extended pain and delay effective treatment, perhaps even limiting their options for effective treatment because of such delays.
- Provider expertise: Individuals with shoulder injuries should see a shoulder specialist first to get an accurate diagnosis and appropriate treatment plan that takes patient preferences into consideration. That is opposite how the system currently works. Consumers want to be evaluated by clinicians who can conduct a thorough shoulder-specific clinical exam to reach a diagnosis, not a generalist. Advanced imaging should not replace a good clinical exam. Radiologists/others who read advanced shoulder imaging studies should be trained specifically in shoulder. Surgeons who operate on rotator cuff tears should have additional training in shoulder; general orthopedic surgeons who are not experts may have worse outcomes than orthopedic shoulder surgeons.
- Consumers want to know how to determine how good a provider is.
- There is a lack of public understanding of which rotator cuff injuries really need surgery.
- Care coordination between different types of providers is often poor, particularly if providers are at different sites.

General Discussion Points

- Very important topic. Second only to spine.
- A common discussion point was the importance of understanding the factors that contribute to an appropriate and effective treatment decision. What is needed for a definitive diagnosis? Is there a way to establish benchmarks that help the diagnosis process? What patient factors matter?

- Different major patient populations – sports injury versus workers compensation versus older patient and chronic tears.
- Terminology matters. Who is describing the pathology influences how the pathology is described? Different disciplines bring different perspectives to bear and use even common language in different ways. For example, a primary care physician orders imaging, the pathology is described by a radiologist. Pathology descriptions by orthopedic surgeons or rehabilitation providers may differ.

Appendix G. Revised List of Rotator Cuff Research Knowledge Gaps

Revised Rotator Cuff Research Gaps

1. Methodological Issues

a. Measurement

- *Outcomes*:
  - Which validated instruments should be used in all studies?
  - What is a minimal clinically-important difference (MCID) in key outcomes?
- *Interventions*: which promising and/or controversial interventions should be studied?
- *Classification of rotator cuff pathology:*
  - Terminology: Clear and consistent definitions (terms) of rotator cuff pathology across providers and imaging reports is needed, including terms for concomitant pathology.
  - What diagnostic imaging best determines the extent of rotator cuff pathology at baseline (MRI, ultrasound, surgical inspection, arthrogram)?
  - What imaging is best to evaluate cuff integrity post-surgery?
  - Which imaging is best for rotator cuff tears superimposed on pre-existing pathology?
  - Tear classification: What provider training and experience thresholds are required for accurate imaging interpretation for rotator cuff for pathology?
- *Cuff integrity:* Define term for (1) nonoperative/pre-operative and (2) postoperative patients
- *Surgical quality*: What constitutes a good or acceptable repair?
- *Surgeon variability:*
  - What surgeon factors are associated with better operative repair and/or better outcomes?
  - Should minimum thresholds (cases, training) be required for complex repairs or revisions?
- *Patient factors:* Which factors should be collected at baseline across all studies?

b. Design and Reporting

- ***Study design****:* A comparison/control group should be employed. Randomization is optimal.
- ***Study conduct****:* Minimize bias: systematic followup independent of return visits; use independent and blinded outcome assessors, use validated outcomes instruments, conceal allocation, and appropriately handle missing data.
- ***Classification of study patients***: Should it be pathology-based or impairment-based?
- ***Reporting****:* Descriptions of specific treatments and reporting of results, including baseline patient differences, needs improvement. CONSORT and STROBE are suggestions.
- ***Omission of conceptual models****:* Failure to control for the influence of multiple predictors on outcomes (baseline demographic/comorbidities, cuff/tear-specifics, treatment specifics, surgeon, rehabilitation, etc.) leads to inaccurate (biased) conclusions about intervention effects.
- ***Sampling issues****:* Small sample sizes, lack of representativeness (acute/chronic, older active/inactive, worker's compensation, other understudied groups).
- ***Long-term outcomes***: What should the minimum followup duration be? Define "long-term."
- ***Data sources/reporting***: Identify additional outcomes data sources (health plan, CMS, VA, other) and develop guidelines for use and reporting (STROBE, other). A registry may be necessary to accrue sufficient patients to examine natural history, baseline factors and outcomes.

2. Scientific Issues

Overarching Questions

- ***Treatment and sequence***: Which treatments help, and in what order (nonoperative, operative)?
- ***Surgical indications***: Which tears require surgery?
  - What is the threshold for surgery, given the rotator cuff tear severity/grade?
  - How does concomitant pathology or patient age modify a surgical threshold?
  - Who does best nonoperatively?
- ***Maintenance of outcomes/improved function***:
  - How long should a good outcome persist after operative or nonoperative intervention and should these recovery duration expectations differ by treatment approach?
  - How should recovery duration expectations differ in older patients?
- ***Rehabilitation***:
  - What is the overall value of rehabilitation/adjunctive care?
  - Timing of rehabilitation (operative and nonoperative): What should be done and when?
    - How should rehabilitation strategies, timing and intensity differ by the tear characteristics, patient age, mechanism of injury, type of repair, and work issues/worker's compensation
  - Post-operative rehabilitation:
    - What is the role of CPM (continuous passive motion)?
    - How does the timing of passive→active→resistive exercise impact tissue healing?
  - What is the impact of range of motion (ROM) and strength on outcomes?
- ***Natural history:*** What is the natural history of rotator cuff tears? What variables (risk factors) are associated with progression of fatty atrophy and tear size?
- ***Predictors of outcomes/covariates***:
  - Which patient and cuff tear factor(s) most strongly predict poor outcomes after surgery?
  - Which patient subgroups (age, tear-based, functional limitation-based) should be identified in RCTs/clinical studies, and which are too heterogeneous to combine for outcomes comparisons?
  - What patient demographics and clinical profiles are important (age, health habits/smoking, hand dominance, worker's compensation, specific comorbidities)?
  - How do tear characteristics affect outcomes: size, age/duration of pathology, pre-existing/chronic changes, mechanism of injury?
  - How do psychosocial factors such as depression, socioeconomic status, motivation/self-efficacy, fear-avoidance, and coping mechanisms modify outcomes?

Nonoperative

- ***Nonoperative treatments*:** Which intervention and which comparisons should be studied (PT, exercise (supervised vs. home-based), cortisone injections, massage therapy, acupuncture, other)?

Nonoperative versus operative interventions

- Which treatment comparisons are most important among patients whose condition may benefit from either approach? (Which patients do equally well when treated nonoperatively or operatively?)

Operative

- ***Operative timing***: Given surgery is indicated, when is early (versus delayed) surgery indicated?
- ***Operative interventions***:
  - Does *cuff integrity* predict patient-centered outcomes? Is a "successful" (intact) rotator cuff repair necessary?
  - Why does surgery often result in improved outcomes, even with evidence of repair failure?
- ***Surgical decisions:***
  1. ***Approach****:* What is the comparative effectiveness of open, mini-open, or arthroscopic approaches?
  2. ***Technique***: What comparisons are warranted, regardless of surgical approach?
  3. ***Associated procedures***: When should associated procedures be performed (distal clavicle excision, biceps tenodesis or tenotomy, Superior Labrum Anterior and Posterior (SLAP) repair, subacromial decompression/acromioplasty?
- ***Repeat procedures:*** Who benefits and when should revision repair be attempted?
- ***Intraoperative/nonoperative adjunctive cuff repair technology***: What is the effectiveness of protein-rich plasma (PRP), growth factors, stem cells, reinforcement meshes or patches, or other adjunctive/biologic technologies?
- ***Irreparable rotator cuff tears****:* Which surgical procedures (tenotomy, muscle transfer, reverse total shoulder replacement, other) should be considered?

Areas needing multispecialty consensus:

- Indications for imaging of the rotator cuff (initial).
- Post-operative imaging: when is it indicated and which imaging?
- A multidisciplinary guideline or standard of care in the assessment and treatment of rotator cuff tears.