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Volume **1**

# Disorders *of the* Shoulder

**DIAGNOSIS AND MANAGEMENT**

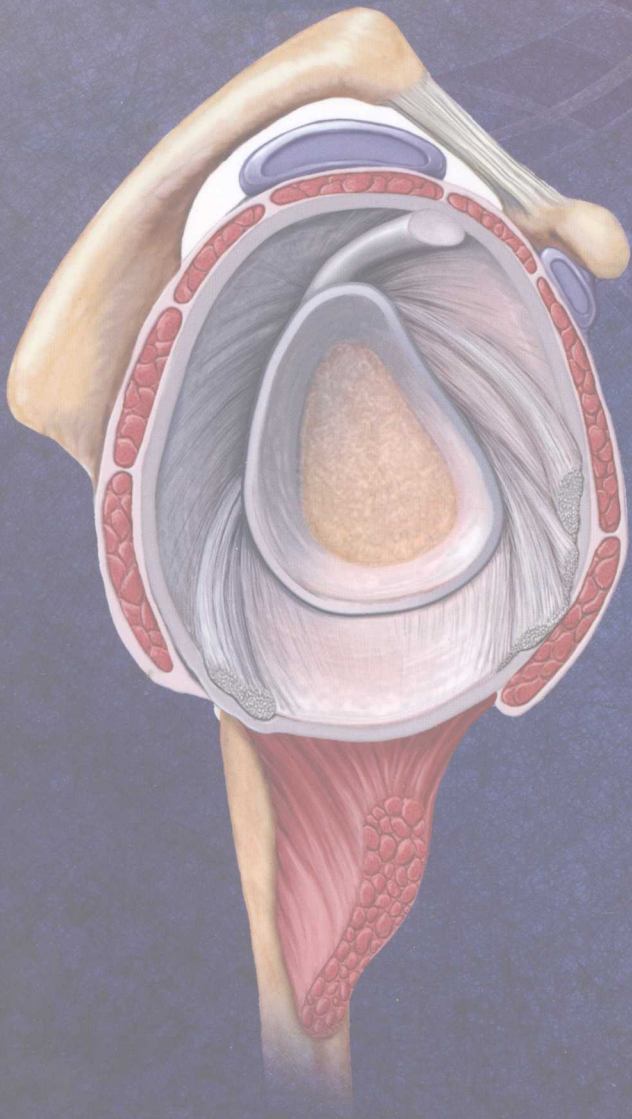
## Shoulder Reconstruction

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# Disorders *of the* Shoulder

*Diagnosis and Management:  
Shoulder Reconstruction*

THIRD EDITION

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*Production Services:* Integra Software Services Pvt. Ltd.  
*Printer:* RR Donnelley Asia

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Second edition © 2007 by Lippincott Williams and Wilkins  
First edition © 1999 by Lippincott Williams & Wilkins

351 West Camden Street  
Baltimore, MD 21201

Two Commerce Square  
2001 Market Street  
Philadelphia, PA 19103 USA

Printed in China

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#### **Library of Congress Cataloging-in-Publication Data**

Disorders of the shoulder: diagnosis & management. — Third edition.

p. ; cm.

Preceded by: Disorders of the shoulder / editors, Joseph P. Iannotti, Gerald R. Williams Jr. 2nd ed. c2007.  
2 v. (xii, 1364, I-42 p.).

Includes bibliographical references and index.

ISBN 978-1-4511-2745-4 (v. 1) — ISBN 978-1-4511-3058-4 (v. 2) — ISBN 978-1-4511-3057-7 (v. 3)

I. Iannotti, Joseph P., editor of compilation. II. Williams, Gerald R., Jr., 1958- editor of compilation.

III. Miniaci, Anthony, editor of compilation. IV. Zuckerman, Joseph D. (Joseph David), 1952- editor of compilation.

[DNLM: 1. Shoulder—surgery. 2. Athletic Injuries—diagnosis. 3. Athletic Injuries—surgery. 4. Joint Diseases—diagnosis. 5. Joint Diseases—surgery. 6. Shoulder Joint—surgery. WE 810]

RD557.5

617.5'72—dc23

2013020790

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## Dedication

To my clinical and research colleagues, the students, residents, fellows, and my patients who together taught me all that I know about the shoulder and all that I will learn in the future.

—*Joseph P. Iannotti*

To my parents Joe and Lina Miniaci, for the struggles, sacrifices, and risks that they endured to make a better life for their family. To my children Sara Lyn, Joseph, and Anthony, who have been a parent's dream and have always been there for me and shown an interest in what I did in my time away from home. And most of all to my wife Judy, my best friend and the love of my life; she has made anything we have ever accomplished possible.

—*Anthony Miniaci*

I would like to dedicate the third edition of *Shoulder Disorders* to my patients, teachers, and students—past, present, and future—without whom this book would not be possible. In addition, I would like to thank Joe Iannotti for his friendship and mentoring over the years. Thanks also to Joe Zuckerman and Tony Miniaci for joining us on this project—it is vastly better because of you. Thanks to Bob Hurley and staff at Lippincott who have pushed us to finish this project. Finally, I would like to thank my wife, Robin, and my two children, Mark and Alexis, for their love and understanding.

—*Gerald R. Williams, Jr.*

To my wonderful family—to my truly special wife Janet and my outstanding sons Scott and Matthew—you have been and always will be the most important and meaningful parts of my life.

—*Joseph D. Zuckerman*

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**L**ike the second edition of *Disorders of the Shoulder: Diagnosis and Management*, the third edition is intended to be a valuable reference text for any student of shoulder disorders—including shoulder, hand, sports medicine and trauma subspecialists, orthopedic generalists with a subspecialty interest in shoulder disorders, orthopedic residents and fellows, and rehabilitation professionals. The field of shoulder surgery, as it relates to trauma and sports-related topics, has expanded greatly in the last 5 years. Therefore, we elected to dedicate an entire volume to each of the three major areas—reconstruction, trauma, and sports medicine. In addition to adding volumes devoted solely to trauma and sports injuries, the reconstructive volume has been thoroughly reworked and updated. Each of the editors are world-recognized experts and the contributing authors are experts from around the world. The multidisciplinary aspect of shoulder disorders remains a common theme for this textbook, with extensive coverage of supportive fields, including anesthesia, pain management, and rehabilitation.

Together the three volumes bring a comprehensive and up-to-date review of many common and complex shoulder problems. Each volume brings more detailed information than the prior editions of this textbook. Separate chapters are included for injuries associated with different sports. Chapters are included on management of surgical complications. The principles and basic science relating to the pathogenesis continue to be emphasized, with a strong effort to correlate the basic science information with clinical practice. The principles of tendon tissue engineering for management of rotator cuff disorders are included as a new chapter.

Treatment recommendations are grounded in peer-reviewed evidence and clinical experience, with concise, clinically relevant bibliographies.

The depth of certain chapters has been expanded to correspond to recent changes in clinical practice. Discussion of minimally invasive and arthroscopic surgery for a wide spectrum of rotator cuff pathology and instability problems is covered in detail. Chapters are included to cover complex and revision surgery for joint replacement, rotator cuff repair, muscle transfer, complex instability surgery, scapular disorders, and brachial plexus injuries. Reverse shoulder arthroplasty for arthritis and cuff deficiency and revision surgery is extensively covered. A new volume specific to diagnosis and treatment of shoulder trauma expands upon the second edition and should be of value to both the general orthopedic surgeon and shoulder and trauma specialist.

One of the challenges of any comprehensive medical text is for the content to be current with the evolution of clinical practice. The field of shoulder surgery is evolving rapidly. It is our intent to include the most recent publications and concepts of treatment up to the final editing of this textbook. It has been our privilege to edit the third edition of this text—a privilege made possible by the interest of you, the readers. We hope this latest edition meets your expectations and piques your interest enough to justify the creation of a fourth edition.

Joseph P. Iannotti, MD, PhD  
 Anthony Miniaci, MD, FRCSC  
 Gerald R. Williams, Jr., MD  
 Joseph D. Zuckerman, MD

# ACKNOWLEDGMENTS

**W**ithout the expertise, hard work, and vision of Jerry Williams, Joe Zuckerman, and Tony Miniaci, this third edition of *The Shoulder* would not have come to completion.

Joseph P. Iannotti

My gratitude to Joe Zuckerman and Tony Miniaci for joining us on this project—it is vastly better because of you. Finally, thanks to the staff at Lippincott who have pushed us to finish this project.

Gerald R. Williams Jr.



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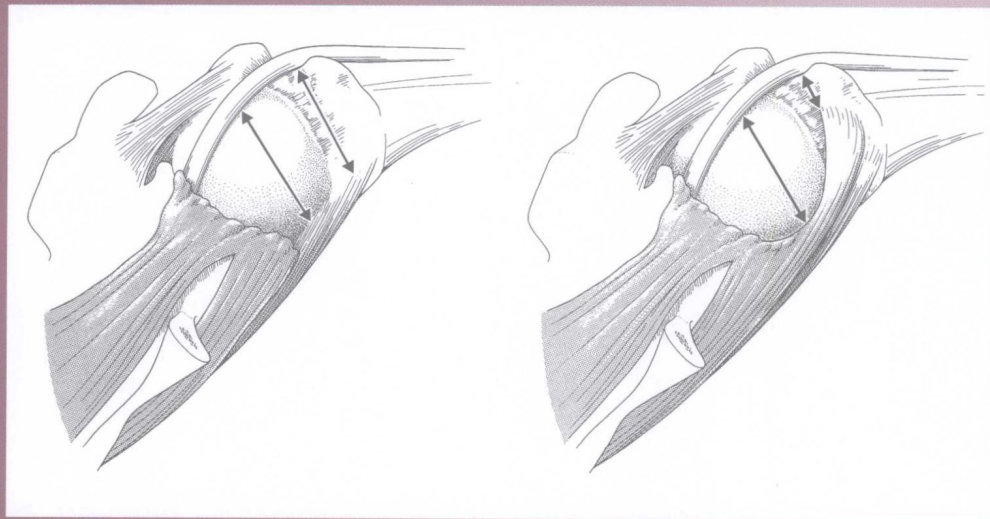
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## INTRODUCTION

Rotator cuff pathology represents the most common source of shoulder pain, and acromioplasty the most common surgical procedure of the shoulder.<sup>1</sup> Age-old debates persist regarding the intrinsic and extrinsic causes of rotator cuff rupture (Table 1-1). However, most authors agree that rotator cuff surgery is generally successful.<sup>20,40,43,219,227</sup> Rotator cuff surgery is routinely performed in the outpatient setting and generally consists of an anterior acromioplasty, rotator cuff repair, or a combination of both.<sup>49</sup> The literature is replete with articles describing the diagnosis and treatment of rotator cuff pathology, espousing new techniques and technology. It is interesting then that there is a relative paucity of data regarding complications of such common surgical procedures. There are a number of causes of persistent shoulder pain following rotator cuff surgery that are either intrinsic or extrinsic to the shoulder girdle. Persistent shoulder pain and poor results are not necessarily complications of surgery, just as complications do not always equate to a poor result or persistent pain. The complications discussed in this chapter, although not all-inclusive, are directly related to the surgical procedure and relate to preoperative, intraoperative, and postoperative etiologic factors. These complications include recurrent rotator cuff tear, acromial fracture, persistent subacromial impingement, heterotopic ossification, postoperative stiffness, infection, suprascapular nerve injury, axillary



**TABLE 1.1** Causes of Persistent Shoulder Pain after Rotator Cuff Surgery

Extrinsic shoulder pathology
Brachial plexopathy
Cervical radiculopathy
Long thoracic neuropathy
Neoplasm
Reflex sympathetic dystrophy
Spinal accessory neuropathy
Suprascapular neuropathy
Thoracic outlet syndrome
Intrinsic shoulder pathology
Intra-articular
Adhesive capsulitis
Articular cartilage defect
Bicipital tendinitis
Instability
Labral tears
Osteoarthritis
Extra-articular
Acromioclavicular arthropathy
Deltoid insufficiency
Rotator cuff defect
Subacromial impingement

From Williams G. Painful shoulder after surgery for rotator cuff disease. *J Am Acad Orthop Surg* 1997;5:97–108, with permission.

nerve injury, deltoid detachment, and anterosuperior humeral head subluxation.

Complications following rotator cuff surgery are probably underreported or under-appreciated. Although several authors have studied the results of operative treatment of failed rotator cuff repairs,<sup>15,59,178</sup> Mansat and colleagues have published the most definitive study regarding complications following rotator cuff repair.<sup>151</sup> In their series of 116 rotator cuff repairs, the combined medical and surgical complication rate was 38% (44 shoulders). While the surgical complication rate was 33% (38 shoulders), complications that affected the final surgical outcome occurred in 16% of patients (23 complications in 19 shoulders). Among these 19 shoulders, complications included failure of tendon healing (17), frozen shoulder (3), deep infection (2), and anterosuperior humeral head dislocation (1). Failure of tendon healing was inferred clinically by an inability to actively flex the arm further than 120 degrees in the absence of stiffness. The actual rate of recurrent tearing may have been higher if postoperative imaging studies had been obtained. In

Mansat's extensive literature review, as well as their reported study, the rate of revision surgery was approximately 3.5%.<sup>151</sup>

Recently, a few studies have specifically addressed the incidence of surgical complications following rotator cuff repair.<sup>8,95,134,184,185,201,217,227</sup> However, most of the studies describe surgical results following reoperation for a particular complication. A recent meta-analysis by Randelli and colleagues attempted to quantify the incidence of complications following arthroscopic rotator cuff surgery and found 414 complications in 2,890 patients.<sup>202</sup> Combining this study with the information from Mansat and colleagues allows for a good estimate of the rate of the most common complications after rotator cuff surgery (Table 1-2). To a certain extent, each complication has its own incidence and associated etiologic factors. These will be discussed individually in the following sections.

The evaluation of patients with persistent pain and dysfunction following rotator cuff surgery requires a thorough knowledge of the potential postsurgical complications. The most important diagnostic components are history and physical examination. In addition to obtaining a history from the patient, clinical records and imaging studies from prior surgeries should be reviewed whenever possible. Potential adjunctive studies may include magnetic resonance imaging, ultrasonography, arthrography, computed tomography, scintigraphy, and electrodiagnostic tests. The history, physical findings, and relevance of various adjunctive tests vary according to the complication(s) present.

The treatment options for patients with complications following rotator cuff surgery vary according to the specific complication. Furthermore, multiple complications may coexist in the same patient and, therefore, require combined treatment strategies. In general, the results following treatment of complications of rotator cuff surgery are inferior to the results that

**TABLE 1.2** Incidence of Postsurgical Complications following Rotator Cuff Surgery

Complication	(%)
Failed tendon repair	11–94
Neurovascular	0.2
Infection	0.1
Deltoid avulsion	0.5 <sup>a</sup>
Stiff shoulder	2.5
Suture granuloma	0.5 <sup>a</sup>
Wound hematoma	0.4 <sup>a</sup>
Dislocation	0.1 <sup>a</sup>
Reflex dystrophy	0.1 <sup>a</sup>
Greater tuberosity fracture	1 <sup>a</sup>
Acromion fracture	1 <sup>a</sup>

<sup>a</sup> Complications reported in 40 series of patients undergoing surgical repairs for rotator cuff tears. The series were published between 1962 and 1995; they included 2,948 operated shoulders. Overall rate of complication was 10.6%.

From Mansat P, Cofield RH, Kersten TE, Rowland CM. Complications of rotator cuff repair. *Orthop Clin North Am* 1997;28:205–213.



would have been obtained following uncomplicated primary rotator cuff surgery. However, when patients are selected carefully and the complications treated appropriately, the symptoms associated with their complications can often be improved.

## FAILURE OF THE REPAIR

### Etiology and Prevention

Since Codman's initial treatise on the surgical treatment of rotator cuff tears in 1911,<sup>45</sup> improved operative techniques have been responsible for a high success rate, with enduring patient satisfaction.<sup>47,57,75,107,108,120,137,214,241</sup> However, recurrent or persistent rotator cuff defects have been reported to occur in 20% to 90% of the cases,<sup>20,38,73,77,90,102,133,141,143,160,161,179,227,232,233,243</sup> with the risk of recurrence increasing relative to the size of the initial tear. The failure rates between arthroscopic and open repairs appear to be equal when the tear is small and involves minimal retraction of the musculotendinous unit. The incidence of failure is highest among elderly patients with chronic and retracted tears involving two or three tendons. Arthroscopic repairs under these conditions represent the highest failure rate in both in vitro and clinical studies,<sup>40,44,73,75,83,160,219,232</sup> although the gap appears to be closing as arthroscopic techniques continue to improve with failure rates anywhere from 30% to 50% for the large to massive tears.<sup>137</sup> Recently, Millar and colleagues showed improvement in outcomes and re-tear rates using arthroscopic methods versus open methods.<sup>160</sup> However, Bishop and colleagues showed an almost threefold increase in re-tear rates for tears greater than 3 cm done by arthroscopic techniques.<sup>20</sup> Clearly, controversy continues to exist for the best method of treating large to massive rotator cuff tears.

Persistent defects are not necessarily the sine qua non for failure, since the presence of a persistent rotator cuff defect is compatible with a good postoperative result following rotator cuff repair.<sup>38,57,73,77,133,143,232</sup> This process of converting a symptomatic tear into an asymptomatic re-tear is not entirely clear, although it may involve adequate subacromial decompression (SAD), debridement, biceps tenotomy, partial healing of the rotator cuff, and adequate postoperative rehabilitation.<sup>30,31,188,210</sup> The quality of functional results, however, depends on the size of the persistent defect, associated atrophy of the rotator cuff muscles, the integrity of the deltoid and the coracoacromial arch, and the age and functional demands of the patient.<sup>57,65,102,103,122,144,171,185,252</sup> Patients with persistent rotator cuff defects will be capable of overhead function when the deltoid is intact and the anterior and posterior portions of the rotator cuff are intact and balanced.<sup>29,31,32,57,232</sup> However, they will generally complain of fatigue with overhead activities, and limitation in activities that require vigorous or sustained overhead strength, as compared with patients with an intact rotator cuff.<sup>77,102,179</sup> Therefore, the goal of rotator cuff repair is long-term restoration of a functional, healed musculotendinous unit. While this may not always be attainable in primary rotator cuff repair, the development of recurrent rotator cuff tears may be minimized through a combination of careful preoperative patient selection, meticulous surgical technique, and attention to appropriate postoperative protection and rehabilitation.

With the understanding that the correlation between postoperative subjective and functional results and anatomic results (i.e., rotator cuff integrity) is variable,<sup>77,85,102,143</sup> outcome

studies have begun to focus on patient satisfaction in terms of patient-derived subjective assessments of symptoms and function.<sup>117,159,182,212,232,243</sup> Preoperative and surgical variables that are associated with poorer patient satisfaction include older patients, patients with chronic or irreparable subscapularis tears, large to massive supraspinatus and infraspinatus tears, tear retraction, atrophy of the rotator cuff muscles, especially the infraspinatus, and fatty infiltration of the muscle bellies.<sup>47,80,82,85,88,107,117,149,182,185,204,214,229,243,250</sup> Objective postoperative variables that are associated with poorer patient satisfaction include diminished and weakened forward elevation, impingement signs, and acromioclavicular joint pain and tenderness. Subjective variables associated with poorer patient satisfaction include persistent pain, functional impairment, and work disability.<sup>182,250</sup> Numerous studies have shown that fat infiltration and muscle atrophy are not reversible after surgery and are positive predictors of re-tear and decreased functional outcomes.<sup>81,83,85,90,141,161,243</sup> In a 13-year follow-up study on the results of rotator cuff repair in patients under 50 years of age, Sperling and colleagues have shown that while patients experience significant long-term pain relief following repair, the functional results are inferior to those seen in a mixed-age population.<sup>229</sup> A prospective longitudinal analysis of rotator cuff repairs by Galatz and colleagues indicated that as patients advance in age, their functional requirements decrease, and therefore satisfaction does not decline.<sup>75</sup> This was also found by Oh and colleagues, who showed that functional outcomes were improved in older patients after rotator cuff repair despite decreased rotator cuff integrity when compared with a younger population.<sup>185</sup>

Associated risk factors for recurrent tears include advanced age, tear size, chronicity and atrophy, poor tendon quality, fatty infiltration of the muscle belly, poor bone quality, inappropriate rehabilitation, inadequate SAD, smoking, steroid injections, and diabetes.<sup>59,77,90,102,175,184,185,204,233</sup>

Preoperative variables exist which will have a bearing on the ability to obtain long-term tendon-to-bone healing. In the presence of an acute rotator cuff tear, the biologic potential for healing appears greater when the repair is performed within 3 weeks of injury.<sup>12,101</sup> In long-standing tears or delayed repairs, muscle atrophy and fatty infiltration may develop, which do not appear to be reversible after rotator cuff healing, and have a negative effect on the outcome following rotator cuff repair.<sup>85,141,220</sup> These changes may be graded using computed tomographic scanning or magnetic resonance imaging, and increase with elapsed time from the tendon rupture.<sup>72,101,161,233,259</sup> Additionally, chronic retraction and scarring of the musculotendinous unit may preclude the surgeon from obtaining an adequate tendon-to-bone repair. Therefore, in the presence of an acute or acute-on-chronic rotator cuff tear with retraction of the tendon, early repair is more likely to result in long-term tendon-to-bone healing as compared with late repair. This potential advantage should be considered in the context of appropriate patient selection criteria such as age, physical demands, comorbidities (diabetes and smoking), and motivation (willingness to comply with rehabilitation), prior to recommending surgical intervention.

The surgical principles that most likely reduce postoperative recurrent tears or persistent defects include adequate mobilization of the tendon to the greater tuberosity, preparation of the tendon and bone interfaces, and secure fixation of