

Published Evidence Relevant to the Diagnosis of Impingement Syndrome of the Shoulder

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Background: Acromioplasty for impingement syndrome of the shoulder is one of the most common orthopaedic surgical procedures. The rate with which this procedure is performed has increased dramatically. This investigation sought high levels of evidence in the published literature related to five hypotheses pertinent to the concept of the impingement syndrome and the rationale supporting acromioplasty in its treatment.

Methods: We conducted a systematic review of articles relevant to the following hypotheses: (1) clinical signs and tests can reliably differentiate the so-called impingement syndrome from other conditions, (2) clinically common forms of rotator cuff abnormality are caused by contact with the coracoacromial arch, (3) contact between the coracoacromial arch and the rotator cuff does not occur in normal shoulders, (4) spurs seen on the anterior aspect of the acromion extend beyond the coracoacromial ligament and encroach on the underlying rotator cuff, and (5) successful treatment of the impingement syndrome requires surgical alteration of the acromion and/or coracoacromial arch. Three of the authors independently reviewed each article and determined the type of study, the level of evidence, and whether it supported the concept of the impingement syndrome. Articles with level-III or IV evidence were excluded from the final analysis.

Results: These hypotheses were not supported by high levels of evidence.

Conclusions: The concept of impingement syndrome was originally introduced to cover the full range of rotator cuff disorders, as it was recognized that rotator cuff tendinosis, partial tears, and complete tears could not be reliably differentiated by clinical signs alone. The current availability of sonography, magnetic resonance imaging, and arthroscopy now enable these conditions to be accurately differentiated. Nonoperative and operative treatments are currently being used for the different rotator cuff abnormalities. Future clinical investigations can now focus on the indications for and the outcome of treatments for the specific rotator cuff diagnoses. It may be time to replace the nonspecific diagnosis of so-called impingement syndrome by using modern methods to differentiate tendinosis, partial tears, and complete tears of the rotator cuff.

Level of Evidence: Diagnostic Level II. See Instructions for Authors for a complete description of levels of evidence.

The term *impingement syndrome* was introduced before modern methods of diagnosis of rotator cuff disorders were widely available. In his 1972 classic article, Neer pointed out that chronic bursitis and partial-thickness tears, calcium deposits, and complete tears of the rotator cuff could not be distinguished one from the others by physical and radiographic findings (nineteen shoulders in the original report had tendinitis or partial tears, while twenty had complete tears of the

supraspinatus)¹. As a result, the term *impingement syndrome* has been used to refer to the full range of rotator cuff abnormalities. There is growing interest in this condition; a PubMed search indicated that the number of articles mentioning “impingement” and “shoulder” in the abstract had doubled in the last decade from seventy-eight per year in 1999 to 159 per year in 2009.

Acromioplasty (Current Procedural Terminology [CPT] code 23130 or 29826) is commonly used as the definitive

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surgical treatment for the so-called impingement syndrome. Several recent reports have indicated a dramatic increase in the rate at which acromioplasty is being performed. Yu et al.² reported a 575% increase in the rate of acromioplasties performed in Olmsted County, Minnesota, over the two decades from the 1980s to the 2000s. Vitale et al.³ reported a 340% increase in the rate of acromioplasties performed in New York State between 1996 and 2006. The rate at which this procedure is performed in New York State is almost four times the rate in Olmsted County. The rate of increase in New York is seven per 100,000 per year, almost ten times the rate in Olmsted County, which is 0.8 per 100,000 per year. Data from the Healthcare Cost and Utilization Project's (HCUP) State Ambulatory Surgery Database (SASD) for Florida, as well as from the Centers for Medicare and Medicaid Services (CMS), show similar increases (Fig. 1).

Vitale et al. also reported a 240% increase in the number of acromioplasties performed per candidate for the American Board of Orthopaedic Surgery (ABOS) from 1999 to 2008³. Garrett et al.⁴ reported that, from 1999 to 2003, arthroscopic acromioplasty had risen from ninth to second place among the CPT codes reported by ABOS Part-II candidates, with the count increasing by 210% over this interval. The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes reported for these cases are nonspe-

cific: 840.4 (rotator cuff [capsule] sprain) and 726.2 (other affections of shoulder region/not elsewhere classified). From the available information, it is not possible to determine how much of the increase in the number of acromioplasties performed per 100,000 individuals is due to an increased prevalence of rotator cuff disease and how much is due to changing indications for surgical treatment.

Against this background, it seems timely to reexamine impingement syndrome as a distinct diagnosis, especially at a time when modern diagnostic tools, such as magnetic resonance imaging (MRI), sonography, and arthroscopy, can accurately differentiate disorders such as tendinosis, partial-thickness rotator cuff tears, and full-thickness rotator cuff tears. The goal of this investigation was to determine the evidence in the peer-reviewed literature for the five following hypotheses that would support the continued use of the term *impingement syndrome* and the rationale supporting its treatment by surgical decompression of the rotator cuff with use of acromioplasty:

1. Clinical signs and tests can reliably differentiate the impingement syndrome from other conditions. If impingement syndrome is a distinct diagnosis, the necessary and sufficient conditions for its differential diagnosis should be specified with satisfactory sensitivity and specificity.

2. Clinically common forms of rotator cuff abnormality are caused by contact with the coracoacromial arch. The underlying

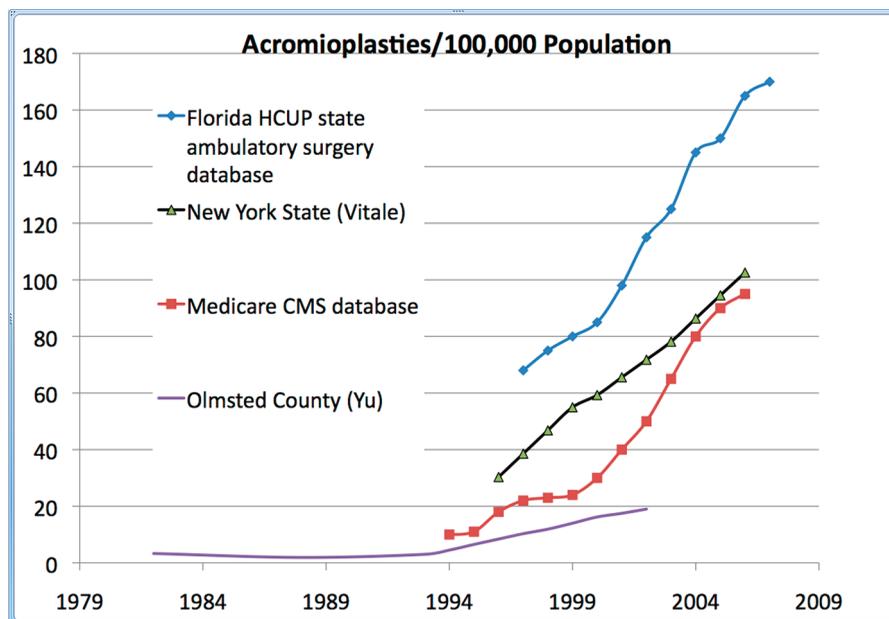


Fig. 1

Rates of acromioplasty per 100,000 individuals. Data are from the Florida Healthcare Utilization Project (HCUP) State Ambulatory Surgery Database (SASD), the recent paper by Vitale et al.³ for the State of New York, the national Centers for Medicare and Medicaid Services (CMS) database, and a recent paper by Yu et al.² regarding Olmsted County, Minnesota. The Medicare data represent the rates of acromioplasty, including inpatient, outpatient, open, and arthroscopic procedures, among Medicare enrollees (individuals sixty-five years and older) from 1994 through 2006 obtained from the CMS. These rates are based on the 5% CMS sample from 1994 to 2001 and the 20% sample from 2002 to 2006. Essentially all of the increase has been in arthroscopic acromioplasty, while the rate of open acromioplasty has remained essentially unchanged. The Florida data show the rate of outpatient acromioplasty among Florida residents over the age of fifteen years from 1997 to 2003. The Florida HCUP SASD database is one of the few available that allows one to calculate population rates of outpatient procedures on the basis of CPT codes rather than ICD codes.

impingement thesis is that “impingement on the tendinous portion of the rotator cuff by the coraco-acromial ligament and the anterior third of the acromion is responsible for a characteristic syndrome of disability of the shoulder.”¹

3. Contact between the coracoacromial arch and the rotator cuff does not occur in normal shoulders. If the contact between the coracoacromial arch and rotator cuff is pathogenic, it should not occur in normal shoulders.

4. Spurs seen on the anterior aspect of the acromion extend beyond the coracoacromial ligament and encroach on the underlying rotator cuff. As the coracoacromial arch is normally congruent with the rotator cuff, in order to disrupt the rotator cuff, the spur should extend beyond the ligament, rather than lying within it.

5. Successful treatment of the impingement syndrome requires surgical alteration of the acromion and/or coracoacromial arch. Since “most supraspinatus and biceps lesions are due to impingement wear, usually caused in part by variations in the shape and slope of the acromion,”⁵ definitive treatment would necessitate decompression by acromioplasty and, furthermore, acromioplasty would be superior to other treatments in randomized controlled trials.

Materials and Methods

To locate the published evidence in support of the five stated hypotheses, we performed a PubMed search for all articles published prior to September 2010 that mentioned “impingement” and “shoulder”; 1739 such abstracts were thus located. Because of the relevance to hypothesis number 2, we performed a similar search for abstracts including the terms “partial,” “cuff,” and “tear”; 330 such abstracts were located. Because of the relevance to hypothesis number 4, we performed a similar search for abstracts including the terms “coracoacromial” and “ligament”; 234 such abstracts were located. The authors read each of these abstracts and, if necessary, the papers themselves to exclude from consideration reviews, commentaries, instructional courses, transactions, book chapters, surgical technique papers, articles that did not relate to impingement in the shoulder, articles discussing only internal impingement, articles dealing with acromioclavicular impingement, articles relating to coracoid impingement, articles describing impingement due to fractures and tumors, articles discussing secondary impingement, articles on impingement as a complication of shoulder arthroplasty, articles presenting the outcome of acromioplasty without comparison with other methods of treatment, articles comparing open with arthroscopic acromioplasty, articles dealing primarily with the evaluation and management of rotator cuff tears, articles not in English, and other articles that did not address one of the five hypotheses. We also excluded from consideration articles demonstrating the well-recognized coexistence of various acromial shapes with rotator cuff tears, recalling the dilemma regarding cause and effect: “a characteristic ridge of proliferative spurs and excrescences on the undersurface of the anterior process was seen frequently, apparently caused by repeated impingement of the rotator cuff and humeral head, with traction on the coracoacromial ligament”¹ as opposed to “most supraspinatus and biceps lesions are due to impingement wear, usually caused in part by variations in the shape and slope of the acromion.”⁵

The remaining 124 articles were each read by three of the authors and were evaluated in terms of their support or nonsupport of each of the five hypotheses, the type of study (clinical, cadaveric, animal, normal subject, histological, and observational investigation), the level of evidence for clinical studies, the critical finding, and the gold standard or outcome measure used in the study. The authors applied the Instructions for Authors guidelines from *The Journal of Bone and Joint Surgery* (American Volume) to determine the levels of evidence.⁶ Each evaluator was blinded to the level of evidence assigned by the

others. With twenty of the 124 articles, one of the three readers disagreed with the other two as to whether a clinical study was a Level I or II on one hand or a Level III or IV on the other. The three readers again reviewed the twenty articles along with a fourth reader. The final levels of evidence displayed in the five results tables (one for each of the five hypotheses) present the median of the independent evaluations of ninety-two articles, excluding the thirty-two Level-III and IV studies. Our conclusions were based on the data in these tables.

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The DePuy/Douglas T. Harryman II Endowed Chair for Shoulder Research funded this study.

Results

The final analysis included ninety-two articles, of which thirty-five were Level-I clinical studies, seventeen were Level-II clinical studies, twenty-eight were cadaver studies, six were studies of normal subjects, two were animal studies, two were observational studies, and two were histological and/or biochemical. The type of study, level of evidence for clinical studies, critical findings, and gold standard are listed in five tables, one for each of the hypotheses; these tables and the references mentioned in them can be found in the Appendix.

Hypothesis 1: Clinical Signs and Tests Can Reliably Differentiate the So-Called Impingement Syndrome from Other Conditions

Evidence to support this hypothesis was lacking. The preponderance of evidence, including Level-I and II clinical studies, indicates that the physical findings used to diagnose the impingement syndrome, i.e., the Neer sign (pain on forced flexion), the Hawkins sign (pain on internal rotation with the arm elevated to 90°), and the Neer injection test (relief of pain on the Neer sign after subacromial injection of local anesthetic)^{1,5,7-9}, may be sensitive, but are not specific. The average sensitivity (and standard deviation) of the Neer sign was 76% ± 11%, while the average specificity was 36% ± 22%. The respective values for the Hawkins sign were 80% ± 11% and 41% ± 19%. The intended subacromial injection of the Neer injection test reached the subacromial space between 60% and 100% of the time, but also reached other structures in as many as 63% of the cases. The Hawkins sign is similar to the tests used for posterior capsular tightness and glenohumeral internal rotation deficit, again pointing to the lack of specificity for this clinical finding¹⁰⁻¹³. (See Table E-1 and associated references in the Appendix.)

Hypothesis 2: Clinically Common Forms of Rotator Cuff Abnormality Are Caused by Contact with the Coracoacromial Arch

Evidence to support this hypothesis was lacking. Animal studies in which subacromial impingement was created did not produce the type of rotator cuff tears most commonly seen in clinical practice. Furthermore, most partial-thickness tears have been observed to start posterior to the anterior edge of the supraspinatus and on the articular, nonacromial aspect of the rotator cuff as a so-called rim rent¹⁴. (See Table E-2 and associated references in the Appendix.)

Hypothesis 3: Contact Between the Coracoacromial Arch and the Rotator Cuff Does Not Occur in Normal Shoulders

Evidence to support this hypothesis was lacking. In normal shoulders in cadavers and in normal living subjects, the rotator cuff contacts the coracoacromial arch. (See Table E-3 and associated references in the Appendix.)

Hypothesis 4: Spurs on the Anterior Aspect of the Acromion Extend Beyond the Coracoacromial Ligament and Encroach on the Underlying Rotator Cuff

Evidence to support this hypothesis was lacking. The coracoacromial ligament is normally under tension. Displacement and increased tensioning of this ligament occur when the proximal part of the humerus passes beneath it. The acromial spur occurs as a traction enthesophyte within this ligament. (See Table E-4 and associated references in the Appendix.)

Hypothesis 5: Successful Treatment of the Impingement Syndrome Requires Surgical Alteration of the Acromion and/or Coracoacromial Arch

Evidence to support this hypothesis was lacking. Physical therapy, injections, and surgery that do not modify the coracoacromial arch have all been shown to be effective in the treatment of impingement syndrome. Multiple Level-I studies have failed to show the superiority of acromioplasty over alternative treatments that do not modify the coracoacromial arch. (See Table E-5 and associated references in the Appendix.)

Discussion

This investigation did not reveal evidential support for the ongoing use of the term *impingement syndrome* or for the use of this diagnosis as an indication for acromioplasty. The evidence does not support the view that such a syndrome can be differentiated from conditions that are now readily and precisely definable with modern imaging techniques, such as rotator cuff tendinosis, partial-thickness tears, and full-thickness tears^{15,16}. The evidence does not support the view that rotator cuff abnormality is, in most cases, caused by rubbing on the coracoacromial arch. Rather, the evidence indicates that the rotator cuff articulates with the coracoacromial arch in the movement of normal shoulders. Furthermore, after an acromioplasty with coracoacromial ligament sectioning was performed in otherwise normal specimens, the superiorly loaded humerus translated anterosuperiorly, indicating that contact between the coracoacromial arch and the rotator cuff normally stabilizes the humerus against upward displacement¹⁷ and suggesting that “the coracoacromial arch has an important duty and should not be thoughtlessly divided at any operation.”¹⁸ The spur that is often associated with rotator cuff tears has been demonstrated to form within the coracoacromial ligament, rather than extending below it. Finally, the evidence indicates that therapeutic approaches that do not alter the coracoacromial arch are successful in managing impingement syndrome, and the evidence does not provide support for the view that acromioplasty is superior to these other methods. It is of note that many of the articles relevant to the five hypotheses were published in

nonsurgical journals, which may not be routinely accessed by orthopaedic surgeons.

We are not the first to suggest a revision of the historical approach to the rotator cuff disorders previously included under the term *impingement syndrome* and the use of acromioplasty to treat it. Zarins, in a commentary on Neer’s classic article, stated, “It is more likely that rotator cuff dysfunction results in upward displacement of the humeral head and causes impingement of the humeral head against the acromion with shoulder use rather than the reverse. Arthroscopy and magnetic resonance imaging arthrography have elucidated many conditions that cause shoulder pain and that previously have been misdiagnosed as impingement. The liberal use of acromioplasty to treat ‘impingement’ is being replaced by a trend toward making an anatomic diagnosis, such as a partial or a complete tear of the rotator cuff, and performing corrective surgery, such as repair of the torn rotator cuff.”¹⁹

Bach and Goldberg¹³ pointed to the potential for confusion between impingement signs and signs of posterior capsular tightness. In a 2006 American Academy of Orthopaedic Surgeons Instructional Course Lecture, McFarland et al. stated, “Future study of the many etiologies of the entity that have been previously called ‘impingement syndrome’ is warranted.”²⁰ In their meta-analysis, Hegedus et al.²¹ concluded that neither the Neer nor the Hawkins sign had diagnostic utility for impingement. Hughes et al.²² found, after a systematic review, that most physical examination tests for rotator cuff disorders were inaccurate and cannot be recommended for clinical use. After their review of the diagnostic labeling of shoulder pain, Schellingerhout et al.²³ found that terms such as *impingement syndrome* lacked uniform definition and that the currently used labels have only fair to moderate reproducibility. They strongly suggested the abolishment of the use of such labels.

A systematic review by Dorrestijn et al.²⁴ led the authors to conclude that “according to the best-evidence synthesis, however, there is no evidence from the available RCTs [randomized controlled trials] for differences in outcome in pain and shoulder function between conservatively and surgically treated patients with subacromial impingement syndrome.” After their systematic review of the literature, Beaudreuil et al.²⁵ concluded, “the most extensively studied tests for subacromial impingement—Neer and Hawkins—are sensitive but lack specificity,” a conclusion similar to that of Jia et al.²⁶ In their 2009 Cochrane review, Coghlan et al.²⁷ concluded, “There is ‘Silver’ . . . level evidence from three trials that there are no significant differences in outcome between open or arthroscopic subacromial decompression and active non-operative treatment for impingement.”

Kuhn²⁸ stated, “Unlike many diagnoses that are based on distorted anatomy, impingement syndrome is a diagnosis based on physical examination. Many different conditions could produce a positive impingement test (e.g., rotator cuff tendinosis, rotator cuff tear, calcific tendinitis, and acute and chronic subacromial bursitis), and perhaps some would respond better to surgery while others to physical therapy. Second, radiographic findings used in determining a diagnosis are no different from those seen in age-matched asymptomatic patients in a control group. When the diagnosis is

not clearly defined and may reflect a variety of disorders, it is difficult to discern differences in treatment responses.” Harrison and Flatow²⁹ pointed out, “The decision to perform arthroscopic acromioplasty in patients whose conditions are refractory to rest, anti-inflammatory medications, subacromial cortisone injections, and physical therapy has been based more on opinion and retrospective reviews than on high-level evidence.” Our broad-based analysis is consistent with the findings of these authors.

Our investigation underscored the observation of Neer¹ that shoulders without rotator cuff tears can have symptoms essentially identical to those with tears. As pointed out by Harryman et al., Sher et al., Yamaguchi et al., and others, the converse is also true: shoulders with rotator cuff tears can be asymptomatic³⁰⁻³⁴. These observations reinforce the view that clinical findings alone are not reliable indicators of the status of the rotator cuff. Instead, scientific studies characterizing rotator cuff disorders and the results of treatment of different rotator cuff abnormalities must include advanced imaging, such as sonography or MRI, or arthroscopy.

The results of our study should be viewed in light of certain limitations. First, although the inclusion and exclusion criteria for the articles are clearly stated, it is possible that the selection of articles was subject to bias. Second, standardized guidelines for evaluating the quality of some study types (basic-science, cadaveric, and observational studies and investigations of normal subjects) have yet to be developed. Finally, this investigation did not attempt to clarify the indications for non-operative or operative management of rotator cuff disorders.

It is appropriate to note that the findings of this study were in large part presaged by Charles Neer in his 1972 article¹. In this preliminary report, he pointed out that the changes in the acromion could be the result of repeated contact with the proximal part of the humerus and the rotator cuff. When he encountered rotator cuff tears in patients with impingement syndrome, they were managed by repair with use of the McLaughlin technique; thus, the results of his surgical treatment were not due to acromioplasty alone. Neer recognized that shoulder stiffness could be associated with impingement syndrome and that often resolution of the stiffness would resolve the patient's clinical problem: “Patients suspected of having incomplete tears were advised not to have surgery until the stiffness of the shoulder had disappeared, and the disability had to persist for at least nine months before surgery was performed. Many patients not included in the series were suspected of having impingement but responded well to conservative treatment. This suggests that while such patients had pathological changes in the cuff that were vulnerable to swelling and inflammation following minor trauma, the acute reaction was reversible.”²¹ Finally, it is of note that Neer performed operations on only

ten patients with impingement syndrome per year (including revision acromioplasties and repairs of full-thickness rotator cuff tears), suggesting his conservative use of the procedure, in contrast to the escalating rate of application being observed today¹.

Clinical Importance

The definition, clinical evaluation, and understanding of rotator cuff disorders have advanced substantially in the last four decades since the introduction of the term *impingement syndrome*. Physicians now have sonography, contrast MRI, and arthroscopy along with the history and the physical examination to differentiate rotator cuff tendinosis, partial-thickness tears, full-thickness tears, and the condition of tight posterior glenohumeral capsule with diminished internal rotation. Enhanced accuracy in diagnosis should enable physicians to replace nonspecific terminology, such as that represented in the current ICD-9 codes 840.4 (rotator cuff [capsule] sprain) and 726.2 (other affections of shoulder region/not elsewhere classified), with more accurate terms indicating the pathological state of the rotator cuff tendons. This enhanced accuracy will enable better clinical determination of the epidemiology and natural history of rotator cuff disorders, the indications for treatment, and the determination of the effectiveness, efficacy, and appropriateness of different therapeutic approaches.

Appendix

eA Tables, one for each of the five hypotheses, showing the type of study, level of evidence for clinical studies, critical findings, and gold standard, as well as the references mentioned in the tables, are available with the online version of this article as a data supplement at jbjs.org. ■

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