

Epidemiological Analysis of Changes in Clinical Practice for Full-Thickness Rotator Cuff Tears From 2010 to 2015

Avinesh Agarwalla,* MD, Gregory L. Cvetanovich,[†] MD, Anirudh K. Gowd,[‡] MD, Anthony A. Romeo,[§] MD, Brian J. Cole,^{||} MD, MBA, Nikhil N. Verma,^{||} MD, and Brian Forsythe,^{||¶} MD

Investigation performed at Rush University Medical Center, Chicago, Illinois, USA

Background: Rotator cuff injuries are a leading cause of shoulder disability among adults. Surgical intervention is a common treatment modality; however, conservative management has been described for the treatment of rotator cuff tears. As the cost of health care increases, the industry has shifted to optimizing patient outcomes, reducing readmissions, and reducing expenditure. In 2010, the American Academy of Orthopaedic Surgeons created clinical practice guidelines (CPGs) to guide the management of rotator cuff injuries. Since their publication, there have been several randomized controlled trials assessing the management of rotator cuff injuries.

Purpose: To quantitatively describe changes in the management of full-thickness rotator cuff tears over time with regard to the publication of the CPGs and prospective clinical trials.

Study Design: Cohort study; Level of evidence, 3.

Methods: Included in the study were Humana-insured patients in the PearlDiver database with the diagnosis of a full-thickness rotator cuff tear from 2010 to 2015. Patients undergoing rotator cuff repair (CPT-29827, CPT-23410, CPT-23412, CPT-23420) and patients undergoing nonoperative management in the queried years were identified. The incidence of physical therapy (PT), nonsteroidal anti-inflammatory drugs (NSAIDs), and corticosteroid injections was assessed.

Results: In 2015, patients with full-thickness rotator cuff tears were less likely to receive a corticosteroid injection (16.5% vs 23.9%, respectively; odds ratio [OR], 0.6; $P < .001$) or undergo PT (7.8% vs 12.1%, respectively; OR, 0.6; $P < .001$) before rotator cuff repair in comparison with 2010. Additionally, patients were no more likely to be prescribed NSAIDs before rotator cuff repair in 2015 in comparison with 2010 (OR, 1.0; $P = .6$). Patients with full-thickness rotator cuff tears were less likely to undergo acromioplasty in 2015 in comparison with 2010 (48.2% vs 76.9%, respectively; OR, 0.4; $P < .001$); however, the rate of concomitant biceps tenodesis slightly increased (14.8% vs 14.6%, respectively; OR, 1.1; $P = .01$).

Conclusion: From 2010 to 2015, there were changes in the management of full-thickness rotator cuff tears, including decreased preoperative utilization of corticosteroid injections and PT as well as a decrease in concomitant acromioplasty, and the rate of biceps tenodesis slightly increased. As CPGs and prospective investigations continue to proliferate, management practices of patients with full-thickness rotator cuff tears continue to evolve.

Keywords: rotator cuff repair; clinical practice guidelines; biceps tenodesis; acromioplasty; value-based care

Rotator cuff injuries are a leading cause of shoulder disability among adults.¹¹ Surgical intervention is a common treatment modality that aims to promote tendon-bone healing by reconstituting the native tendinous footprint at its insertion on the humerus and to re-establish normal biomechanical behavior.⁵ Despite the frequency of performing rotator cuff repair, only a minority of rotator cuff tears require surgical intervention.¹² Pharmacological

treatments, such as nonsteroidal anti-inflammatory drugs (NSAIDs), and nonpharmacological treatments, such as corticosteroid injections and physical therapy (PT), have been described in the management of rotator cuff tears, with the goal of reducing pain and physical disability and improving function.^{4,17,28,30}

As the cost of health care increases, the industry has shifted to optimizing patient outcomes, reducing readmissions, and reducing expenditures.^{33,37,42} In 2010, the American Academy of Orthopaedic Surgeons (AAOS) created clinical practice guidelines (CPGs) to optimize the management of rotator cuff tears.^{2,35} After a rigorous systematic

The Orthopaedic Journal of Sports Medicine, 7(5), 2325967119845912

DOI: 10.1177/2325967119845912

© The Author(s) 2019

This open-access article is published and distributed under the Creative Commons Attribution - NonCommercial - No Derivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits the noncommercial use, distribution, and reproduction of the article in any medium, provided the original author and source are credited. You may not alter, transform, or build upon this article without the permission of the Author(s). For article reuse guidelines, please visit SAGE's website at <http://www.sagepub.com/journals-permissions>.

review, the CPGs were synthesized based on current evidence in the available literature. The AAOS provided a consensus agreement that surgery should not be performed for asymptomatic, full-thickness rotator cuff tears. Furthermore, a moderate strength of recommendation was given to not perform routine acromioplasty at the time of index rotator cuff repair, treating non-full thickness rotator cuff tears conservatively with exercise or NSAIDs. An additional finding was that workers' compensation status correlated with less favorable outcomes after rotator cuff repair. The CPGs on rotator cuff tears were based on lower levels of evidence, such as case series or case-control investigations.²³

Many randomized controlled trials regarding rotator cuff tears have been published since the publication of the CPGs in 2010. Clinical trials regarding operative versus nonoperative management of rotator cuff tears,^{18,32} concomitant procedures,^{1,21} operative techniques,^{22,38} biological augmentation,^{9,13} and postoperative rehabilitation protocols^{20,29} have been performed. The results of these investigations have indicated that rotator cuff repair for full-thickness rotator cuff tears offers improved outcomes in comparison with conservative treatment; however, the difference may not reach clinical importance.^{18,32} Randomized controlled trials are the highest form of scientific evidence; therefore, the results of these investigations have the potential to alter or guide clinical management.

The purpose of this study was to assess the current practice patterns of full-thickness rotator cuff tears and compare them with practice patterns before the publication of the CPGs and the majority of prospective clinical trials. We hypothesized that the practice patterns of full-thickness rotator cuff tears have changed more than time and more closely align with the CPGs as well as the outcomes of recent clinical trials.

METHODS

The present study was a retrospective review of Humana patient data within the PearlDiver patient records

database (PearlDiver Inc) from 2010 and 2015. This private-insurer database represents more than 20 million patients in the United States, containing data regarding patient demographics, details regarding hospitalization, diagnoses, procedures, and reimbursement. Comparatively, the Medicare database within PearlDiver includes patients insured by Medicare beneficiaries from 2005 to 2014, totaling approximately 55 million patients. These databases use the International Classification of Diseases–9th Revision, Clinical Modification, and –10th Revision, Clinical Modification (ICD-9-CM and ICD-10-CM, respectively), procedural codes as well as Current Procedural Terminology (CPT) codes. The accessed data represent procedures and diagnoses that were billed to the insurance company by the provider during that period. All information in the PearlDiver database is deidentified and anonymous, and the database allows for longitudinal tracking of patients through Boolean search commands. Because of the anonymity of the database, institutional review board approval was not needed for this investigation.

Two reference groups were created: a repair group of patients with full-thickness rotator cuff tears treated with open or arthroscopic rotator cuff repair (CPT-29827, CPT-23410, CPT-23412, CPT-23420)¹² and a nonoperative group of patients diagnosed with full-thickness rotator cuff tears without undergoing rotator cuff repair (Table 1). To correspond with the publication of the CPGs by the AAOS in December 2010, a reference group was formed in the final year before the release of the CPGs (2010) as well as in 2015. A summary of the CPGs is provided in Table 2. Although the CPGs did not offer any recommendations regarding biceps tenodesis, management of the biceps tendon remains an important variable during rotator cuff repair because of its role as an independent anterior shoulder pain generator.⁸ Therefore, changes in operative management that included concomitant biceps tenodesis were assessed. Several CPGs that have at least moderate evidence, such as workers' compensation status or use of cold therapy postoperatively, could not be accurately discernible from the database; therefore, these variables were not investigated. Distinguishing between symptomatic and

*Address correspondence to Brian Forsythe, MD, Midwest Orthopaedics at Rush, Rush University Medical Center, 1611 West Harrison Street, Chicago, IL 60612, USA (email: brian.forsythe@rushortho.com).

†Department of Orthopaedic Surgery, Westchester Medical Center, Valhalla, New York, USA.

‡Department of Orthopaedics, The Ohio State University Wexner Medical Center, Columbus, Ohio, USA.

§Department of Orthopaedic Surgery, Wake Forest University Baptist Medical Center, Valhalla, Winston-Salem, North Carolina, USA.

¶Department of Orthopaedic Surgery, The Rothman Institute, Philadelphia, Pennsylvania, USA.

||Midwest Orthopaedics at Rush, Rush University Medical Center, Chicago, Illinois, USA.

One or more of the authors has declared the following potential conflict of interest or source of funding: G.L.C. has received research support from Arthrex and educational support from Medwest and Smith & Nephew. A.A.R. has received consulting fees and receives royalties from Arthrex. B.J.C. has received research support from Aesculap/B. Braun, Arthrex, Geistlich, Sanofi-Aventis, and Zimmer Biomet; consulting fees from Anika Therapeutics, Arthrex, Bioventus, Flexion, Geistlich, Genzyme, Pacira, Smith & Nephew, Vericel, and Zimmer Biomet; nonconsulting fees from Arthrex, LifeNet Health, and Pacira; educational support from Arthrex; hospitality payments from GE Healthcare; receives royalties from Arthrex, DJO, and Elsevier; and has stock options in Aqua Boom, Biometrix, Giteliscop, Ossio, and Regentis. N.N.V. has received research support from Arthrex, ArthroSurface, DJO, Ossur, Athletico, ConMed Linvatec, Miomed, and Mitek; consulting fees from Arthrex, Medacta, Minivasive, OrthoSpace, and Smith & Nephew; nonconsulting fees from Pacira; educational support from Medwest; receives royalties from *Arthroscopy*, Smith & Nephew, and Vindico Medical Education–Orthopedics Hyperguide; and has stock options in CyMedica, Minivasive, and Omeros. B.F. has received research support from Arthrex, ArthroSurface, DJO, Ossur, Smith & Nephew, and Stryker; educational support from Medwest, Smith & Nephew, and Ossur; consulting fees from Arthrex, Sonoma Orthopedics, and Stryker; speaking fees from Arthrex; receives royalties from Arthrex and Saunders/Mosby-Elsevier; and has stock options in Jace Medical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval was not sought for the present study.

TABLE 1
Queried ICD-9/10 and CPT/HCPCS Codes^a

	ICD-9/10 Code	CPT/HCPCS Code
Full-thickness rotator cuff tear	727.61, 726.10, 840.3, 840.4, 840.5, 840.6, M75.120, M75.121, M75.122, S46.011A, S46.012A, S46.019A, M75.110, S43.80XA, S43.429A	
Corticosteroid injection		J0702, J0704, J1020, J1030, J1040, J1094, J1100, J1700, J1720, J2650, J2920, J2930, J3300, J3301, J3302, J3303
Physical therapy		97001, 97002, 97003, 97010, 97014, 97032, 97033, 97035, 97110, 97112, 97140, 97530

^aBecause of the vast number of National Drug Codes (NDCs) for nonsteroidal anti-inflammatory drugs, these codes were not provided. The PearlDiver database groups all NDCs for medication classes together. CPT, Current Procedural Terminology; HCPCS, Healthcare Common Procedure Coding System; ICD, International Classification of Diseases.

TABLE 2
Summary of Clinical Practice Guidelines^a

Guideline	Strength of Recommendation
Surgery should not be performed for asymptomatic, full-thickness rotator cuff tears	Consensus
Patients who have rotator cuff-related symptoms in the absence of a full-thickness tear should be initially treated nonoperatively using exercise or NSAIDs	Moderate
Workers' compensation status correlates with a less favorable outcome after rotator cuff surgery	Moderate
Routine acromioplasty is not required at the time of rotator cuff repair	Moderate
Surgeons should not use a non-crosslinked, porcine, small intestine submucosal xenograft to treat patients with rotator cuff tears	Moderate
Local cold therapy is beneficial to relieve pain after rotator cuff surgery	Consensus
We cannot recommend for or against exercise programs for patients with rotator cuff tears	Inconclusive
We cannot recommend for or against subacromial injections for patients with rotator cuff tears	Inconclusive
We cannot recommend for or against the use of NSAIDs for the nonoperative management of rotator cuff tears	Inconclusive

^aFrom the American Academy of Orthopaedic Surgeons (2010).² NSAID, nonsteroidal anti-inflammatory drug.

asymptomatic rotator cuff tears was unable to be performed in this database. The use of a xenograft could not accurately be discernible from the database, as this may code for superior capsular reconstruction; therefore, it was excluded from analysis. In both the repair and the nonoperative groups, patients who underwent rotator cuff repair before the queried year were excluded. In the nonoperative group, only patients with a diagnosis of a rotator cuff tear who did not undergo repair in the queried year were included.

In the repair group, patients who underwent rotator cuff repair because of a full-thickness tear in the queried year and who previously underwent PT, received a corticosteroid injection, or received an NSAID for the full-thickness rotator cuff tear before surgery were identified through administrative claims records. In the nonoperative group, patients who underwent PT, received a corticosteroid injection, or received an NSAID in the same year as the diagnosis of a full-thickness tear without rotator cuff repair were also identified. Only patients with an ICD-9 or ICD-10 diagnosis code of a full-thickness rotator cuff tear in their record were included in this investigation. Corticosteroid injections were identified with large-joint injection codes (CPT-20610, CPT-20611) with the respective corticosteroid Healthcare Common Procedure Coding System (HCPCS) codes. To guarantee that the investigators solely captured shoulder injections, only injections with an ICD-9 or ICD-10 diagnosis code of a full-thickness rotator cuff tear on the day of the injection were included in this investigation. PT codes specific to full-thickness rotator cuff tears were queried as described by Arshi et al.³ Last, NSAIDs were identified by a group of National Drug Codes within the PearlDiver database.

Patients who underwent concomitant acromioplasty (CPT-23130, CPT-29826, CPT-29826-51, CPT-29826-59) or biceps tenodesis (CPT-29828, CPT-23430) with rotator cuff repair were also identified. Patients who underwent magnetic resonance imaging (CPT-73221, CPT-73222, CPT-73223) with the diagnosis of a full-thickness rotator cuff tear before operative management were also identified.

Statistical Analysis

Statistical analysis was conducted using Excel (Microsoft). Frequencies and percentages were used to report discrete variables. Chi-square analysis was performed for all categorical variables to calculate odds ratios (ORs) and *P* values. Statistical significance was set at *P* ≤ .05.

RESULTS

In 2010, there were 60,665 diagnoses of full-thickness rotator cuff tears, with 5601 rotator cuff repairs (9.2% of total diagnoses), while in 2015, there were 99,251 diagnoses of full-thickness rotator cuff tears and 9878 rotator cuff repairs (10.0% of total diagnoses) (*P* < .001) (Table 3). Patient demographics are provided in Table 4.

TABLE 3
Distribution of Rotator Cuff Diagnoses^a

	2010 (n = 60,665 Tears)	2015 (n = 99,251 Tears)
Repair group	5601 (9.2)	9878 (10.0)
Nonoperative group	55,064 (90.8)	89,373 (90.0)

^aData are reported as n (%).

TABLE 4
Patient Demographics^a

	2010		2015	
	Repair	Nonoperative	Repair	Nonoperative
Male	2675 (47.8)	24,406 (44.3)	3515 (53.2)	38,955 (43.6)
Female	2926 (52.2)	30,658 (55.7)	3094 (46.8)	50,420 (56.4)
Age group, y				
<50	486 (8.7)	7932 (14.4)	429 (6.5)	9467 (10.6)
50-59	924 (16.5)	8052 (14.6)	1141 (17.3)	12,060 (13.5)
60-69	2149 (38.4)	14,930 (27.1)	2668 (40.4)	26,016 (29.1)
70-79	1741 (31.1)	15,973 (29.0)	2074 (31.4)	28,542 (31.9)
≥80	301 (5.4)	8177 (14.8)	297 (4.5)	13,286 (14.9)

^aData are reported as n (%).

Physical Therapy

In 2010, a total of 679 patients (12.1%) in the repair group and 9412 patients (17.1%) in the nonoperative group underwent PT ($P < .001$). However, in 2015, a total of 775 patients (7.8%) in the repair group and 12,082 patients (13.5%) in the nonoperative group were prescribed PT ($P < .001$) (Table 5). In 2015, patients were less likely to undergo PT before rotator cuff repair in comparison with 2010 (OR, 0.6; $P < .001$).

Corticosteroid Injections

In 2010, a total of 1340 patients (23.9%) in the repair group and 16,573 patients (30.1%) in the nonoperative group received a corticosteroid injection ($P < .001$). In 2015, a total of 1631 patients (16.5%) in the repair group and 28,332 patients (31.7%) in the nonoperative group were administered a corticosteroid injection ($P < .001$) (Table 5). Compared with 2010, patients were less likely to receive a corticosteroid injection before rotator cuff repair as part of their care (OR, 0.6; $P < .001$).

Nonsteroidal Anti-inflammatory Drugs

In 2010, a total of 299 patients (5.3%) in the repair group and 4341 patients (7.9%) in the nonoperative group were prescribed an NSAID ($P = .2$). However, in 2015, a total of 509 patients (5.2%) in the repair group and 8653 patients (9.7%) in the nonoperative group were prescribed an NSAID ($P < .001$) (Table 5). There was no difference in

being prescribed an NSAID before rotator cuff repair in 2015 versus 2010 (OR, 1.0; $P = .6$).

Operative Management

Before operative management, magnetic resonance imaging was more likely to be ordered in 2015 than in 2010 (78.8% vs 75.9%, respectively; OR, 1.2; $P < .001$). In 2010, there were 4305 cases (76.9%) of rotator cuff repair with concomitant acromioplasty, while the proportion of concomitant acromioplasty decreased in 2015 (4762 cases, 48.2%; OR, 0.4; $P < .001$). The distribution of concomitant procedures is provided in Table 6. Additionally, there was a slight difference in the rate of concomitant biceps tenodesis in 2015 and 2010 (14.8% vs 14.6%, respectively; OR, 1.1; $P = .01$).

DISCUSSION

In this investigation, we established that the operative treatment of full-thickness rotator cuff tears is slightly increasing and that patients are less likely to undergo conservative management as an initial treatment modality. Although these data suggest that physicians are treating rotator cuff tears more aggressively, concomitant procedures are being performed more selectively. During rotator cuff repair, performing concomitant acromioplasty is decreasing, while the trend of concomitant biceps tenodesis slightly increased. Although a causal relationship was unable to be established in this investigation, the CPGs developed by the AAOS as well as the publication of prospective investigations have improved our understanding of the treatment, outcomes, and natural history of rotator cuff injuries, which has factored significantly into changes in patient management.

The results of our investigation suggest that the majority of patients are not undergoing conservative management at the time of initial presentation of a rotator cuff tear. Although based on the best available evidence at the time of conception, the CPGs were met with skepticism. Opponents of the CPGs believed that guidelines must be based on adequate evidence to dictate standards of practice; however, higher level investigations did not exist at that time.²³ Since the publication of the CPGs, several randomized clinical trials published from 2010 to 2015 have directly compared clinical outcomes in patients undergoing rotator cuff repair and those undergoing conservative management.^{18,19,31,32} Although Kukkonen et al¹⁸ and Lambers Heerspink et al¹⁹ demonstrated equivalent outcomes at short-term follow-up, Moosmayer et al³¹ demonstrated that patients treated with rotator cuff repair had better outcomes that reached clinical significance than those treated conservatively by 1 year postoperatively. However, operative management only offered moderate improvement that did not reach the minimal clinically important difference by 5 years postoperatively.^{32,36} The CPGs offered inconclusive recommendations regarding the conservative management of full-thickness rotator cuff tears. Despite the technical difficulties associated with tear progression after

TABLE 5
Distribution of Nonoperative Treatment Modalities^a

	2010		2015	
	Repair (n = 5601 Tears)	Nonoperative (n = 55,064 Tears)	Repair (n = 9878 Tears)	Nonoperative (n = 89,373 Tears)
Physical therapy	679 (12.1)	9412 (17.1)	775 (7.8)	12,082 (13.5)
Corticosteroid injection	1340 (23.9)	16,573 (30.1)	1631 (16.5)	28,332 (31.7)
NSAIDs	299 (5.3)	4341 (7.9)	509 (5.2)	8653 (9.7)

^aData are reported as n (%). NSAID, nonsteroidal anti-inflammatory drug.

TABLE 6
Distribution of Concomitant Procedures^a

	2010	2015
Acromioplasty	4305 (76.9)	4762 (48.2)
Biceps tenodesis	815 (14.6)	1465 (14.8)

^aData are reported as n (%).

nonoperative care, it is important to note that there is high-level evidence that suggests that conservative and operative management yield equivalent outcomes.^{19,32} Therefore, surgeons must consider additional factors when discussing clinical management. For example, young, active patients may have higher functional demands that may limit the efficacy of conservative treatment. Additional patient factors including insurance status, age, obesity, or status of medical optimization may influence clinical decision making. It is imperative that physicians offer treatment options that best fit the needs of their patients, irrespective of the inconclusive recommendations by the CPGs.

Moosmayer et al³¹ found that, despite no difference in functional outcomes at final follow-up, 37% of patients who were treated nonoperatively had worsening tear progression at final follow-up, which was also associated with inferior outcomes. Patients may elect for nonoperative management, or insurers may require initial conservative management; however, these treatment options may not be efficacious and may ultimately require further surgical intervention. Approximately half of patients treated conservatively for full-thickness rotator cuff tears are reported to experience a clinically significant increase in tear size, which may eventually be unresponsive to nonoperative treatment.⁴⁰ Subsequent increases in tear size may reduce the likelihood of successful rotator cuff repair.¹⁰ Therefore, primary surgical repair may be viewed as a more definitive treatment option in patients with full-thickness tears¹⁵ and may also prevent further tear progression or further degeneration of the tissue.¹⁰

Another consideration for performing rotator cuff repair is the economic and societal values of operative versus nonoperative management for full-thickness rotator cuff tears. Operative management has been shown to yield a societal savings of US\$13,771 over a patient's lifetime, ranging

from US\$77,662 for patients aged 30-39 years to US\$11,997 for patients aged 70-79 years.²⁷ Furthermore, on an annual basis, rotator cuff repair for full-thickness tears yields an estimated US\$3.44 billion in societal savings.²⁷ Rotator cuff tears represent a substantial economic burden to society, and rotator cuff repair may be the most efficacious treatment to improve clinical outcomes and reduce the cost burden. Furthermore, it is imperative for patients who are employed at the time of surgery to return to work. The motivation to return to work is multifactorial, as it is influenced by economic need, disability coverage, social situation, comorbid conditions, and health care and benefits. However, patients may be counseled that 89% of those with workers' compensation status were able to return to work at maximal medical improvement by 7.6 months postoperatively after rotator cuff repair.⁶ Additionally, the nonoperative management of rotator cuff tears may lead to tear progression.⁴⁰ Arthroscopic rotator cuff repair and reverse total shoulder arthroplasty are more cost-effective treatment modalities in comparison with nonoperative management. Although arthroscopic rotator cuff repair may have a high rate of retears for large-to-massive rotator cuff tears, it offers a more cost-effective treatment modality with slightly improved clinical outcomes in comparison with reverse total shoulder arthroplasty.²⁴ As health care shifts toward more efficient care,⁷ physicians may focus on treatment modalities that minimize costs while simultaneously improving clinical outcomes.

Concomitant acromioplasty has been commonly performed with rotator cuff repair, as it offers several theoretical advantages by increasing the subacromial space to facilitate repair and relieve compression on the repaired construct.³⁴ However, there is mounting evidence to suggest that concomitant acromioplasty does not offer any added clinical benefit in comparison with rotator cuff repair without acromioplasty.^{1,25,26,39,41} Performing acromioplasty reduces the critical shoulder angle to a favorable range of 30° to 35°, which decreases contact between the acromion and rotator cuff.¹⁴ The CPGs published by the AAOS offer moderate strength of recommendation that routine acromioplasty should not be performed at the time of rotator cuff repair.^{2,23,35} The results of this investigation suggest that significantly fewer physicians are performing concomitant acromioplasty in patients with full-thickness rotator cuff tears. Therefore, it is possible that physicians are selectively performing acromioplasty in patients with

certain anatomic variations instead of performing this adjuvant procedure in all patients. Additionally, the proportion of patients who underwent biceps tenodesis has slightly increased. Because the long head of the biceps tendon is a potential pain generator, surgeons may elect to perform biceps tenodesis as a concomitant procedure to rotator cuff repair to eliminate a source of pain and to reduce the risk of returning to the operating room for a separate biceps tenodesis procedure. However, the threshold for identifying biceps tendinopathy may not have changed and may contribute to the trends observed in this investigation. As further investigations are conducted regarding the clinical outcomes and histopathology of biceps tendinopathy, indications for biceps tenodesis may be more clearly defined.

Although the Humana database provides a large sample size that allows for the evaluation of overall national trends in clinical practice, the use of this database has inherent limitations. Because of the retrospective nature of this study, we were unable to standardize clinical indications, operative techniques, or rehabilitation protocols, which may have affected the overall results of our investigation. Additionally, the results of this investigation are dependent on accurate coding within the database. While this database contained data for more than 20 million patients, it is not representative of the entire population. Patient factors such as age, diabetes mellitus, smoking status, and osteoporosis have been shown to affect clinical outcomes after rotator cuff repair.¹⁶ The effects of these factors on the management of rotator cuff tears could not be assessed in this study. Additional factors such as fatty infiltration, tear size, tear location, involved tendon, and muscle atrophy could also not be assessed in this investigation. Furthermore, it was unclear if the diagnosis of a rotator cuff tear was based on clinical findings or magnetic resonance imaging. Additionally, NSAIDs are readily available over the counter and do not require a prescription; therefore, the incidence of NSAID usage may have been underreported. The incidence of concomitant biceps tendon release was unable to be assessed because this procedure does not have a specific CPT code. Some surgeons prefer to perform this procedure instead of biceps tenodesis, and changes in management may have occurred over the duration of the study period. Last, laterality could not be accurately identified in this investigation. Thus, it is possible that patients included in this investigation underwent conservative management for rotator cuff dysfunction on the contralateral side.

CONCLUSION

From 2010 to 2015, there were changes in the management of full-thickness rotator cuff tears, including decreased preoperative utilization of corticosteroid injections and PT as well as a decrease in concomitant acromioplasty, and the rate of biceps tenodesis slightly increased. As CPGs and prospective investigations continue to proliferate, management practices of patients with full-thickness rotator cuff tears continue to evolve.

REFERENCES

- Abrams GD, Gupta AK, Hussey KE, et al. Arthroscopic repair of full-thickness rotator cuff tears with and without acromioplasty: randomized prospective trial with 2-year follow-up. *Am J Sports Med.* 2014; 42(6):1296-1303.
- American Academy of Orthopaedic Surgeons. Optimizing the management of rotator cuff problems: guideline and evidence report. https://www.aaos.org/research/guidelines/rcp_guideline.pdf. Published December 4, 2010.
- Arshi A, Kabir N, Cohen JR, et al. Utilization and costs of postoperative physical therapy after rotator cuff repair: a comparison of privately insured and Medicare patients. *Arthroscopy.* 2015;31(12):2392-2399.
- Babatunde OO, Jordan JL, Van der Windt DA, Hill JC, Foster NE, Protheroe J. Effective treatment options for musculoskeletal pain in primary care: a systematic overview of current evidence. *PLoS One.* 2017;12(6):e0178621.
- Bailey JR, Kim C, Alentorn-Geli E, et al. Rotator cuff matrix augmentation and interposition: a systematic review and meta-analysis. *Am J Sports Med.* 2019;47(6):1496-1506.
- Bhatia S, Piasecki DP, Nho SJ, et al. Early return to work in workers' compensation patients after arthroscopic full-thickness rotator cuff repair. *Arthroscopy.* 2010;26(8):1027-1034.
- Epstein AM. Revisiting readmissions: changing the incentives for shared accountability. *N Engl J Med.* 2009;360(14):1457-1459.
- Erickson BJ, Basques BA, Griffin JW, et al. The effect of concomitant biceps tenodesis on reoperation rates after rotator cuff repair: a review of a large private-payer database from 2007 to 2014. *Arthroscopy.* 2017;33(7):1301-1307.
- Flury M, Rickenbacher D, Schwyzer HK, et al. Does pure platelet-rich plasma affect postoperative clinical outcomes after arthroscopic rotator cuff repair? A randomized controlled trial. *Am J Sports Med.* 2016; 44(8):2136-2146.
- Gladstone JN, Bishop JY, Lo IK, Flatow EL. Fatty infiltration and atrophy of the rotator cuff do not improve after rotator cuff repair and correlate with poor functional outcome. *Am J Sports Med.* 2007; 35(5):719-728.
- Hashimoto T, Nobuhara K, Hamada T. Pathologic evidence of degeneration as a primary cause of rotator cuff tear. *Clin Orthop Relat Res.* 2003;415:111-120.
- Jensen AR, Cha PS, Devana SK, et al. Evaluation of the trends, concomitant procedures, and complications with open and arthroscopic rotator cuff repairs in the Medicare population. *Orthop J Sports Med.* 2017;5(10):2325967117731310.
- Jo CH, Shin JS, Shin WH, Lee SY, Yoon KS, Shin S. Platelet-rich plasma for arthroscopic repair of medium to large rotator cuff tears: a randomized controlled trial. *Am J Sports Med.* 2015;43(9): 2102-2110.
- Kathagen JC, Marchetti DC, Tahal DS, Turnbull TL, Millett PJ. The effects of arthroscopic lateral acromioplasty on the critical shoulder angle and the anterolateral deltoid origin: an anatomic cadaveric study. *Arthroscopy.* 2016;32(4):569-575.
- Keener JD, Galatz LM, Teefey SA, et al. A prospective evaluation of survivorship of asymptomatic degenerative rotator cuff tears. *J Bone Joint Surg Am.* 2015;97(2):89-98.
- Kim YS, Kim SE, Bae SH, Lee HJ, Jee WH, Park CK. Tear progression of symptomatic full-thickness and partial-thickness rotator cuff tears as measured by repeated MRI. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(7):2073-2080.
- Kuhn JE, Dunn WR, Sanders R, et al. Effectiveness of physical therapy in treating atraumatic full-thickness rotator cuff tears: a multicenter prospective cohort study. *J Shoulder Elbow Surg.* 2013;22(10): 1371-1379.
- Kukkonen J, Joukainen A, Lehtinen J, et al. Treatment of nontraumatic rotator cuff tears: a randomized controlled trial with two years of clinical and imaging follow-up. *J Bone Joint Surg Am.* 2015;97(21): 1729-1737.
- Lambers Heerspink FO, van Raay JJ, Koorevaar RC, et al. Comparing surgical repair with conservative treatment for degenerative rotator

- cuff tears: a randomized controlled trial. *J Shoulder Elbow Surg.* 2015;24(8):1274-1281.
20. Lee BG, Cho NS, Rhee YG. Effect of two rehabilitation protocols on range of motion and healing rates after arthroscopic rotator cuff repair: aggressive versus limited early passive exercises. *Arthroscopy.* 2012;28(1):34-42.
 21. Lee HJ, Jeong JY, Kim CK, Kim YS. Surgical treatment of lesions of the long head of the biceps brachii tendon with rotator cuff tear: a prospective randomized clinical trial comparing the clinical results of tenotomy and tenodesis. *J Shoulder Elbow Surg.* 2016;25(7):1107-1114.
 22. Liu J, Fan L, Zhu Y, Yu H, Xu T, Li G. Comparison of clinical outcomes in all-arthroscopic versus mini-open repair of rotator cuff tears: a randomized clinical trial. *Medicine (Baltimore).* 2017;96(11):e6322.
 23. Lubowitz JH, McIntyre LF, Provencher MT, Poehling GG. AAOS rotator cuff clinical practice guideline misses the mark. *Arthroscopy.* 2012;28(5):589-592.
 24. Makhni EC, Swart E, Steinhaus ME, et al. Cost-effectiveness of reverse total shoulder arthroplasty versus arthroscopic rotator cuff repair for symptomatic large and massive rotator cuff tears. *Arthroscopy.* 2016;32(9):1771-1780.
 25. Mall NA, Tanaka MJ, Choi LS, Paletta GA Jr. Factors affecting rotator cuff healing. *J Bone Joint Surg Am.* 2014;96(9):778-788.
 26. Mardani-Kivi M, Karimi A, Keyhani S, Hashemi-Motlagh K, Saheb-Ekhtiari K. Rotator cuff repair: is there any role for acromioplasty? *Phys Sportsmed.* 2016;44(3):274-277.
 27. Mather RC 3rd, Koenig L, Acevedo D, et al. The societal and economic value of rotator cuff repair. *J Bone Joint Surg Am.* 2013;95(22):1993-2000.
 28. Mathiasen R, Hogrefe C. Evaluation and management of rotator cuff tears: a primary care perspective. *Curr Rev Musculoskelet Med.* 2018;11(1):72-76.
 29. Mazzocca AD, Arciero RA, Shea KP, et al. The effect of early range of motion on quality of life, clinical outcome, and repair integrity after arthroscopic rotator cuff repair. *Arthroscopy.* 2017;33(6):1138-1148.
 30. Mitchell C, Adebajo A, Hay E, Carr A. Shoulder pain: diagnosis and management in primary care. *BMJ.* 2005;331(7525):1124-1128.
 31. Moosmayer S, Lund G, Seljom U, et al. 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. *J Bone Joint Surg Br.* 2010;92(1):83-91.
 32. Moosmayer S, Lund G, Seljom US, et al. Tendon repair compared with physiotherapy in the treatment of rotator cuff tears: a randomized controlled study in 103 cases with a five-year follow-up. *J Bone Joint Surg Am.* 2014;96(18):1504-1514.
 33. Orszag PR, Emanuel EJ. Health care reform and cost control. *N Engl J Med.* 2010;363(7):601-603.
 34. Pedowitz RA, Yamaguchi K, Ahmad CS, et al. Optimizing the management of rotator cuff problems. *J Am Acad Orthop Surg.* 2011;19(6):368-379.
 35. Pedowitz RA, Yamaguchi K, Ahmad CS, et al. American Academy of Orthopaedic Surgeons clinical practice guideline on optimizing the management of rotator cuff problems. *J Bone Joint Surg Am.* 2012;94(2):163-167.
 36. Piper CC, Hughes AJ, Ma Y, Wang H, Neviasser AS. Operative versus nonoperative treatment for the management of full-thickness rotator cuff tears: a systematic review and meta-analysis. *J Shoulder Elbow Surg.* 2018;27(3):572-576.
 37. Porter ME. What is value in health care? *N Engl J Med.* 2010;363(26):2477-2481.
 38. Randelli P, Stoppani CA, Zaolino C, Menon A, Randelli F, Cabitza P. Advantages of arthroscopic rotator cuff repair with a transosseous suture technique: a prospective randomized controlled trial. *Am J Sports Med.* 2017;45(9):2000-2009.
 39. Ranebo MC, Bjornsson Hallgren HC, Norlin R, Adolfsson LE. Clinical and structural outcome 22 years after acromioplasty without tendon repair in patients with subacromial pain and cuff tears. *J Shoulder Elbow Surg.* 2017;26(7):1262-1270.
 40. Safran O, Schroeder J, Bloom R, Weil Y, Milgrom C. Natural history of nonoperatively treated symptomatic rotator cuff tears in patients 60 years old or younger. *Am J Sports Med.* 2011;39(4):710-714.
 41. Song L, Miao L, Zhang P, Wang WL. Does concomitant acromioplasty facilitate arthroscopic repair of full-thickness rotator cuff tears? A meta-analysis with trial sequential analysis of randomized controlled trials. *Springerplus.* 2016;5(1):685.
 42. Weinstein MC, Skinner JA. Comparative effectiveness and health care spending: implications for reform. *N Engl J Med.* 2010;362(5):460-465.