

An Analysis of the Shoulder and Elbow Section of the Orthopaedic In-Training Examination

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Abstract

The Orthopaedic In-Training Examination (OITE) has been administered to orthopedic residents to assess knowledge and measure teaching quality.

We performed a detailed analysis of the shoulder and elbow (S&E) section of the OITE relating to question content, recommended American Academy of Orthopaedic Surgeons references, and resident performance. S&E questions from the 2005–2009 examinations were analyzed for resident performance scores, tested topics, tested imaging modalities, tested treatment modalities, taxonomy classification, and recommended references.

The S&E section made up 5.9% of the OITE. Mean resident performance on the entire OITE and on the S&E section improved during each training year. Imaging modality questions typically involved radiographs, magnetic resonance imaging, and computed tomography. These questions made up 37.5% of the S&E section. Treatment modality questions made up 45% of the S&E section and related mostly to shoulder arthroplasty and rehabilitation. Taxonomy classification showed that recall questions were most common. However, mean resident performance was minimally affected by question type. Recommended references were most commonly journal articles.

Results of this study provided unique information related to content, recommended references, and resident performance on the S&E section of the OITE. We hope that use of this information will help improve resident performance and optimize S&E curricula.

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In 1963, the American Academy of Orthopaedic Surgeons (AAOS) developed an orthopedic specialty training examination, the Orthopaedic In-Training Examination (OITE). The OITE was the first specialty training examination. Its proposed rationales were to assess resident knowledge against a national norm, determine minimal national resident standards in training programs, and measure the quality of teaching within individual programs.¹ Resident preparation and performance on the OITE have become priorities for orthopedic residency training programs in measuring individual resident knowledge and performance.²⁻⁷ Although controversial, the OITE has also been used as a benchmark for measuring orthopedic resident selection criteria and as a predictor of success in passing the American Board of Orthopaedic Surgery (ABOS) Part I Examination.⁴⁻¹⁰

As expected, the OITE has evolved dramatically over the years. It now maintains a standardized format.¹¹ Currently, 275 questions are divided into 12 sections: foot and ankle, hand, hip and knee reconstruction, medically related issues, musculoskeletal trauma, orthopedic diseases, basic science and tumors, pediatric orthopedics, rehabilitation, shoulder and elbow, spine, and sports medicine. An in-depth analysis of the OITE appears to be an important endeavor that could ultimately result in improving resident performance through focused trainee study techniques and innovative alterations in program curricula. More specifically, independent analysis of each OITE section is crucial and may ultimately allow for more focused attention to be given to a resident trainee's particular areas of knowledge deficiency. Analysis of each OITE section separately may also empower each orthopedic subspecialty to work with its respective residency training program to improve clinical rotations with the mission of providing enhanced educational opportunities relating to both knowledge-based and practical, hands-on learning.

With these goals in mind, several authors more recently have been evaluating OITE sections with respect to question content, recommended references, and resident performance. The foot and ankle, hand, sports medicine, and tumor/pathology sections have been analyzed with a focus on their content.¹²⁻¹⁵ Other researchers have conducted more general assessments of recommended

Table I. No. of Shoulder and Elbow Questions by Orthopaedic In-Training Examination (OITE) Year

Questions	OITE Year					Total
	2005	2006	2007	2008	2009	
Shoulder and elbow	18	16	15	16	15	80
Total	272	271	268	270	270	1351
%	6.6	5.9	5.6	5.9	5.6	5.9

Table II. No. of Questions in Shoulder/Elbow Topics, Tested at Least 2 Times, by OITE Year

Shoulder/Elbow Topic ^a	OITE Year					Total
	2005	2006	2007	2008	2009	
Shoulder						
Anterior instability/dislocation	1	2	5	2	1	11
Glenohumeral arthritis/arthroplasty	0	3	1	2	3	9
Posterosuperior rotator cuff injuries	4	1	0	2	0	7
Rotator cuff arthropathy/reverse TSA	1	1	1	3	1	7
Basic anatomy	2	0	0	1	1	4
Proximal humerus fracture	0	4	0	0	0	4
Internal impingement	0	0	1	0	2	3
Posterior dislocation	0	2	0	1	0	3
Suprascapular nerve entrapment	2	0	1	0	0	3
Multidirectional instability	0	1	0	0	1	2
Pectoralis major tendon injuries	0	0	2	0	0	2
Elbow						
Medial collateral ligament injuries	0	0	1	2	1	4
Thrower's elbow	0	0	0	0	2	2

Abbreviation: TSA, total shoulder arthroplasty.

^aDuring the study period, 19 shoulder/elbow topics were tested only 1 time with 14 shoulder questions and 5 elbow questions:

Shoulder: acromioclavicular joint dislocation, adhesive capsulitis, anesthesia considerations, biceps tendon injury, clavicular fracture, humeral avulsion of glenohumeral ligament, inflammatory arthritis, mesoacromiale, neuropathic arthropathy, rotator cuff calcific tendinitis, scapular dyskinesis, sternoclavicular subluxation, subacromial impingement, subscapularis injury.

Elbow: elbow arthroscopy, elbow dislocation, lateral epicondylitis, radial head fracture, triceps rupture.

references and resident performance—not always related to each specific OITE section.^{2-4,16-21}

Therefore, we analyzed the S&E section of the OITE to identify patterns in question content and recommended references and to evaluate resident performance according to training year. It is hoped that analysis of these data will help orthopedic residents, program directors, and faculty in enhancing the S&E curriculum to optimize educational opportunities.¹¹

MATERIALS AND METHODS

We evaluated the OITE over a 5-year period (2005–2009). We recorded total number of questions on the OITE for each year and the entire study period. We then specifically analyzed all the S&E questions as delineated by the AAOS over this period, excluding questions that had been discarded by OITE examiners before commencement of test scoring. The final number of questions, in the S&E section and the OITE as a whole, was recorded for each year. We then calculated the actual weight of the S&E section as a fraction of the entire OITE and compared it with the intended weight (6%) as established by the AAOS Evaluation Committee.¹¹ After composing the final list of S&E questions for each year tested, we analyzed the OITE to evaluate content parameters, recommended references, and resident performance.

Content Parameters

The content parameters of the S&E section were fully analyzed for the 5-year study period by assessing tested topics, imaging modalities, and treatment modalities, as well as question classification as described by several authors.^{12,13,15,22} Tested topics were classified by anatomical location (shoulder, elbow) and diagnosis. Questions that involved an illustration of an imaging modality were then recorded; these modalities were radiograph, radiographic arthrogram, magnetic resonance imaging (MRI), computed tomography (CT), clinical photograph, intraoperative photograph, arthroscopic photograph, and MRI and arthroscopic photograph. Treatment modalities were also tested in a portion of the S&E section and were categorized by type of procedure. Last, questions were subdivided according to taxonomic classification by 2 separate examiners, as previously described for the OITE: recall questions (taxonomy 1), diagnosis questions (taxonomy 2), and evaluation and decision-making questions (taxonomy 3).^{12,13,15,22}

Recommended References

To evaluate the recommended references, we reviewed the cited readings supplied by the AAOS Evaluation Committee within the OITE answer key for each S&E question during the 5-year study period. The readings were classified by type of reference, including book,

Table III. No. of Imaging Modality Questions by OITE Year

Imaging Modality	OITE Year					Total
	2005	2006	2007	2008	2009	
Radiograph	3	7	2	4	0	16
Radiographic arthrogram	1	0	0	0	0	1
Magnetic resonance imaging (MRI)	3	1	2	2	0	8
Computed tomography	0	3	0	1	2	6
Clinical photograph	2	0	1	0	0	3
Arthroscopic photograph	1	0	0	0	0	1
Intraoperative photograph	1	0	0	0	0	1
MRI and arthroscopic photograph	1	0	0	0	0	1
Total	12	11	5	7	2	37

Table IV. No. of Treatment Modality Questions by OITE Year

Treatment Modality	OITE Year					Total
	2005	2006	2007	2008	2009	
Shoulder arthroplasty	1	5	1	4	2	13
Rehabilitation	5	1	2	0	2	10
Bristow/Latarjet procedure	0	1	1	0	1	3
Tendon transfer	0	1	0	1	0	2
Open reduction and internal fixation	0	1	0	1	0	2
Tendon repair	1	0	0	0	0	1
Tendon release	1	0	0	0	0	1
Closed reduction/immobilization	0	1	0	0	0	1
Shoulder arthrodesis	0	1	0	0	0	1
General arthroscopy	0	0	0	1	0	1
Bone excision	0	0	0	0	1	1
Total	8	11	4	7	6	36

Table V. No. of Taxonomy Classification Questions by OITE Year

Taxonomy Classification	OITE Year					Total
	2005	2006	2007	2008	2009	
1	8	3	10	9	10	40
2	5	4	4	3	1	17
3	5	9	1	4	4	23

review book, journal, and review journal, and were sub-classified by title of reference.

Resident Performance

We recorded the number of overall orthopedic surgery residents who completed the OITE for each year of the study period (2005–2009) and then subdivided this information by training year (TY): TY-1 (postgraduate year 2), TY-2 (postgraduate year 3), TY-3 (postgraduate year 4), and TY-4/5 (postgraduate years 5 and 6). Therefore, these data did not include TY-0 (postgraduate year 1), as they are not supplied by the AAOS Evaluation Committee, and this TY involves general surgery internship with variable program-specific orthopedic experiences and OITE participation rates. Cumulative (all-residents) and TY-specific resident performance data, as represented by mean OITE score, were then documented for the S&E section for each year of the study period.

Statistical Analysis

For each calendar year of the 5-year study period, cumulative national mean scores for the S&E section were

considered a primary outcome measure across all TYs, as previously described.^{23,24} Rate ratios and their respective 95% confidence intervals (CIs) were calculated to compare scores between residents beyond their first TY and the reference category (TY-1 residents). $P \leq .05$ was considered statistically significant.

Multivariate regression analysis was then conducted to determine the effect of number of taxonomy 3 questions and TY on OITE performance. The independent variable of taxonomy 1, 2, and 3 questions and TY were force-entered into the model. Number of taxonomy questions was evaluated as a continuous variable, and TY was assessed as a binary variable with the reference group being TY-4/5. Given the explanatory nature of the analyses, all variables were included and retained in the final model. However, $P \leq .05$ were considered statistically significant and determined to be significant predictors of mean OITE score. For all regression models, standardized and unstandardized β coefficients and their 95% CIs were evaluated. Statistical analyses were performed with SPSS version 14.0 (SPSS, Chicago, Illinois).

Table VI. No. of Recommended References by OITE Year

Reference	OITE Year					Total
	2005	2006	2007	2008	2009	
<i>Journal of Bone and Joint Surgery—American Volume</i> (J)	6	9	4	7	10	36
<i>Journal of Shoulder and Elbow Surgery</i> (J)	9	9	2	4	1	25
<i>American Journal of Sports Medicine</i> (J)	4	2	8	1	3	18
<i>Journal of the American Academy of Orthopaedic Surgeons</i> (RJ)	2	1	3	3	3	12
<i>Arthroscopy: Journal of Arthroscopic and Related Surgery</i> (J)	4	3	4	1	0	12
<i>Journal of Bone and Joint Surgery—British Volume</i> (J)	0	0	2	5	1	8
<i>Orthopedic Clinics of North America</i> (RJ)	4	2	1	0	0	7
<i>Journal of Arthroplasty</i> (J)	0	2	0	2	1	5
<i>Orthopaedic Knowledge Update Shoulder and Elbow</i> (RB)	0	2	0	1	1	4
<i>Orthopaedic Knowledge Update Sports Medicine</i> (RB)	0	0	0	0	3	3
<i>Acta Orthopaedica Scandinavica</i> (J)	0	0	1	2	0	3
<i>Clinical Orthopaedics and Related Research</i> (J)	1	0	0	0	1	2
<i>Master Technique in Orthopaedic Surgery: The Shoulder</i> (B)	2	0	0	0	0	2
<i>Instructional Course Lectures</i> (RB)	0	0	1	1	0	2
<i>American Journal of Orthopedics</i> (J)	0	0	1	1	0	2
<i>Clinics in Sports Medicine</i> (RJ)	1	0	0	1	0	2

Abbreviations: B, book; J, journal; RB, review book; RJ, review journal.

Table VII. No. of Correct Answers on Shoulder and Elbow Section by Training Year and OITE Year

Training Year	OITE Year					Mean
	2005	2006	2007	2008	2009	
1	9.94	8.72	7.8	10.14	7.11	8.74
2	11.54	10.48	9.4	11.27	7.92	10.12
3	12.77	11.46	10.3	11.94	8.54	11.00
4 & 5	13.49	12.31	10.8	12.4	8.95	11.59

RESULTS

The OITE included a total of 1351 questions over the 5-year study period. Mean (range) number of questions per year was 270.2 (268-272). The S&E section included a total of 80 questions over the same period. Mean (range) number of questions per year was 16 (15-18). Actual weight of the S&E section over the study period was steady and made up 5.9% (range, 5.6%-6.6%) of the OITE—consistent with the 6% intended weight defined by the AAOS Evaluation Committee (Table I).

Content Parameters

The content parameters of the S&E section were analyzed by assessing tested topics, imaging modalities, treatment modalities, and taxonomy classification. In the 80-question S&E section, there was a significantly increased mean percentage of shoulder questions (86.3%) compared with elbow questions (13.7%) for each year of the OITE over the 5-year study period. The most common tested diagnoses are listed in Table II. When specific diagnoses were combined to reflect more general topics, 54.2% of all S&E questions over the study period were generated from questions related to 3 topics, including shoulder instability (21.4%), shoulder arthritis/arthroplasty (21.4%), and rotator cuff pathology (11.4%).

Imaging and treatment modalities were also often tested on the S&E section. Imaging modalities were tested on 37 of 80 S&E questions over the 5-year

study period. Eight combinations of imaging studies were assessed, with only 3 imaging modalities tested at least once per year over the study period, including 16 radiograph, 8 MRI, and 6 CT questions (Table III). Treatment modalities tested also varied significantly over the study period—from 26.7% to 68.8% (mean, 45.0%) of the S&E questions each year. With regard to the questions that tested a treatment modality, only 2 types of treatment appeared at least once per year over the study period; there were 13 shoulder arthroplasty questions (8 on total shoulder arthroplasty/hemiarthroplasty, 5 on reverse total shoulder arthroplasty) and 10 rehabilitation questions (7 preoperative/nonoperative, 3 postoperative) (Table IV).

Taxonomy classification was assessed for the S&E section over the 5-year study period. Of the 80 S&E questions, taxonomy 1 recall questions were most often tested, followed by taxonomy 3 evaluation and decision-making questions and taxonomy 2 diagnosis questions (Table V). Number and type of taxonomy question varied widely during each year of the same period. After the effect of TY on S&E section was adjusted for, type of taxonomy question, though statistically significant, had a minor effect on overall performance ($P < .05$).

Recommended References

Over the 5-year study period, approximately 2 recommended references (161 references) per each S&E question (80

questions; mean, 21.2 questions/year) were cited. The recommended references were most often derived from journal articles (74.5%), followed by review journals (15.5%), review books (6.2%), and books (3.7%) (Table VI).

Resident Performance

During the 5-year study period, the OITE was administered 17,316 times, or to a mean of 3463 orthopedic surgery residents per year (range, 3261-3707). Mean resident performance on the entire OITE improved with each TY; scores based on the mean number of questions per year (270.2) were 143.7 (53.2%) for TY-1, 163.1 (60.3%) for TY-2, 174.3 (64.5%) for TY-3, and 182.5 (67.6%) for TY-4/5. With each successive TY, mean resident performance on the entire OITE improved. However, rate of improvement between successive TYs declined over the course of residency. In the evaluation of each year of OITE administration, resident OITE performance (mean, 61.2%; range, 57.6%-63.0%) was fairly consistent between successive years.

Overall mean resident performance on the S&E section improved over each TY; scores based on the mean number of questions per year (16) were 8.7 (54.6%) for TY-1, 10.2 (63.3%) for TY-2, 11.0 (68.8%) for TY-3, and 11.6 (72.4%) for TY-4/5 (Table VII). There was a statistically significant ($P<.001$) increase in scores over the entire orthopedic residency during the 5-year study period. Resident performance on the S&E section over each year (mean, 64.8%; range, 54.2%-71.5%) was not as consistent as performance on the entire OITE.

DISCUSSION

We performed a detailed analysis of the S&E section of the OITE relating to question content, recommended AAOS references, and resident performance. We hope that results of this study will provide orthopedic trainees, orthopedic residency programs, and the AAOS Evaluation Committee with important information that can be used to improve orthopedic residency education. Overall, TY was the most important predictor of resident performance on the S&E section, as type of taxonomy question had a minor effect on overall performance. Mean resident performance on the entire OITE, and on the S&E section, improved during each TY. However, the rate of improvement decreased with each successive TY. Resident performance also appeared to improve at a higher rate with each successive TY in comparison with performance on the entire OITE. These findings indicate there is an opportunity to improve education within S&E topics and, ultimately, mean resident performance each year.

In terms of OITE topic content, shoulder questions made up the overwhelming majority (86.3%) of tested topics in relation to number of elbow questions. Therefore, orthopedic trainees should expect to focus most of their preparation time on shoulder questions. Forty-five percent of the 11 elbow questions asked over the 5-year study period were assessed within the

most recent (2009) OITE. Therefore, OITE examiners may have realized the trend toward testing shoulder pathology, so trainees may see more elbow questions in the future. Interestingly, elbow questions were also not assessed often in the sports medicine section of the OITE in 2 recent studies, which may accentuate the need for OITE test designers from the AAOS Evaluation Committee to dedicate more questions to elbow pathology on future examinations.^{15,25}

An analysis of the general topics and recommended references also revealed several trends. More than half (54.2%) of S&E questions related to 3 general topics: shoulder instability, shoulder arthritis/arthroplasty, and rotator cuff pathology, which should provide additional areas of focus for trainees. In terms of recommended references, the overwhelming majority of S&E questions were cited from journals, and the 3 most common journals, *Journal of Bone and Joint Surgery—American Volume* (JBJS-Am), *Journal of Shoulder and Elbow Surgery*, and *American Journal of Sports Medicine* represented about 50% of the references. Orthopedic trainees seeking to improve their S&E performance scores should consider reviewing the literature relating to these journals.

Review of previous studies of recommended references for the OITE, including its hand, sports medicine, hip and knee, and trauma sections, showed that JBJS-Am was one of the top 3 journals referenced for each section.^{14,15,19,23-25} Similarly, Marker and colleagues¹⁹ found that JBJS-Am was the journal OITE recommended the most, which corresponded to a high rating by both residents and practicing surgeons. Therefore, JBJS-Am remains an excellent resource for overall orthopedic trainee education in improving knowledge as well as preparing for the OITE. Its high status supports the decision by many orthopedic programs to use the journal for journal clubs.

Imaging and treatment modalities also are often tested on the OITE. As the imaging modalities that are tested most often involve radiographs and MRI, orthopedic residents should familiarize themselves with them, particularly as they relate to the shoulder. This finding corresponds to that from other studies of imaging modalities on the OITE—that radiographs are consistently tested on most OITE sections.^{13,15,23-25} MRI is also consistently tested on OITE sections having shoulder questions.^{15,25} In addition, treatment modalities appeared on almost half the questions, with shoulder arthroplasty and rehabilitation topics being most commonly tested. Therefore, orthopedic trainees should thoroughly review these topics. As many orthopedic residency programs do not spend a significant amount of time on rehabilitation, orthopedic residency programs should design curricula to focus on this topic during the course of rotations focusing on the shoulder and elbow.

Type of questions assessed during OITE in relation to taxonomy classification may also provide useful

information for guiding trainees in their studies. Recall questions continue to be a focus on the OITE, which corresponds to findings from earlier studies evaluating other OITE sections.^{13,15,23-25} However, mean resident performance was minimally affected by type of taxonomy question on the S&E section. Given the importance of preparing orthopedic trainees during residency for the ABOS Part I and Part II examinations, studies that address the taxonomy classification of questions from these examinations should provide OITE test designers with further information that can be used to develop appropriate OITE questions.

The present study had several limitations. First, although many OITE sections (eg, sports medicine, trauma) include questions regarding shoulder and elbow topics, we reviewed only those appearing in the S&E section. Second, the 5-year study period (2005–2009) was relatively short. This review, however, was recent and represents the typical period over which an individual orthopedic resident completes the OITE during residency. Third, there may be some bias to our independent categorization of data, including taxonomy classification. However, Buckwalter and colleagues²² found 85% agreement between test designers and residents of varying levels of training when classifying a particular question related to taxonomy. The AAOS Evaluation Committee also does not provide this breakdown of information for the OITE questions, and we used separate examiners in accordance with previous studies.

Since the 1963 inception of the OITE, this instrument has become an increasingly important component in evaluating orthopedic residency education. The OITE provides orthopedic trainees and programs with a unique opportunity to identify gaps in education within the individual resident or educational curriculum, respectively. Resident preparation and performance on the OITE have become priorities for orthopedic residency training programs in measuring individual resident knowledge and performance, and several studies have illustrated that the OITE may be useful in predicting passage of the ABOS Part I and Part II examinations.^{8,9} A recent publication based on an orthopedic educators' forum and outlining proposals for change in orthopedic education concluded that passing the ABOS Part I and Part II examinations should be an "absolute minimum outcome of a residency" and promoted debriefing residents who scored in the top 10% of the OITE as an important benchmarking tool for orthopedic residency programs.²⁶ We hope that our findings will provide orthopedic trainees, orthopedic residency programs, and the AAOS Evaluation Committee with valuable information that will help improve resident knowledge and performance, as well as resident preparation for the ABOS examinations and for the lifelong career of an orthopedic surgeon.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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