

8-1-2022

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The number of shoulder and elbow questions on the orthopedic in-training examination is increasing with greater emphasis on critical thinking over recall



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ARTICLE INFO

Keywords:

Orthopedic in-training examination (OITE)
Shoulder and elbow
Residency education
Exam preparation
Taxonomy
References

Level of evidence: Level IV

Background: It is critical for orthopedic surgery residents and residency programs to have a current understanding of the content and resources utilized by the Orthopedic In-Training Examination (OITE) to continuously guide study and educational efforts. This study presents an updated analysis of the shoulder and elbow section of the OITE.

Methods: All OITE questions, answers, and references from 2013 to 2019 were reviewed. The number of shoulder and elbow questions per year was recorded, and questions were analyzed for topic, imaging modalities, cognitive taxonomy, and references. We compared our data to the results of a previous study that analyzed shoulder and elbow OITE questions from 2002 to 2007 to examine trends and changes in this domain overtime.

Results: There were 177 shoulder and elbow questions (126 shoulder, 71.2%; 51 elbow, 28.8%) of 1863 OITE questions (9.5%) over a 7-year period. The most commonly tested topics included degenerative joint disease/stiffness/arthroplasty (31.6%), anatomy/biomechanics (16.9%), instability/athletic injury (15.3%), trauma (14.7%), and rotator cuff (13.6%). Half of all questions involved clinical management decisions (49.7%). A total of 417 references were cited from 56 different sources, the most common of which were the *Journal of Shoulder and Elbow Surgery* (23.3%), *Journal of the American Academy of Orthopaedic Surgeons* (20.4%), and *Journal of Bone and Joint Surgery (American Volume)* (16%). The average time lag from article publication to OITE reference was 7.7 years. Compared with a prior analysis from 2002 to 2007, there was a significant increase in the number of shoulder and elbow questions on the OITE (5.5% to 9.5%; $P < .001$). Recent exams incorporated more complex multistep treatment questions (4.4% vs. 49.7%; $P < .001$) and fewer recall questions (42.2% vs. 22%; $P < .001$). There was a significant increase in the use of imaging modalities (53.3% vs. 79.1%; $P < .001$). No significant differences in the distribution of question topics were found.

Conclusions: The percentage of shoulder and elbow questions on the OITE has nearly doubled over the past decade with greater emphasis on critical thinking (eg, clinical management decisions) over recall of facts. These findings should prompt educators to direct didactic efforts (eg, morning conferences and journal club) toward case-based learning to foster critical thinking and clinical reasoning skills.

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Institutional review board approval was not required for this study.

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<https://doi.org/10.1016/j.xrrt.2022.03.006>

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The Orthopedic In-Training Examination (OITE) is the most objective measure of orthopedic surgery resident knowledge and has been administered by the American Academy of Orthopaedic Surgeons (AAOS) each year since 1963.¹³ The OITE is composed of roughly 275 questions that test knowledge in 11 categories: pediatrics, trauma, hand, hip and knee, adult spine, foot and ankle,

Table I
Number of shoulder and elbow questions by year of examination.

Question type	2013	2014	2015	2016	2017	2018	2019	7-Year total (%)*	7-Year average
Shoulder questions	13	15	16	16	16	22	28	126 (71.2)	18.0
Elbow questions	7	11	6	4	5	8	10	51 (28.8)	7.3
Total no. of OITE questions	264	265	266	269	271	269	259	1863	25.3
Percentage of shoulder and elbow questions	7.6	9.8	8.3	7.4	7.8	11.1	14.7	9.5	

OITE, orthopedic in-training examination.

*A total of 1863 questions were present on the OITE in the 7-year period from 2013 to 2019.

Table II
Shoulder and elbow questions by taxonomy classification.

Taxonomy classification	2013	2014	2015	2016	2017	2018	2019	7-Year total (%)*	7-Year average
Level 1	2	5	8	3	1	10	10	39 (22.0)	5.6
Level 2	3	4	6	5	4	12	16	50 (28.2)	7.1
Level 3	15	17	8	12	16	8	12	88 (49.7)	12.6

*Based on a total of 177 questions related to shoulder and elbow in the 7-year period from 2013 to 2019.

Table III
Shoulder and elbow questions related to imaging.

Type of imaging	2013	2014	2015	2016	2017	2018	2019	7-Year total (%)*	7-Year average
Radiographs	10	14	7	9	13	8	16	77 (43.5)	11
Magnetic resonance images	5	6	1	4	3	2	7	28 (15.8)	4
Computerized tomography scans	2	3	2	1	2	2	1	14 (7.3)	2
Arthroscopic images	0	1	3	4	2	1	3	14 (7.9)	2
Clinical photo	0	0	3	2	1	1	1	8 (4.5)	1
Total	17	24	16	20	21	14	28	140 (79.1)	20

*Based on a total of 177 questions related to shoulder and elbow in the 7-year period from 2013 to 2019.

sports medicine, shoulder and elbow, oncology, basic science, and practice management. This exam compares a resident’s performance with others in the same year of training and is also used to evaluate the effectiveness of a residency program’s educational structure.^{9,19} Recent studies have demonstrated a strong correlation between OITE performance and success on the American Board of Orthopaedic Surgery part I written examination,^{15,28} which must be passed by senior residents to receive board certification.¹⁹

Many residents depend on assessment of previous OITE exams to direct their study,⁸ which has been shown to correlate with higher scores.¹⁵ Old exams are equipped with an answer key and provide pertinent references for further learning and to support the correct answer. Previous studies have examined various domains of the OITE for content, taxonomy, and references.^{5-7,10,16,24,26,27} However, because the OITE evolves overtime to reflect recent scientific discovery and changes in clinical practice patterns,²⁰ updated question analyses are necessary to optimize resident preparation.

The most recent evaluation of the shoulder and elbow domain analyzed questions used over one decade ago.¹⁶ Because shoulder and elbow surgery represents one of the fastest growing fields in orthopedics,¹⁷ we suspect that the OITE has adapted accordingly. The purpose of this study was to evaluate all shoulder and elbow OITE questions from 2013 to 2019 and to explore changes from previously administered exams. We hypothesized that the number of shoulder and elbow questions on the OITE has increased overtime with greater focus on critical thinking questions and topics pertaining to shoulder arthroplasty.

Methods

All shoulder and elbow OITE questions, answers, and references from 2013 to 2019 were identified and analyzed. Questions that the

AAOS deleted because of poor performance were not included in this study. For examinations between 2013 and 2016, the AAOS published publicly available OITE study guides that provided the exam questions categorized by domain. Questions listed within the shoulder and elbow category were extracted and reviewed for each of those years. The AAOS discontinued the production of formal OITE study guides after 2016. For examinations between 2017 and 2019, individual resident score reports (provided by the AAOS) were blinded and used to identify which questions were categorized under the shoulder and elbow domain. Each score report provides the total number of examination questions by domain and groups individually missed questions into their associated domains. If a question was not missed by any residents, it was reviewed on the AAOS “ResStudy” portal (learm.aaos.org) to determine its domain. This process was repeated until all questions were categorized and the total number of questions in each domain matched the values indicated on the AAOS score reports. This methodology has been used in similar studies evaluating OITE questions after 2016.^{1,6,10,20}

The following data were abstracted for each question: topic, taxonomy, type of imaging used, and reference source with publication year. Shoulder and elbow question topics were adopted from a previous study²⁶ and included trauma, anatomy/biomechanics, degenerative joint disease/stiffness/arthroplasty, instability/athletic injury, rotator cuff, and miscellaneous. A well-described taxonomy classification system was used to classify each question.³ Taxonomy 1 questions involve simple knowledge recall. Taxonomy 2 questions require the examiner to make a diagnosis, interpret imaging, or identify an intraoperative problem. Taxonomy 3 questions are often multistep and pertain to management, decision-making, or treatment. Question topic and classification were categorized by 2 independent reviewers (S.Y.S. and C.R.M.). A consensus agreement was reached with inclusion of a third party (M.E.M.) in the event of discordance.

Table IV
Shoulder and elbow questions by category.

Subcategory	2013	2014	2015	2016	2017	2018	2019	7-Year total (%)*	7-Year average
Trauma	5	6	2	2	4	3	4	26 (14.7)	3.7
Anatomy/biomechanics	1	5	4	3	5	7	5	30 (16.9)	4.3
DJD/stiffness/arthroplasty	7	9	7	6	7	6	14	56 (31.6)	8.0
Instability/athletic injury	2	1	1	4	2	9	8	27 (15.3)	3.9
Rotator cuff	2	3	4	2	2	5	6	24 (13.6)	3.4
Miscellaneous	3	2	4	3	1	0	1	14 (7.9)	2.0

DJD, degenerative joint disease.

*Based on a total of 177 questions related to shoulder and elbow in the 7-year period from 2013 to 2019.

Table V
Most common references cited among shoulder and elbow questions.

Journal	2013	2014	2015	2016	2017	2018	2019	7-Yr total (%)	7-Yr average
<i>Journal of Shoulder and Elbow Surgery</i>	9	14	10	12	12	18	22	97 (23.3)	13.9
<i>Journal of the American Academy of Orthopaedic Surgeons</i>	5	4	6	14	12	15	29	85 (20.4)	12.1
<i>Journal of Bone and Joint Surgery (Am)</i>	7	19	9	7	6	11	7	66 (15.8)	9.4
<i>American Journal of Sports Medicine</i>	3	5	3	2	3	5	6	27 (6.5)	3.9
<i>Arthroscopy</i>	3	5	1	4	2	2	3	20 (4.8)	2.9
<i>Journal of Bone and Joint Surgery (Br)</i>	2	2	10	2	3	0	0	19 (4.6)	2.7
<i>Clinical Orthopaedics and Related Research</i>	4	3	3	2	0	3	4	19 (4.6)	2.7
<i>Journal of Hand Surgery</i>	1	1	0	0	0	0	0	2 (0.5)	0.3
<i>Journal of Orthopaedic Trauma</i>	2	0	0	0	1	3	0	6 (1.4)	0.9
<i>Orthopaedics</i>	0	0	2	0	1	0	3	6 (1.4)	0.9
Other*	7	5	8	6	8	24	12	70 (16.8)	10.0
Total	43	58	52	49	48	81	86	417	59.6

*The other 70 references stem from 40 journals, 4 books, 1 website, and 1 instructional course.

Table VI
Publication lag of reference publications relative to OITE exam date.

Year	Reference year	Publication lag (Years)	N	%
2013	2007 (1983-2012)	7.7 (6.7)	43	10.3
2014	2007 (1985-2014)	8.0 (6.2)	58	13.9
2015	2008 (1983-2015)	9.7 (8.2)	52	12.5
2016	2010 (1997-2015)	7.2 (5.6)	49	11.8
2017	2012 (1997-2017)	6.9 (5.5)	48	11.5
2018	2013 (1988-2018)	7.1 (5.7)	81	19.4
2019	2013 (1991-2019)	7.5 (6.0)	86	20.6
Total	2010 (1983-2019)	7.7 (.9)	417	100

OITE, orthopedic in-training examination. Reference year reported as median (range). Publication lag reported as mean (SD).

The presence or absence of the following imaging studies was noted: standard radiographs (XR), magnetic resonance imaging, computerized tomography, arthroscopic images, and clinical photographs. Publication lag was defined as the difference between the reference publication year and the year that question appeared on the OITE. We compared our data to the results of a previous study that analyzed shoulder and elbow OITE questions from 2002 to 2007²⁶ to examine trends and changes in this domain overtime.

Pearson chi-squared analysis was used to compare categorical data, whereas student *t*-tests were used to compare continuous data. A *z*-score test for 2 population proportions were used to compare fractional data. Kappa statistics were used to evaluate interobserver reliability.¹⁴ The level of statistical significance was designated as *P* < .05.

Results

There were 177 shoulder and elbow questions (126 shoulder, 71.2%; 51 elbow, 28.8%) of 1863 OITE questions (9.5%, range 7.6% to 14.7%) from 2013 to 2019 (Table I). Cohen’s kappa coefficient was 0.90 for question topic categorization and 0.94 for question taxonomy classification. About half (49.7%) of all shoulder and elbow questions involved complex management decisions (taxonomy 3), 28.2% involved interpretive skills (taxonomy 2), and 22% involved

direct recall (taxonomy 1) (Table II). The majority of shoulder and elbow questions were associated with images (79.1%), the most common of which were XRs (43.5%) (Table III). The most commonly tested topics included degenerative joint disease/stiffness/arthroplasty (31.6%) and anatomy/biomechanics (16.9%) (Table IV).

A total of 417 references were cited from 56 different sources (50 journal articles, 4 books, 1 website, and 1 instructional course), averaging 2.4 citations per shoulder and elbow question over the 7-year period (Table V). The most common sources were the *Journal of Shoulder and Elbow Surgery* (JSES) (23.3%), *Journal of the American Academy of Orthopaedic Surgeons* (JAAOS) (20.4%), and *Journal of Bone and Joint Surgery* (JBJS) American Volume (15.8%). Overall, there was an average publication lag of 7.7 ± 0.9 years (Table VI), with nearly half of all citations (46.8%) falling within 5 years and nearly three-quarters of all citations (72.9%) falling within 10 years of the question date (Table VII). Of the most commonly referenced sources, the lowest publication lag was associated with JAAOS (5.5 ± 4 years) while the highest was associated with JBJS British Volume (12.6 ± 5.6 years) (Table VIII).

We compared our data from 2013 to 2019 with those of a previously published analysis from 2002 to 2007.²⁶ Compared with prior data, the percentage of shoulder and elbow questions on the OITE significantly increased from 5.5% to 9.5% (*P* < .001). The percentage of complex multistep treatment questions increased over 11-fold (4.4% vs. 49.8%, *P* < .001), whereas the percentages of recall questions (42.2% vs. 22%, *P* < .001) and interpretive questions (53.3% vs. 28.2%, *P* < .001) nearly halved. Overall, there was a significant increase in the use of imaging modalities (53.3% vs. 79.1%; *P* < .001), with more questions utilizing XRs (25.6% vs. 43.5%; *P* = .003). No significant differences in the distribution of question topics were found.

Discussion

This study provides an updated analysis of the shoulder and elbow section of the OITE from 2013 to 2019. We found that the percentage of shoulder and elbow questions on the OITE has nearly

Table VII
Date of reference publications relative to OITE exam date.

Publication date relative to examination date	2013	2014	2015	2016	2017	2018	2019	7-Year total (%)*	7-Year average
<1 Yr prior	3	4	9	6	8	7	15	52 (12.5)	7.4
1 to 5 Yr prior	17	22	11	18	16	35	24	143 (34.3)	20.4
6 to 10 Yr prior	12	15	14	10	12	21	25	109 (26.1)	15.6
>10 Yr prior	11	17	18	15	12	18	22	113 (27.1)	16.1

OITE, orthopedic in-training examination.

*Based on a total of 417 references cited among shoulder and elbow questions in the 7 year period from 2013 to 2019.

Table VIII
Publication lag among commonly cited references.

Reference name	Reference year	Publication lag (Years)	N	%
<i>Journal of Shoulder and Elbow Surgery</i>	2012 (1996-2018)	6.2 (5.1)	97	23.3
<i>Journal of the American Academy of Orthopaedic Surgeons</i>	2012 (1998-2019)	5.5 (4.0)	85	20.4
<i>Journal of Bone and Joint Surgery (Am)</i>	2006 (1985-2017)	9.8 (6.4)	66	15.8
<i>American Journal of Sports Medicine</i>	2010 (1983-2017)	10.1 (8.3)	27	6.5
<i>Arthroscopy</i>	2008 (1997-2018)	8.6 (5.6)	20	4.8
<i>Journal of Bone and Joint Surgery (Br)</i>	2000 (1991-2012)	12.6 (5.6)	19	4.6
<i>Clinical Orthopaedics and Related Research</i>	2011 (1988-2015)	11.7 (9.6)	19	4.6
<i>Journal of Hand Surgery</i>	2008	5.0 (4.2)	2	0.5
<i>Journal of Orthopaedic Trauma</i>	2010 (2006-2016)	5.7 (3.3)	6	1.4
<i>Orthopaedics</i>	2012 (1993-2016)	8.5 (9.4)	6	1.4
Other*			70	16.8
Total	2010 (1983-2019)	8.4 (2.7)	417	100

Reference year reported as median (range). Publication lag reported as mean (SD).

*The other 70 references stem from 40 journals, 4 books, 1 website, and 1 instructional course.

doubled over the past decade, with far greater emphasis on complex multistep treatment questions, the use of imaging studies, and the incorporation of recent literature. Nearly half of all question references were provided by JSES and JAAOS. The data in this study may be used to identify important trends in question topic and reference citations and thereby direct a methodological approach of study and curricula preparation for orthopedic surgery residents and programs.

Compared with data from a previous analysis of OITE exams administered between 2002 and 2007,²⁶ the percentage of shoulder and elbow questions has nearly doubled in present times (5.5% to 9.5%, $P < .001$). This rise parallels the growing popularity of shoulder and elbow surgery, which represents one of the fastest growing fields in orthopedics.¹⁷ Interestingly, no significant change in the distribution of question topics has occurred during these periods. Degenerative joint disease/stiffness/arthroplasty remain the most frequently tested shoulder and elbow topic since 2002, accounting for nearly one-third of questions on each exam. This finding is likely driven by the rising incidence of reverse shoulder arthroplasty (RSA), which has nearly tripled in the past decade.² RSA was initially approved by the US Food and Drug Administration in 2004 to treat cuff tear arthropathy. Since then, surgical indications have expanded considerably to include glenohumeral osteoarthritis,^{18,23} proximal humerus fracture,⁴ malunion and avascular necrosis of the humeral head,²¹ inflammatory arthritis,²² failed total shoulder arthroplasty and hemiarthroplasty,^{11,12} and massive rotator cuff tears.²⁵ Growth rate projection models for shoulder arthroplasty report a 235.2% increase in volume over the next decade, which far outpaces that for hip and knee replacement.²⁹ Overall, these trends indicate that the shoulder and elbow section of the OITE may continue to gain prominence in years to come. It may be beneficial for future OITE analyses to subcategorize popular question topics, such as degenerative joint disease/stiffness/arthroplasty, into procedure types (eg, RSA, total shoulder arthroplasty, and hemiarthroplasty) and indications (eg, glenohumeral arthritis with or without an intact rotator cuff) in order to refine study patterns.

While question topic has remained consistent overtime, profound changes in question taxonomy have occurred. From 2002 to 2007, the number of level 3 questions increased over 11-fold (4.4% vs. 49.7%, $P < .001$), whereas the number of level 1 (42.2% vs. 22.0%, $P < .001$) and level 2 questions (53.3% vs. 28.2%, $P < .001$) nearly halved. According to recent analyses, level 3 questions also represent the most prevalent question types within the hip and knee,²⁰ pediatrics,⁶ and hand¹⁰ domains of the OITE. These findings indicate a greater emphasis on multistep decision-making and treatment and less focus on simple recall and diagnostic interpretation. It is important to note, however, that the use of imaging modalities has increased considerably and is now associated with 79.1% of shoulder and elbow questions. Thus, even though the number of level 2 questions has decreased, the need for imaging interpretation and diagnostic skill is still ever present. However, residents are now required to determine the next best step in management of the particular diagnoses in question.

Analysis of OITE question references is important to guide resource selection for morning conferences, journal clubs, and independent resident study. We found that nearly two-third of the 417 citations referenced 1 of 3 orthopedic journals: JSES, JAAOS, and JBJS American Volume. JSES has remained the most commonly referenced academic journal for OITE shoulder and elbow questions for over 2 decades and has been referenced by more than one-quarter of questions. In addition, we found that the average publication lag for all citations was 7.7 years (range, 6.9 to 9.7 years), with nearly half (46.8%) falling within 5 years, and nearly three-quarters (72.9%) falling within 10 years of the question date. Interestingly, publication lag was lower for JSES (6.2 years [range, 0 to 20 years]) and JAAOS (5.5 years [range, 0 to 20 years]) but greater for JBJS American Volume (9.8 years [range, 0 to 29 years]). These data indicate that the OITE is attempting to incorporate recent literature on the exam.

This study has several limitations. First, because study guides for examinations administered between 2017 and 2019 were not provided by the AAOS, question categorization into the shoulder and elbow domain was achieved by using a combination of the

AAOS “ResStudy” online platform, blinded resident OITE score reports containing incorrect question numbers, and knowledge of the number of questions assigned to each domain by the AAOS for that given year. In the rare case of discrepancy between the score report question number and the examination question numbers provided by ResStudy, the authors' judgment was used to categorize questions. Second, question categorization is not mutually exclusive. As a result, shoulder and elbow questions may be categorized into other domains. Conversely, questions of other domains may be categorized into the shoulder and elbow domain. For example, a 4-part proximal humerus fracture treated with a RSA may be classified at times by the AAOS as a trauma question or as a shoulder and elbow question. Finally, our data may not accurately represent the most present-day shoulder and elbow section of the OITE since our analysis ended with the 2019 OITE exam and the orthopedic landscape is continuously changing.

Conclusion

The percentage of shoulder and elbow questions on the OITE has nearly doubled over the past decade with greater emphasis on critical thinking (eg, clinical management decisions) over recall of facts. These findings should prompt educators to direct didactic efforts (eg, morning conferences and journal club) toward case-based learning to foster critical thinking and clinical reasoning skills.

Disclaimers:

Funding: No funding was disclosed by the authors.

Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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