Gaps in exposure to essential competencies in hand surgery fellowship training: a national survey of program directors

Erika Davis Sears · Bradley P. Larson · Kevin C. Chung

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Abstract

Background Graduate medical education has moved towards competency-based training. The aim of this study was to assess hand surgery program directors' opinions of exposure gaps in core competencies rated as essential for hand surgery training.

Methods We surveyed the 74 ACGME hand surgery fellowship program directors. Respondents rated their opinion of 9 general areas of practice, 97 knowledge topics, and 172 procedures into one of three categories: essential, exposure needed, or unnecessary. Program directors also rated trainee exposure of each component at their respective program. Moderate and large exposure gaps were respectively defined as presence of at least 25 and 50 % of programs rating trainees as not having proficiency in the component at the end of training.

Results Sixty-two of 74 program directors (84 %) responded to the survey. For the 76 knowledge topics and 98 procedures rated as essential, a majority of the knowledge topics (61 %; $n=46$) and procedures (72 %; $n=71$) had at least a moderate exposure gap. In addition, 22 % ($n=17$) of the essential knowledge topics and 26 % ($n=25$) of the essential procedures had a large exposure gap.

Conclusion This study illuminates the discrepancies between what is believed to be important for practicing hand surgeons and graduates' proficiency as perceived by program directors. The field of hand surgery must work to determine if program directors have unrealistic expectations for what is essential for practicing hand surgeons or if

reforms are needed to improve exposure to essential skills in hand surgery training.

Keywords Competencies · Competency-based training · Hand surgery fellowship · Hand surgery training · Medical knowledge · Patient care

Competency-based training has become a reality for all specialties participating in graduate medical education, including hand surgery [4, 13, 16]. The teaching and objective assessment of six competency domains is now required for all accredited programs [1, 8, 15]. For competency-based training to truly become a reality, it is integral for training programs to identify specialty-specific core competencies, especially as it relates to patient care and medical knowledge. Defining specialty-specific core competencies helps to ensure that graduates clearly know what is expected of them and helps programs to direct exposure toward essential skills and knowledge. After competencies are defined, a global evaluation must be performed to determine whether trainees have adequate exposure to reach proficiency upon completion of training. The process of defining core competencies and evaluating exposure within the current training environment is critical to all specialties.

We previously conducted a survey to assess hand surgery program directors' opinions of essential procedures and knowledge topics in hand surgery training [9]. However, there is little understanding whether there are gaps in exposure to essential knowledge topics and procedures among hand surgery fellowship programs. Several surgical specialties have attempted to define specific procedural or knowledge competencies in which trainees are expected to attain proficiency [5, 7, 11, 17–19]. However, only general surgery has published data addressing whether a gap exists between expectation and actual experience on a national level [6]. For hand surgery in particular, there has been little

E. D. Sears · B. P. Larson · K. C. Chung (✉)
Section of Plastic Surgery, Department of Surgery, University of Michigan Health System, 1500 E. Medical Center Drive, 2130 Taubman Center, SPC 5340, Ann Arbor, MI 48109-5340, USA
e-mail: kecchung@med.umich.edu

new data to provide understanding of core competencies and exposure during fellowship training.

In order to establish competency-based training in hand surgery, it is important to identify whether trainees realistically have the opportunity to achieve proficiency in procedures and knowledge thought to be essential. The purpose of this study was to determine whether there is adequate exposure in core competencies of knowledge and procedures that were rated as essential by a majority of hand surgery fellowship program directors. We hypothesize that not all hand surgery fellowship programs will be able to provide adequate exposure to reach proficiency in all competencies rated as essential by the majority of program directors.

Materials and Methods

The institutional review board approved this study. Completion of the survey was inferred as implied consent to participate.

Study Sample

The study sample included program directors from the 76 ACGME-accredited hand surgery fellowship training programs as of September 2011 [12]. There were 60 programs overseen by the orthopedic surgery Residency Review Committee (RRC), 15 programs overseen by the plastic surgery RRC, and 1 program overseen by the general surgery RRC. Two programs were overseen by both plastic surgery and orthopedic RRCs, thus 74 program directors were recruited for the study. Participants were invited to participate in a web-based survey via email, with two weekly reminders to non-responders. Program directors were chosen for the study sample because of their intimate involvement with hand surgery fellow training and in defining fellowship curricula.

Survey Instrument

We developed and distributed a web-based survey to assess program directors' opinions of the general areas of practice, specific knowledge, and procedural skills that are essential for graduates to master by the end of hand fellowship training. Respondents rated their opinion of the essential nature of components into one of the following three categories: (1) essential, (2) exposure needed, and (3) unnecessary (Table 1). We also asked respondents to rate the level of exposure provided for each component at their respective fellowship program. Exposure of each component was rated into one of three categories: (1) extensive, (2) some, and (3) none (Table 2). An "extensive" rating was defined as a program that provides enough exposure to reach proficiency. A "some" rating was defined as a program that provides some exposure, but not enough to reach proficiency. A

Table 1 Rating descriptions for opinions of components

Opinions of components	
Essential	Graduates must be fully knowledgeable of the topic and be able to perform the procedure by the end of training
Exposure needed	Graduates ideally should be familiar with the topic and procedure, but not necessarily proficient to manage by the end of training
Unnecessary	Graduates do not need to be familiar with the topic, nor proficient to perform the procedure by the end of training

"none" rating was defined as a program that does not provide any exposure to the component.

Survey Components

Respondents were asked to assess 9 general areas of practice, 97 knowledge topics, and 172 procedures. The general areas of practice categories included management of conditions outside of the hand for the following: wrist, distal radius/ulna, mid/proximal forearm, elbow, upper arm/shoulder, clavicle/scapula, peripheral nerve, brachial plexus conditions, and microsurgery as it relates to free tissue transfer. The detailed components included: hand, wrist, forearm, peripheral nerve, and brachial plexus conditions and procedures. The detailed components were divided into 18 thematic categories and were based on items included in the Surgery of the Hand and Upper Extremity Curriculum developed for 2-year hand and upper extremity fellowship pilot programs [2, 3].

Data Analysis

The analysis of this study focused on evaluating exposure to components of hand surgery training that were rated as essential by the majority of program directors. Components were considered essential if 50 % or more of respondents felt that graduates must have proficiency in the component by the end of training. Based on our prior analysis, 4 general areas of practice, 76 knowledge topics, and 98 procedures were rated as essential [9]. Burns was the only thematic category with no components rated as essential. Within

Table 2 Rating descriptions for program exposure

Exposure of your program	
Extensive	My program provides exposure to reach level of proficiency
Some	My program provides some exposure, but not enough to reach proficiency
None	My program does not provide exposure

these essential components, we analyzed exposure ratings to determine whether deficiencies were present based on program directors' opinions.

Frequency calculations were used to compare the distributions of exposure ratings among essential components. We determined the frequency of program directors who rated their graduates as being proficient for each essential component. Proficiency or exposure gap was defined as the percentage of program directors who rated graduates as not having proficiency in the component at the end of training. We identified instances where the exposure gap within essential competencies was greater than 25 % and greater than 50 %. For ease of presenting the results, we have defined high and moderate exposure gaps as an exposure gap of at least 50 and 25 %, respectively.

Results

Survey Response

We had 62 out of 74 program directors (84 %) who responded to the survey, including program directors from 49 orthopedic, 12 plastic, and 1 general surgery program.

Exposure in General Areas of Practice

The general areas of practice rated as essential included wrist, distal radius/ulna, mid/proximal forearm, and peripheral nerve conditions. The mid forearm/proximal forearm general area of practice had the largest exposure gap (34 %), whereas the remaining general areas of practice all had an exposure gap of less than 5 % (Table 3).

Exposure in Detailed Components

Of the 76 knowledge topics that were rated as essential, more than half (61 %; $n=46$) had at least a moderate exposure gap, and more than one-fifth (22 %; $n=17$) had a large

exposure gap. The exposure gap for each essential knowledge component is provided in the [Appendix A](#) in Supplemental materials section. The following six thematic categories represented a large majority (76 %; $n=58$) of the essential knowledge components: congenital conditions, fractures/acute dislocations/nonunions/malunions, infections/bites, instability, tendon conditions, and vascular conditions (Table 4). Among these overrepresented categories, congenital conditions and vascular conditions both had moderate exposure gaps in every essential knowledge topic ($n=9$ and $n=6$, respectively). There were large exposure gaps in more than half of the components in these two categories (60 %; $n=9$). The instability category also had moderate exposure gaps in eight of nine essential knowledge topics. There were four categories (arthritis, Dupuytren's contracture, peripheral nerve, and soft tissue defects) that did not contain any components with at least a moderate exposure gap.

Of the 98 procedures that were rated as essential, nearly three-quarters (72 %; $n=71$) had at least a moderate exposure gap, and more than a quarter (26 %; $n=25$) had a large exposure gap. The exposure gap for each essential procedure is provided in [Appendix B](#) of the Supplemental materials section. The four thematic categories of arthritis, fractures/acute dislocations/nonunions/malunions, infections/bites, and peripheral nerve represented a majority (50 %; $n=49$) of the procedures that were rated as essential (Table 5). Of the 49 essential procedures within these four categories, 63 % ($n=31$) had at least a moderate exposure gap and 21 % ($n=10$) had a large exposure gap. All categories containing an essential procedure had at least one component with a moderate exposure gap.

We found a relationship between the degree of agreement of essential rating and degree of exposure gap. Among the 22 knowledge topics with greater than 90 % agreement of an essential rating among respondents, there were no instances of components with at least a moderate exposure gap (Table 6). Among the 28 essential knowledge topics that had between 75–90 % agreement of an essential rating, three-quarters (75 %; $n=21$) had at least a moderate exposure gap. A similar relationship is demonstrated among ratings of essential procedures (Table 6).

Table 3 Gaps in Exposure* to Essential General Areas of Practice ($N=62$)

Essential general areas of practice	Essential rating (%)	Exposure gap (%)
Wrist conditions	96.8	4.8
Distal radius and ulna conditions	95.2	4.8
Mid forearm and proximal forearm conditions	61.3	33.9
Peripheral nerve conditions	98.4	1.6

*Gaps in exposure defined as percentage of respondents who rated graduates to not have proficiency in component at the end of training

Discussion

In order to realistically achieve competency-based training in hand surgery, it is not only important to define competencies, but to also determine the ability of programs to provide exposure in core competencies. Ideally, all programs should provide sufficient and uniform exposure for the components that are deemed essential to the practice of hand surgery. This study found that more than 60 % of the

Table 4 Summary of exposure gaps in essential knowledge topics by thematic categories

Thematic categories	No. essential (<i>N</i>)	Large Gap ^a , <i>N</i> (%)	Moderate Gap ^b , <i>N</i> (%)
Category 1: Amputations and Fingertip Injuries	3	1 (33)	1 (33)
Category 2: Anesthesia and Pain Management	2	1 (50)	2 (100)
Category 3: Arthritis	2	0 (0)	0 (0)
Category 4: Burns	0	-	-
Category 5: Compartment Syndrome	1	0 (0)	1 (100)
Category 6: Congenital Conditions	9	4 (44)	9 (100)
Category 7: Contracture, Spasticity, Stiffness & Weakness	1	0 (0)	1 (100)
Category 8: Dupuytren's Contracture	1	0 (0)	0 (0)
Category 9: Fractures, Acute Dislocations, Nonunions, Malunions	17	0 (0)	4 (24)
Category 10: Infections and Bites	11	1 (9)	8 (73)
Category 11: Injections and Extravasations	1	1 (100)	1 (100)
Category 12: Instability	9	3 (33)	8 (89)
Category 13: Osteonecrosis	2	1 (50)	2 (100)
Category 14: Peripheral Nerve	2	0 (0)	0 (0)
Category 15: Soft Tissue Defects	1	0 (0)	0 (0)
Category 16: Tendon Conditions	6	0 (0)	1 (17)
Category 17: Tumors	2	0 (0)	2 (100)
Category 18: Vascular Conditions	6	5 (83)	6 (100)
Total	76	17 (22.4)	46 (60.5)

^aLarge gap defined as at least 50 % respondents rated graduates to not have proficiency in component at the end of training

^bModerate gap defined as at least 25 % respondents rated graduates to not have proficiency in component at the end of training

components rated as essential had at least a moderate exposure gap, meaning that at least 25 % of program directors

felt that their graduates did not reach proficiency in the component. We also found that approximately more than

Table 5 Summary of exposure gaps in essential procedures by thematic categories

Thematic categories	No. Essential (<i>N</i>)	Large Gap ^a , <i>N</i> (%)	Moderate Gap ^b , <i>N</i> (%)
Category 1: Amputations and Fingertip Injuries	5	1 (20)	4 (80)
Category 2: Anesthesia and Pain Management	1	0 (0)	1 (100)
Category 3: Arthritis	15	4 (27)	9 (60)
Category 4: Burns	0	—	—
Category 5: Compartment Syndrome	4	1 (25)	4 (100)
Category 6: Congenital Conditions	3	0 (0)	2 (67)
Category 7: Contracture, Spasticity, Stiffness & Weakness	3	1 (33)	3 (100)
Category 8: Dupuytren's Contracture	4	2 (50)	4 (100)
Category 9: Fractures, Acute Dislocations, Nonunions, Malunions	14	4 (29)	10 (71)
Category 10: Infections and Bites	9	1 (11)	6 (67)
Category 11: Injections and Extravasations	1	1 (100)	1 (100)
Category 12: Instability	6	2 (33)	6 (100)
Category 13: Osteonecrosis	3	2 (67)	3 (100)
Category 14: Peripheral Nerve	11	1 (9)	6 (55)
Category 15: Soft Tissue Defects	6	2 (33)	3 (50)
Category 16: Tendon Conditions	6	2 (33)	4 (67)
Category 17: Tumors	3	0 (0)	2 (67)
Category 18: Vascular Conditions	4	1 (25)	3 (75)
Total	98	25 (25.5)	71 (72.4)

^aLarge gap defined as at least 50 % respondents rated graduates to not have proficiency in component at the end of training

^bModerate gap defined as at least 25 % respondents rated graduates to not have proficiency in component at the end of training

Table 6 Summary of essential knowledge topics and procedures with at least moderate exposure gaps based on agreement of essential rating

	>90 % Agreement		75–90 % Agreement		50–74 % Agreement	
	<i>N</i>	Moderate Gap, <i>N</i> (%)	<i>N</i>	Moderate Gap, <i>N</i> (%)	<i>N</i>	Moderate Gap, <i>N</i> (%)
Knowledge Topics	22	0 (0)	28	21 (75)	26	26 (100)
Procedures	23	1 (4)	32	27 (84)	42	42 (100)
Combined	45	1 (2)	60	48 (80)	68	68 (100)

Moderate exposure gap defined as at least 25 % of respondents rated graduates to not have proficiency in component at the end of training

one-fifth of the components rated as essential had a large exposure gap, meaning that at least 50 % of program directors felt their graduates did not reach proficiency in the component.

We found a relationship between the degree of agreement of the essential rating and the degree of exposure gap. Of the 45 knowledge topics and procedures with at least 90 % agreement of an essential rating, there was only one procedure with at least a moderate exposure gap. However, a greater proportion of components have at least a moderate exposure gap among components with less than 90 % agreement of essential rating. Specifically, greater than three-quarters of components having agreement of essential rating between 75 and 90 % had at least a moderate exposure gap. All components having less than 75 % agreement in essential rating had moderate exposure gaps. In other words, only the components with very high agreement of essential ratings had respondents reliably rate graduates as being proficient in the competency. Prior to our analysis, we hypothesized that respondents who rated a component as essential would nearly always rate the component with the highest exposure rating. However, our data show that this was not the case. For many components, there were higher proportions of respondents rating the component as essential compared to a lower proportion of respondents rating graduates as having proficiency.

These data highlight some of the challenges program directors face if they wish to establish a standard curricula to achieve competency-based training. Based on published experience in which exposure to essential competencies is compared to real world exposure, it should not be surprising that there is a gap between expectations of program directors and actual experience provided in training. General surgery is one of the few surgical specialties to evaluate resident case logs on a national level compared to the group of procedures rated as essential by program directors [6]. Many procedures that were rated as essential were found to have zero cases logged most commonly among residents and many other essential procedures had very low numbers of cases logged on average. It is unknown whether program directors have unrealistic expectations about essential

procedures for training, or if the current experience provided in training is insufficient.

There were several limitations to our study. There are many possible methods to measure exposure during training, including direct observation, review of case logs, review of institutional case volume, survey of program directors, and survey of recent graduates. Case logs have been used in previous studies of trainee exposure in other specialties [6, 10, 14]. However, hand surgery fellows are required to submit case logs, but do not have specific requirements for individual cases as most surgical residency programs have. Thus, hand fellows likely have more variability in logging all cases performed because there are no specific case requirements. In addition, case logs of recent hand surgery graduates were inaccessible for analysis in this study. Lastly, numbers of cases needed to achieve proficiency vary among procedures and among individuals. Consequently, we chose to rely on the feedback of program directors for evaluation of their graduates' proficiency so that proficiency was not judged by arbitrary case numbers. Rather, proficiency was based on the judgment of informed program directors who directly observe trainees. However, it is possible that the definition of proficiency may vary among respondents. In the future, it would also be insightful to assess graduates' opinions of proficiency in core competencies in order to compare graduates' opinions to program directors' opinions. This would allow better understanding of the differences between program directors' and graduates' perceptions of proficiency.

Competency-based training is the growing reality for graduate medical education. Beyond establishing competencies, program directors must evaluate whether their individual programs offer trainees the exposure needed to become proficient. This study illuminates the discrepancies between what is believed to be important for practicing hand surgeons and graduates' proficiency as perceived by program directors. The field of hand surgery must work to determine if program directors have unrealistic expectations for what is essential for practicing hand surgeons or if reforms are needed to improve exposure to essential skills in hand surgery training.

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Conflict of interest The authors declare that they have no conflict of interest.

Appendix A

Table 7 Essential knowledge topics and exposure gap by thematic category

Category 1: Amputations and Fingertip Injuries	Essential*	Exposure Gap**
Nail bed injury	90.3 %	21.0 %
Nail matrix lesions (pigmented and nonpigmented)	58.1 %	58.1 %
Traumatic amputation	96.8 %	8.1 %
Category 2: Anesthesia and Pain Management	Essential*	Exposure Gap**
Local anesthetic and pain medication pharmacology	75.8 %	27.4 %
Complex regional pain syndrome (medical and surgical management)	51.6 %	67.7 %
Category 3: Arthritis	Essential*	Exposure Gap**
Hand and wrist osteoarthritis (incl. SLAC, SNAC wrist, DRUJ arthritis)	96.8 %	4.8 %
Hand and wrist inflammatory arthritis (incl. rheumatoid arthritis)	90.3 %	22.6 %
Category 4: Burns	Essential*	Exposure Gap**
None	n/a	n/a
Category 5: Compartment Syndrome	Essential*	Exposure Gap**
Acute compartment syndrome of the hand and forearm	82.3 %	43.6 %
Category 6: Congenital Conditions	Essential*	Exposure Gap**
Classification of congenital conditions	72.6 %	38.7 %
Syndactyly and symbrachydactyly	74.2 %	43.6 %
Trigger thumb	82.3 %	30.7 %
Clinodactyly and camptodactyly	67.7 %	50.0 %
Thumb hypoplasia	61.3 %	53.2 %
Radial and ulnar club hand	50.0 %	59.7 %
Polydactyly and supernumerary digit	67.7 %	43.6 %
Madelung deformity	50.0 %	67.7 %
Physeal arrest	50.0 %	71.0 %
Category 7: Contractures, Spasticity, Stiffness & Weakness	Essential*	Exposure Gap**
Post-traumatic injury of the hand and forearm (evaluation)	71.0 %	33.9 %
Category 8: Dupuytren's contracture	Essential*	Exposure Gap**
Dupuytren's contracture / Dupuytren's diathesis	95.2 %	3.2 %
Category 9: Fractures, Acute Dislocations, Nonunions, Malunions	Essential*	Exposure Gap**
Principles of bone healing and bone grafts (incl. autografts, allografts, bone substitutes)	90.3 %	6.5 %
AO principles of fracture fixation	91.9 %	3.2 %
Principles of pediatric fractures (incl. Salter classification, torus/greenstick fracture, both-bone forearm fracture, Seymour fracture)	87.1 %	19.4 %
Phalangeal fractures and dislocations (incl. open and closed, intra/extra-articular, condylar, mallet fracture)	100.0 %	0.0 %
Phalangeal nonunion and malunion (incl. boutonniere deformity, collateral avulsions)	95.2 %	14.5 %
Metacarpal fractures and dislocations (incl. open and closed, intra/extra-articular)	100.0 %	1.6 %
Metacarpal nonunion and malunion	88.7 %	24.2 %

Table 7 (continued)

Scaphoid and carpal bone fractures (incl. displaced and nondisplaced)	100.0 %	4.8 %
Intercarpal ligament injury and dislocation (incl. perilunate dislocation / scaphocapitate syndrome)	95.2 %	12.9 %
Scaphoid and carpal bone nonunion (incl. associated chronic SL ligament tear, SLAC)	93.6 %	6.5 %
Distal radius fracture (incl. intra and extra-articular)	95.2 %	3.2 %
Distal radius nonunion and malunion (incl. associated distal ulna instability, intra / extra-articular)	90.3 %	17.7 %
DRUJ dislocation (incl. acute / chronic and volar / dorsal)	87.1 %	35.5 %
Distal ulna fracture (incl. styloid, head, neck, complex)	87.1 %	24.2 %
Distal ulna nonunion	71.0 %	50.0 %
Forearm fracture (incl. radius/Galeazzi, ulna/Monteggia, both bone fracture)	72.6 %	40.3 %
Forearm fracture nonunion and malunion	64.5 %	50.0 %
Category 10: Infections and Bites	Essential*	Exposure Gap**
Human bites	82.3 %	25.8 %
Dog, cat, and other animal bites	82.3 %	24.2 %
Cellulitis and abscesses	90.3 %	17.7 %
Osteomyelitis	82.3 %	33.9 %
Necrotizing fasciitis and gas gangrene	66.1 %	58.1 %
Acute and chronic paronychia	85.5 %	22.6 %
Pyogenic granuloma	83.9 %	32.3 %
Septic arthritis (incl. wrist, MCP, and IP joints)	87.1 %	37.1 %
Flexor tenosynovitis (incl. septic, mycobacterial, and chronic)	85.5 %	27.4 %
Deep space infections	82.3 %	37.1 %
Bursal infections	77.4 %	41.9 %
Category 11: Injections and Extravasations	Essential*	Exposure Gap**
Injection injuries (incl. oil-based, paint-based, water, air)	56.5 %	72.6 %
Category 12: Instability	Essential*	Exposure Gap**
Biology and biomechanics of muscle, tendon, and ligaments	77.4 %	37.1 %
IP and MCP joint collateral ligament laxity (incl. collateral ligament tears, gamekeeper thumb, thumb dorsoradiocapsular strain)	85.5 %	19.4 %
Locked MCP joint	67.7 %	62.9 %
MCP volar plate avulsion	69.4 %	46.8 %
Carpometacarpal joint instability (incl. thumb, ring, and small finger)	80.7 %	43.5 %
Ulnar translocation of the carpus	64.5 %	66.1 %
Carpal and midcarpal instability (incl. perilunate dislocation/fracture-dislocation, SL/LT ligament injury)	82.3 %	32.3 %
DRUJ instability	83.9 %	35.5 %
Essex-Lopresti injury	61.3 %	67.7 %
Category 13: Osteonecrosis	Essential*	Exposure Gap**
Lunate AVN / Kienbock's disease	80.7 %	45.2 %
Scaphoid AVN / Preiser's disease	59.7 %	72.6 %
Category 14: Peripheral Nerve	Essential*	Exposure Gap**
Nerve pathophysiology (incl. normal, abnormal, principles of nerve compression, laceration, repair, grafting, and transfer)	87.1 %	11.3 %
Forearm and hand nerve compression syndromes (incl. CTS, pronator, cubital tunnel, Guyon canal, Radial tunnel, Wartenberg's, PIN)	96.8 %	4.8 %
Category 15: Soft Tissue Defects	Essential*	Exposure Gap**
Wound healing	91.9 %	14.5 %
Category 16: Tendon Conditions	Essential*	Exposure Gap**
Biomechanics of tendon repair and connective tissue healing	83.9 %	24.2 %
Principles of rehabilitation (incl. biology, methods, and splinting)	85.5 %	25.8 %
Forearm and hand tendon trauma (incl. flexor and extensor tendons)	96.8 %	9.7 %
Swan neck and boutonniere deformities (incl. traumatic, atraumatic, fixed, flexible)	93.6 %	21.0 %
Hand and forearm flexor tendon inflammatory tenosynovitis (incl. FCR, FCU, trigger finger, carpal tunnel syndrome, flexor tendon)	93.6 %	8.1 %

Table 7 (continued)

Hand and forearm extensor tendon inflammatory tenosynovitis (incl. DeQuervain's, EPL, EDC, EDQ, ECU)	95.2 %	4.8 %
Category 17: Tumors	Essential*	Exposure Gap**
Skin and nail tumors	75.8 %	41.9 %
Soft tissue and bone tumors	79.0 %	41.9 %
Category 18: Vascular Conditions	Essential*	Exposure Gap**
Acute occlusive disease (incl. thrombus and embolus)	64.5 %	62.9 %
Chronic occlusive disease (incl. atherosclerosis, Buerger's, scleroderma, dermatomyositis)	62.9 %	62.9 %
Vascular trauma (incl. small and large vessel)	79.0 %	37.1 %
Vascular aneurysm (incl. small and large vessel)	58.1 %	72.6 %
Vascular malformations (incl. AVM, venous malformation, hemangioma, lymphatic malformation)	51.6 %	74.2 %
Vasospasm and Raynauds	62.9 %	58.1 %

*Proportion of respondents rating component as essential ($n=62$)

**Proportion of respondents rating graduates' as not having proficiency in component based on exposure at respective program ($n=62$)

Appendix B

Table 8 Essential procedures and exposure gap by thematic category

Category 1: Amputations and Fingertip Injuries	Essential*	Exposure Gap**
Nail bed excision, repair, and biopsy	87.1 %	27.4 %
Ray amputation	72.6 %	50.0 %
Thumb and digit amputation and revision amputation	85.5 %	24.2 %
Thumb reconstruction with local and regional flaps	64.5 %	54.8 %
Thumb and digit replantation	58.1 %	48.4 %
Category 2: Anesthesia and Pain Management	Essential*	Exposure Gap**
Nerve blocks of forearm and hand (LABCN, radial, median, ulnar, Bier, wrist, digital)	72.6 %	25.8 %
Category 3: Arthritis	Essential*	Exposure Gap**
Corticosteroid injection of the hand (incl. fingers, CMC, wrist)	98.4 %	4.8 %
Excision of mucous cyst and inflammatory nodules / lesions (incl. tophus, rheumatoid nodule)	95.2 %	6.5 %
Tenosynovectomy and synovectomy (incl. finger and wrist joints)	95.2 %	16.1 %
Thumb CMC arthrodesis	61.3 %	53.2 %
Finger arthrodesis (incl. MCP and IP joints)	93.6 %	19.4 %
Limited intercarpal arthrodesis (incl. radiocarpal, four-corner fusion, STT, midcarpal)	87.1 %	27.4 %
Complete wrist arthrodesis	91.9 %	25.8 %
Radioulnar arthrodesis / Sauve-Kapandji procedure	50.0 %	72.6 %
MCP and PIP joint implant arthroplasty	80.7 %	38.7 %
Thumb CMC arthroplasty (incl. trapeziectomy +/- LRTI)	95.2 %	3.2 %
Proximal row carpectomy	79.0 %	22.6 %
Radial styloidectomy	56.5 %	64.5 %
Darrach procedure	67.7 %	56.5 %
Ulnar shortening osteotomy	75.8 %	40.3 %
Intra and extra-articular distal radius osteotomy	74.2 %	40.3 %
Category 4: Burns	Essential*	Exposure Gap**
None	n/a	n/a
Category 5: Compartment Syndrome	Essential*	Exposure Gap**
Compartment pressure measurement	74.2 %	50.0 %
Hand fasciotomies and carpal tunnel release	82.3 %	43.6 %
Forearm fasciotomies (volar and dorsal)	80.7 %	51.6 %
External neurolysis of median and ulnar nerves	77.4 %	37.1 %
Category 6: Congenital Conditions	Essential*	Exposure Gap**

Table 8 (continued)

Trigger thumb release	83.9 %	22.6 %
Excision supernumerary digit	71.0 %	29.0 %
Syndactyly release (incl. simple and complex)	67.7 %	37.1 %
Category 7: Contractures, Spasticity, Stiffness & Weakness	Essential*	Exposure Gap**
Post-traumatic tenolysis	69.4 %	30.7 %
MCP / IP and CMC post-traumatic capsulectomy and joint release	72.6 %	30.7 %
Tendon transfers (for CP, stroke, TBI, SCI, myopathy, etc.)	56.5 %	56.5 %
Category 8: Dupuytren's Contracture	Essential*	Exposure Gap**
Finger and palm fasciotomy	72.6 %	30.7 %
Finger and palm fasciectomy and dermofasciectomy	72.6 %	38.7 %
Revision excision of Dupuytren's contracture	62.9 %	54.8 %
PIP joint release	67.7 %	51.6 %
Category 9: Fractures, Acute Dislocations, Nonunions, Malunions	Essential*	Exposure Gap**
CRPP phalangeal / metacarpal fractures and dislocations (incl. central slip avulsion fractures, pilon fractures)	91.9 %	11.3 %
ORIF phalangeal / metacarpal fractures and dislocations (incl. FDP avulsion fractures, central slip avulsion fractures, pilon fractures)	95.2 %	9.7 %
External fixation phalangeal / metacarpal fractures and dislocations (incl. pilon fractures)	64.5 %	41.9 %
Thumb CMC anterior oblique ligament repair and reconstruction	53.2 %	58.1 %
CRPP scaphoid / carpal fracture and intercarpal ligament tear	82.3 %	32.3 %
ORIF and open reduction and pinning scaphoid / carpal fracture and intercarpal ligament tear (incl. scaphocapitate syndrome treatment)	91.9 %	14.5 %
Excision scaphoid / carpal fracture (incl. hook of hamate, pisiform, distal scaphoid pole)	80.7 %	35.5 %
Scaphoid fracture ORIF with vascularized graft	62.9 %	51.6 %
Open reduction of complete perilunate dislocation	80.7 %	37.1 %
CRPP distal radius and ulna fracture (incl. intra/extra-articular)	77.4 %	33.9 %
External fixation distal radius and ulna fracture (incl. intra/extra-articular)	66.1 %	53.2 %
ORIF distal radius and ulna fracture (incl. intra/extra-articular, volar, dorsal, combined approaches)	95.2 %	11.3 %
Open reduction DRUJ dislocation (incl. volar and dorsal)	67.7 %	59.7 %
ORIF forearm fracture (incl. Galeazzi, Monteggia)	66.1 %	50.0 %
Category 10: Infections and Bites	Essential*	Exposure Gap**
Drainage of a felon	91.9 %	24.2 %
Drainage of an acute paronychia	90.3 %	22.6 %
Irrigation of tendon sheath for acute septic flexor tenosynovitis	87.1 %	22.6 %
Incision and drainage of bursal infection	79.0 %	41.9 %
Incision and drainage of a deep space infection	82.3 %	37.1 %
MCP, PIP, and DIP arthrotomy for septic arthritis	80.7 %	38.7 %
Wrist arthroscopic irrigation and debridement for septic arthritis	58.1 %	56.5 %
Debridement of osteomyelitis (incl. curettage, sequestrectomy, saucerization, and diaphysectomy)	71.0 %	46.8 %
Excision of retained foreign bodies	80.7 %	30.7 %
Category 11: Injections and Extravasations	Essential*	Exposure Gap**
Irrigation and debridement of injection injuries	53.2 %	71.0 %
Category 12: Instability	Essential*	Exposure Gap**
Closed and open reduction of CMC joint dislocation	61.3 %	46.8 %
Thumb CMC volar ligament reconstruction	59.7 %	59.7 %
Intercarpal ligament repair and reconstruction (incl. LT, SL)	80.7 %	38.7 %
Intercarpal arthrodesis (incl. LT, CHLT, STT, SC)	74.2 %	41.9 %
Dorsal capsulodesis	58.1 %	54.8 %
Diagnostic wrist arthroscopy (incl. radiocarpal, midcarpal) and TFCC debridement and repair	82.3 %	29.0 %
Category 13: Osteonecrosis	Essential*	Exposure Gap**
Scaphoid excision and four-corner fusion	82.3 %	35.5 %
Vascularized graft (for lunate, scaphoid, or capitate AVN)	50.0 %	59.7 %

Table 8 (continued)

Wrist denervation	51.6 %	64.5 %
Category 14: Peripheral Nerve	Essential*	Exposure Gap**
Primary digital nerve repair	96.8 %	6.5 %
Digital nerve repair with graft (incl. autograft, allograft, and vein graft)	93.6 %	9.7 %
Neuroma excision and transposition/burial	85.5 %	33.9 %
Open carpal tunnel release (incl. redo CTR)	96.8 %	3.2 %
Radial nerve decompression (incl. superficial sensory branch and radial tunnel release)	50.0 %	64.5 %
In-situ ulnar nerve decompression and ulnar nerve transposition (incl. subcutaneous, intramuscular, submuscular)	93.6 %	11.3 %
Primary repair of major peripheral nerve (incl. median, radial, ulnar)	96.8 %	9.7 %
Major peripheral nerve reconstruction with autograft or cable grafts (incl. median, radial, ulnar nerves)	72.6 %	38.7 %
Nerve autograft harvest (incl. sural nerve harvest, LABC, MABC, AIN)	75.8 %	33.9 %
Reconstruction of neuroma with restoration of nerve continuity (incl. autograft, allograft, and nerve tube reconstruction)	69.4 %	43.6 %
Tendon transfers for radial, median, and ulnar nerve palsy	87.1 %	35.5 %
Category 15: Soft Tissue Defects	Essential*	Exposure Gap**
Skin grafts (incl. autologous split and full thickness grafts)	96.8 %	9.7 %
Skin substitutes (incl. allografts and xenografts)	62.9 %	43.6 %
V.A.C. application and therapy	85.5 %	17.7 %
Local and regional flaps (incl. flag, kite, Moburg, Atasoy, Kutler, Brand, reverse adipofascial, cross finger, island, random, and axial pattern flaps)	90.3 %	22.6 %
Distant flaps (incl. groin, abdomen, chest)	67.7 %	61.3 %
Neurovascular island flap	53.2 %	72.6 %
Category 16: Tendon Conditions	Essential*	Exposure Gap**
Extensor/flexor tendon repair	98.4 %	11.3 %
Tendon reconstruction (silastic rod, grafting, tenolysis)	88.7 %	27.4 %
Swan neck and boutonniere release and reconstruction (incl. arthroplasty, arthrodesis)	82.3 %	43.6 %
Trigger finger and DeQuervain's release	96.8 %	4.8 %
Flexor and EDC/ECU tenosynovectomy	64.5 %	56.5 %
EPL, EDQ, and ECU transposition	50.0 %	58.1 %
Category 17: Tumors	Essential*	Exposure Gap**
Amputation	90.3 %	24.2 %
Curettage and bone grafting	82.3 %	35.5 %
Incisional and excisional biopsy	85.5 %	30.7 %
Category 18: Vascular Conditions	Essential*	Exposure Gap**
Repair small artery and vein laceration	91.9 %	21.0 %
Repair small artery aneurysm	64.5 %	61.3 %
Repair large artery and vein laceration	77.4 %	30.7 %
Vein graft artery and vein laceration (small and large size)	75.8 %	45.2 %

*Proportion of respondents rating component as essential ($n=62$)

**Proportion of respondents rating graduates' as not having proficiency in component based on exposure at respective program ($n=62$)

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