

Early Analysis of the United States Army's Telemedicine Orthopaedic Consultation Program

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Telemedicine is a recent development, designed to assist patients with limited physical access to expert subspecialty medical care. The United States Army has established a telemedicine program, consisting of e-mail consultations from deployed health care providers to subspecialty consultants. Orthopaedic surgery became a participating consultant group in July 2007. The goal of this study is to describe the Army's telemedicine orthopaedic program and to review its progress and achievements. All consults initiated from July 2007 through April 2009 were reviewed. A total of 208 consults were received by the telemedicine orthopaedic consultation program. Predominant regions of origin were Iraq, Navy Afloat, and Afghanistan. The Army accounted for the majority of consults. Prevalent musculoskeletal complaints were fracture, sprain, neuropathy, and tendon injury. Of the 74 fracture consultations, hand and wrist fractures were most common. Symptomatic treatment or casting/splinting were the most common recommended treatments for all orthopaedic consults. Of the 170 consults requesting specific treatment recommendations for patients who likely otherwise would have been evacuated for further evaluation, surgical intervention or medical evacuation was only recommended in 25% and 16% of the consultations, respectively. The novel Army telemedicine orthopaedic consultation program developed for combat-deployed service members provides expert treatment recommendations for a variety of musculoskeletal injuries. Deployed health care providers located in austere combat environments can better determine both the necessity of medical evacuation and appropriate treatments for service members with musculoskeletal injuries when aided by orthopaedic surgery consultants, thereby limiting the number of unnecessary medical evacuations. (Journal of Surgical Orthopaedic Advances 20(1):50–55, 2011)

Key words: musculoskeletal injury, orthopaedic consultation, teleconsultation, telemedicine

Telemedicine is becoming a key aspect of providing expert subspecialty medical care in remote settings. Telemedicine utilizes information and communications technology to provide medical services between patients and providers separated by distance (1). Applications of telemedicine vary from providing diagnostic and consultative support to health care providers at a distant site to

directly delivering medical care to patients at a distant location (2).

The use of telemedicine in orthopaedics has become more feasible with advancing technology. The advent of digital radiography as well as digital photography has facilitated electronic image transmission. One study on the impact of electronically transmitted radiographs showed that the use of these images changed the management of fractures acutely, in 10% of patients evaluated (3). Additionally, the use of digital photography has also been efficacious. Tangtrakulwanich et al. reported that while digitized radiographs resulted in better image transmission, digital pictures of x-rays were still found to have a sensitivity and specificity of 83% and 80%, respectively, for fracture diagnosis (4). Clinical photographs have also been useful in the evaluation of upper extremity trauma, allowing more detailed evaluations and reliable treatment plans, especially in potential replantation cases (5, 6). Analysis of teleconsultations in orthopaedic practice has found satisfactory results, with Abboud et al. finding

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Received for publication November 4, 2010; accepted for publication November 5, 2010.

For information on prices and availability of reprints call 410-494-4994 X232.
1548-825X/11/2001-0050\$22.00/0

excellent interobserver reliability for diagnosis (κ 0.86) and treatment plan (κ 0.90) based on electronic patient evaluation (7, 8).

The military first began augmenting medical support for peacekeeping units in Somalia in 1992 (9) and Macedonia in 1993 (10), utilizing a satellite-based system capable of performing video-teleconference consults. However, these early systems were plagued by cumbersome technical demands, including required equipment compatibility and specialized training. As technology improved, especially regarding asynchronous (store-and-forward) formats, transmitting teleconsult data via e-mail became more practical. The Army's initial e-mail program was developed at Walter Reed Army Medical Center, utilizing the group mail function of the Composite Health Care System (CHCS). Analysis of this system demonstrated an increased usage over time, noting that because most providers were familiar with the CHCS system, no additional training was required (11). In 2004, the current program utilizing the Army Knowledge Online (AKO) e-mail system was developed. The program initially was comprised of 11 formal group members (12). Since then, the participation of consultant groups has expanded, with orthopaedic surgery becoming a formal group member in July 2007.

The present study evaluated the utilization of the orthopaedic teleconsult group during its first 22 months of membership. All consults were retrospectively reviewed. First, an analysis was performed of the consults for patterns in originating location, branch of service, and type of injury. Second, the consultants' treatment recommendations were evaluated to determine if the program had any effect on medical evacuation for deployed military service members.

Methods

The AKO e-mail system was selected as the platform for the telemedicine program on the basis of its accessibility and existing low bandwidth technology. All deployed medical personnel currently have access to the system from all operational medical facilities. AKO provides a centralized data repository and management tool for information exchange between the Army and any Department of Defense designated affiliate. Additionally, AKO users can establish online communities, which include discussion forums, user groups, and protected websites for authorized users.

Deployed providers enter new consultations into the AKO system, which are reviewed by a program manager. Pertinent information includes a history and physical exam, as well as corresponding clinical photographs, radiographs, and laboratory results. The program manager monitors all incoming consults for compliance with

provisions of the Health Insurance Portability and Accountability Act of 1996. The consult is then directed to the appropriate subspecialty. If collaboration between multiple specialties is required, the project manager oversees the routing of consults between subspecialty groups. The program manager also ensures that the consultant response is transmitted within 24 hours, as mandated by the Office of the Surgeon General.

The orthopaedic consultants rotate on a monthly call schedule based on their assigned military treatment facility. Consultants stationed at the designated military treatment facility are the initial respondents to new consults received during that month. The consultants are able to submit their comments, which may include diagnosis, treatment recommendations, or requests for additional diagnostic studies. If further recommendations are needed from a provider at a separate military treatment facility, the consult is redistributed to other members of the consult group for additional review. Responses are transmitted to the requesting provider as well as to group members. All e-mail transmissions, including attached imaging, between requesting and consulting providers are compiled into a Microsoft Word (Microsoft, Inc., Redmond, WA) file by the program manager. These files are maintained in the event that subsequent review or further inquiry is needed. In order to comply with file size limitations, the project manager uses compression technology to keep the official records under 100 kBs.

All consults initiated to the orthopaedic group from July 2007 through April 2009 were reviewed. Data, such as location of origin, branch of service, anatomic origin of complaint, type of injury, and treatment recommendation, were extracted from each file. A descriptive analysis was performed following compilation of data into Microsoft Excel (Microsoft Inc., Redmond, WA). This study received Institutional Review Board approval from William Beaumont Army Medical Center Department of Clinical Investigation.

Results

Between July 2007 and April 2009, a total of 214 orthopaedic consults were received by the teleconsultation system. Seven of these files were follow-up questions or information pertaining to a previous consultation, although one included a new consultation for which a separate file was not created. These follow-up consults were discarded from the analysis, resulting in 208 original orthopaedic consultations.

Consultations were received from a variety of locations worldwide. The majority of the consults originated from Iraq (62%). Additional originating locations include Navy Afloat (15%), Afghanistan (10%), Honduras (4%), Egypt (3%), and other locations (5%). Since its inception, the

program has seen an increase in the number of consults received each fiscal year. The number of consults received from Iraq has remained stable, while there has been a marked increase in those from Afghanistan and Navy Afloat. The consults received each year by originating location are shown in Table 1.

The Army requested 58% of the consults entered. The Navy initiated 14% of the consults, while the Marines and Air Force constituted 7% and 8%, respectively. While the number of consults received involving Army service members has remained consistent, there has been an increase in those requested by Navy personnel. The service-specific consults by fiscal year are shown in Table 2.

The majority of the consults submitted involved the upper extremity, with the hand being the focus of 22%. The foot was the subject of 18% of inquiries submitted.

TABLE 1 Originating locations of orthopaedic consultations

Location	2007 ^{a,b}	2008 ^a	2009 ^{a,c}	Location Total
Afghanistan	0	5	15	20
Bahrain	0	0	1	1
CONUS	0	1	0	1
Djibouti	1	0	0	1
Egypt	1	0	6	7
Honduras	0	3	6	9
Kenya	1	1	0	2
Kyrgyzstan	0	3	0	3
Iraq	6	80	43	129
United Arab Emirates	0	3	0	3
Navy Afloat	1	7	24	32
Yearly totals	10	103	95	208

^aYearly totals are based on the fiscal year, which spans October through September.

^bData collection began when orthopaedic surgery became a formal consultation group in July 2007.

^cData collected through April 2009.

TABLE 2 Consultations based on branch of service

Branch of Service	2007 ^{a,b}	2008 ^a	2009 ^{a,c}	Service Totals
Air Force	0	11	6	17
Army	3	74	44	121
Marines	1	2	12	15
Navy	1	7	21	29
Contractors	0	1	1	2
Detainee	0	1	0	1
Noncombatant	2	4	1	7
Foreign Service	1	3	2	6
Not stated	2	0	8	10

^aYearly totals are based on the fiscal year, which spans October through September.

^bData collection began when orthopaedic surgery became a formal consultation group in July 2007.

^cData collected through April 2009.

The array of consults by anatomic location is shown in Table 3. The majority of the consults pertained to fracture management (36%). Complaints of pain without a specific diagnosis were also frequent reasons for consult (30%), followed by inquiries regarding sprains (10%), neuropathy (5%), and tendon injury (5%). The breakdown of musculoskeletal complaints is shown in Figure 1. A total of 74 consults pertaining to fractures were received. Of these, fractures of the hand (41%) and wrist (16%) were most common. The distribution of extremity fractures is shown in Table 3.

The majority of the consults sought specific treatment recommendations for the presenting musculoskeletal complaint. In most cases, the consultants recommended in-theater management, with symptomatic treatment (44%) and casting or splinting (21%) accounting for the majority of recommendations provided. Several consults specifically inquired whether surgical intervention or medical evacuation for further orthopaedic treatment or evaluation was warranted. Following review of the information provided, the consultants only recommended

TABLE 3 Distribution of consultations and diagnosed fractures by anatomic location

Anatomic Location	Total Consultations	Diagnosed Fractures
Upper extremity	100	50
Shoulder/clavicle	23	6
Arm/elbow	11	2
Forearm	3	0
Wrist	17	12
Hand	46	30
Lower extremity	93	22
Hip/thigh	7	0
Knee	19	4
Leg	7	3
Ankle	23	7
Foot	37	8
Spine	11	1
Other	4	1

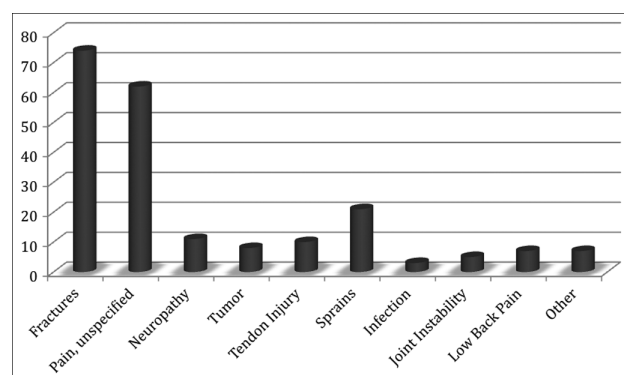


FIGURE 1 Distribution of musculoskeletal complaints.

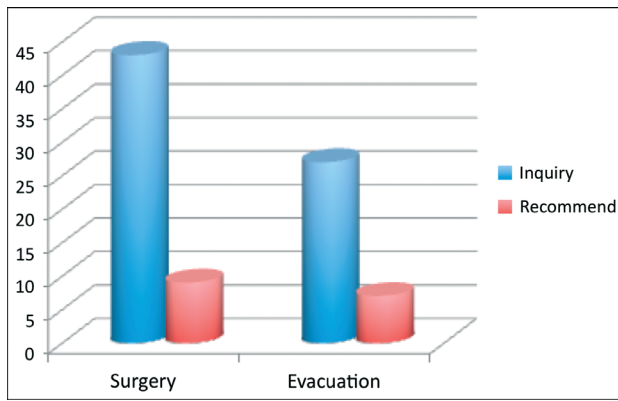


FIGURE 2 Surgery and evacuation recommendations.

surgical intervention and medical evacuation in 25% and 16% of these cases, respectively, as illustrated in Figure 2.

Discussion

In United States military personnel, musculoskeletal injuries are a leading cause of morbidity, lost training time, and reduced operational readiness (13). During combat deployments, military personnel attrition from the combat force secondary to musculoskeletal injuries is broadly categorized into either combat casualties or nonbattle injuries. Extremity combat wounds, excluding the spine and pelvis, have been reported to comprise 58% to 61% of combat injuries sustained by U.S. military personnel from World War II through the Vietnam War (14–16). An initial evaluation of casualties sustained during the Global War on Terror indicated that 70% had musculoskeletal injuries, necessitating over 40,000 orthopaedic procedures (17, 18). Two recent studies detailing combat-related injuries sustained by military service members in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) have reported that extremity wounds comprise between 49% and 54% of all combat injuries (19, 20). However, historical records of musculoskeletal nonbattle injuries have not been adequately documented.

Recently, two longitudinal cohort studies have detailed the musculoskeletal combat casualty care and musculoskeletal nonbattle injury statistics, distribution of wounds, and mechanisms of injury incurred by a U.S. Army Brigade Combat Team during “The Surge” phase of OIF. The musculoskeletal combat casualty and musculoskeletal nonbattle injury rates for the Brigade Combat Team were 34.2 and 129.5 per 1000 soldier combat-years, respectively (21, 22). Because combat casualties often have multiple injuries and are assessed immediately by the nearest forward surgical team, the majority of the orthopaedic consultations that have been entered into the

teleconsultation system primarily involve musculoskeletal nonbattle injuries.

During this study period, the majority of the consultations were initiated by providers caring for service members in Iraq. At the time, U.S. forces there were still conducting counterinsurgency as well as stability and reconstruction operations. Since the completion of this study, the presence of U.S. personnel in Iraq has significantly declined and offensive operations have been discontinued. Concurrently, U.S. troop levels in Afghanistan have increased to over 100,000 personnel. It will be interesting to observe in the future how the personnel shift to Afghanistan will affect the originating location of orthopaedic telemedicine consultations. Additionally, during this study, the Navy Afloat showed the largest increase in consultations. The expanding awareness of the orthopaedic telemedicine consultation program will also affect the originating location consultation data.

U.S. Army personnel comprised the majority of the initiated consults. The Army has supplied the greatest number of deployed personnel, especially to the current conflicts in Iraq and Afghanistan. Utilization by Army personnel remained consistent during this study period. In addition to a greater number of deployed Army personnel, it is also likely that Army providers initially had a greater familiarity with the system because of their AKO access as opposed to providers from other services. Use of the consultation systems by Navy providers out to sea increased toward the conclusion of the study period. As knowledge of this program continues to expand, increasing participation by Navy, Air Force, and Marine personnel deployed to remote locations is anticipated.

The majority of the consults entered into the AKO system were questions regarding the upper extremity. Hand consultations provided 22% of the consults, with those pertaining to foot pathology following at 18%. Overall, the distribution of consults for upper and lower extremity complaints was relatively equivalent. This is consistent with a previous finding of an equivalent distribution of injuries between the upper and lower extremities in combat (19). One distinction is that our data is derived from consultations placed by providers in a primary care capacity so the musculoskeletal complaints reviewed by the system are generally not related to a combat mission. These data stand in contrast to those of Almeida et al., who found that 82% of the musculoskeletal injuries in a population of Marine recruits occurred in the lower extremity (13).

Pain complaints and fractures were the predominant etiologies for initiated consults. Fractures consisted of 36% of the consultations. Fractures during the conflicts in Iraq and Afghanistan have been reported to account for 10% of musculoskeletal nonbattle injuries and 26% of the combat-related extremity wounds (19). Our consultation

data showed a predominance of upper extremity fractures, with hand being the most common site of fracture at 41%.

The underlying reason for the majority of the consults was treatment recommendations for orthopaedic issues. Therapeutic recommendations were also the predominant reason for utilization of the infectious diseases teleconsultative service, while an analysis of the teledermatology program demonstrated that most of their consultations were for diagnostic purposes (23, 24). Several consults inquired as to whether surgical intervention or medical evacuation was necessary, indicating that without this system in place, the involved service members likely would have been evacuated to a higher echelon of care for further evaluation. The orthopaedic consultants recommended either surgery or medical evacuation in only 25% and 16% of cases, respectively. While our data on the exact number of medical evacuations facilitated or prevented remained incomplete during our data collection, we are assuming success in the prevention of unnecessary evacuations based on the consultants' comments. However, specialties that went online at an earlier date have demonstrated success in preventing medical evacuations. An earlier analysis of the teledermatology program reported that it prevented 50 medical evacuations from Southeast Asia, while a more recent analysis recommended evacuation to the United States in only 1.4% of their consultations (12, 24).

The greatest limitation of this study is the lack of follow-up on the outcome of the service members for whom consultations were initiated. Information transmitted via AKO teleconsultation is not encrypted. In order to remain in compliance with regulations established by the Health Insurance Portability and Accountability Act, protected health information cannot be included in the requesting information. This precludes us from retrospectively reviewing the service members' electronic medical record to determine whether the recommendations provided by the consultants were utilized by the treating physician. We are basing a presumed level of early success, especially regarding the prevention of unnecessary medical evacuations, on review of the recommendations that were formulated by the consultants. However, because we do not have access to the service members' protected health information, we are unable to determine what treatment was actually rendered.

The United States military maintains a global presence, with service members often stationed in remote locations. Orthopaedic injuries are common in active duty personnel in both combat and noncombat situations. Management of musculoskeletal problems is often difficult or uncertain for providers not familiar with orthopaedic conditions. Our early analysis of the orthopaedic teleconsultation program demonstrates that nonorthopaedic providers in austere conditions can successfully manage some orthopaedic

conditions based on the recommendations provided by consultants via the AKO system.

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