



Enhanced casualty care from a Global Military Orthopaedic Teleconsultation Program[☆]



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ABSTRACT

Background: Since its advent, telemedicine has facilitated access to subspecialty medical care for the treatment of patients in remote and austere settings. The United States military introduced a formal orthopaedic teleconsultation system in 2007, but few reports have explored its scope of practice and efficacy, particularly in a deployed environment during a time of conflict.

Methods: All teleconsultations placed to the orthopaedic service between April 2009 and December 2012 were obtained and retrospectively reviewed. Case files were abstracted and anatomical location of injury, type of injury, origin of consult (country or Navy Afloat), branch of service, and treatment recommendations, were recorded for descriptive analysis. The final result of the consult was also determined, with service members transported from the combat theatre or deployment location defined as medically evacuated. Instances where teleconsultations averted a medical evacuation were also documented as a separate outcome.

Results: Over a 32-month period, 597 orthopaedic teleconsultations were placed, with the majority derived from Army (46%) and Navy (32%) personnel deployed in Afghanistan, Iraq, or with Navy Afloat. Approximately 51% of consults involved the upper extremity, including 197 hand injuries, followed by lower extremity (37%) and spine (7.8%) complaints. Fractures comprised over half of all injuries, with the hand and foot most commonly affected. The average response time for teleconsultations was 7.54 h. A total of 56 service members required immediate evacuation for further orthopaedic management, while at least 26 medical evacuations were prevented due to the teleconsultation system.

Conclusions: The teleconsultation system promotes early access to orthopaedic subspecialty care in a resource-limited, deployed military setting. The telemedicine network also appears to mitigate unnecessary aeromedical evacuations, reducing healthcare costs, lost duty time, and treatment delays. These findings have important meaning for the future of telemedicine in both the military and civilian setting.

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Introduction

With the development of medical technology in the modern era, patient care has also evolved to allow greater access to services and more expeditious diagnostic evaluation and treatment. Inspired by the data-sharing principles common to radiology imaging systems, military telemedicine's role in providing healthcare is a burgeoning resource that has expanded rapidly since its initial utilization in 1992 [1]. Formal operational telemedicine support was officially established for the United States (US) military in 2004, and all medical and surgical specialties, including orthopaedic surgery, are currently accessible through a centralized Army-sponsored consultation system.

Given the prevalence and burden of musculoskeletal conditions during military deployments, especially among non-battle injuries [2], the US Army teleconsultation system has streamlined provider access to orthopaedic resources while promoting continuity of care from remote point-of-injury to definitive management at a tertiary care facility. Furthermore, orthopaedic teleconsultations potentially mitigate unnecessary medical evacuations and a delay in either diagnosis or treatment that may otherwise contribute to preventable complications. However, despite early evaluations [3,4], research on the effectiveness of this system as it relates to orthopaedic care has been limited. The purpose of this study was to describe the nature and disposition of musculoskeletal conditions prompting orthopaedic teleconsultations in deployed military service members, while exploring the efficacy of this system in informing care and minimizing unnecessary evacuation. We hypothesized that the current telemedicine consultation programme improves timeliness of early definitive musculoskeletal care, while limiting unnecessary evacuations for manageable musculoskeletal conditions, thereby reducing military healthcare costs.

Methods

This study was approved by the William Beaumont Institutional Review Board. Under the auspices of the US Army Telemedicine and Advanced Technology Research Center and overarching US Army Medical Research and Materiel Command, the Army teleconsultation programme utilizes the Army Knowledge Online (AKO) e-mail system to transmit consults in a clinical reach-back format to obtain medical treatment recommendations. Designed for the forward battlefield position and lower echelons of medical care, the AKO e-mail platform is ubiquitous among military servicemembers and is nearly universally accessible at every deployed medical facility. The use of the orthopaedic consultation allows for a single that every provider, in any theatre of operations can use to place a consult. This eliminates the need for multiple email addresses to multiple consultants, depending on the location of origin of the consult. Further, the radiologists and surgical support at various places in theatre, like Kandahar, serve on a rotating basis and change frequently. This makes it difficult for providers at remote locations to contact them consistently.

This programme allows for improved surveillance over the system as a whole, and provides teleconsultation support in geographic areas without regional assets. Additionally, convenient access to subspecialty-trained orthopaedic surgeons is an extremely valuable service for primary care providers and general orthopaedic surgeons deployed to a resource-limited environment with minimal collaborative support. This would also be mutually applicable to those providers on a ship or in a remote location in Afghanistan or Africa.

Providers in the field employ this e-mail-based programme to convey the necessary clinical history, physical findings, and ancillary diagnostic tools, such as clinical photographs, laboratory results, and/or imaging studies. Due to a lack of encryption, Protected Health Information (PHI) and digital images with identifiable features are removed in accordance with Public Law 104-191, Health Insurance Portability and Accountability Act (HIPAA). Once the consult is placed, a centralized programme manager receives the e-mail and routes it to the appropriate consultant(s). This allows the programme manager to ensure secure, expeditious, and reliable communication between the requesting provider and designated consultant physicians. Additionally, the programme manager can coordinate with multiple subspecialties when necessary and make certain a response is delivered within the 24-hour window mandated by the Office of the Surgeon General of the Army for routine consultations.

Orthopaedic consults are routed to a list-serve comprised of active duty military orthopaedic surgeons based at one of the six Army Medical Centers (MEDCEN) in the United States. As tertiary care academic centres, these MEDCENs respond to teleconsultations on a rotating schedule with review by a subspecialty orthopaedic surgeon, typically within 24–72 h. If necessary, the consultants can request further studies and/or confer with other subspecialty-trained orthopaedic surgeons, radiologists or other physicians as needed. The consultant's response is then sent to the requesting provider, other members of the consulting group, and the programme manager. The programme manager compiles all transmitted data for future reference if needed.

Every teleconsultation for a musculoskeletal condition transmitted to the Army telemedicine programme between April 2009 and December 2012 was obtained and retrospectively reviewed. All consults regarding enemy combatants, prisoners, or civilian host nationals were excluded from this study. Individual files of included cases were abstracted and data, such as anatomical location of injury, type of injury, origin of consult (country or Navy Afloat), branch of service, and treatment recommendations, were extracted for descriptive analysis. The mechanism of injury and ultimate treatment was not reported in this study. These parameters were not routinely provided in the consultation and de-identification of patient data limited secondary chart review or clinical follow-up. Additionally, operational security concerns may preclude description of some of these injuries. The final result of the consult was recorded, with those service members transported from the combat theatre or their deployment location in order to receive treatment for their musculoskeletal injuries defined as medically evacuated (MEDEVAC). The requirement for MEDEVAC was the primary outcome of interest. Teleconsultation was determined to have prevented MEDEVAC when the initial consult indicated the physician in the deployed setting desired to evacuate the patient, but the consultant recommended against evacuation and this recommendation was accepted.

Results

During the 32-month study period, 597 consults were placed to the Orthopaedic Telemedicine service. The highest number of consults was received in 2011 ($n=233$), while the fewest consultations occurred during 2012 ($n=114$). When evaluating by time of year, August corresponded to the highest number of orthopaedic consultations, although significant variability occurred between calendar years and months without consistent trends (Table 1).

Table 1
Total orthopaedic teleconsultations by month and year.

	2009	2010	2011	2012	Average per month
January	–	8	22	22	17.3
February	–	13	17	11	13.6
March	–	14	27	7	16
April	–	7	20	7	11.3
May	10	8	26	11	13.8
June	14	8	18	6	11.5
July	8	15	22	12	14.3
August	26	7	23	7	15.8
September	13	9	16	12	12.5
October	18	11	13	8	12.5
November	13	11	10	6	10
December	21	16	19	5	15.3
Total	123	127	233	114	149.3

Table 2
Origin of orthopaedic teleconsultation by calendar year.

Origin of consult	2009 (May–December)	2010	2011	2012	Total
Afghanistan	7	28	56	18	109
Bahrain	1	1	0	2	4
Bosnia	0	5	1	2	7
CONUS	0	0	1	0	1
Djibouti	10	3	33	22	68
Egypt	3	13	31	9	56
Haiti	0	1	0	0	1
Honduras	2	3	10	8	23
Iraq	61	21	25	0	107
Kuwait	2	2	2	0	6
Kyrgyzstan	0	2	1	0	3
Pakistan	1	0	0	0	1
Qatar	0	2	1	0	3
Ukraine	0	0	1	0	1
United Arab Emirates	2	0	1	0	3
Navy Afloat	34	46	69	53	202
Canadian Navy (HMCS)	0	0	1	0	1
Year total	123	127	233	114	597

CONUS, Continental United States.

Provider location

Consults originated from 17 different locations spanning five continents (Table 2), 25 U.S. Navy vessels, and one Canadian Navy vessel. The Navy Afloat accounted for the greatest proportion of consults ($n = 202$; 34%), followed by coalition forces in Afghanistan ($n = 109$; 18%) and Iraq ($n = 107$; 18%). Most locations had 10 or fewer during the time period investigated.

Patient demographics

Of all consults, 521 patients were male and 68 were female, whereas gender was not specified in 8 cases. The average age was 29.2 years, and 93% were US servicemembers. Army or Navy servicemembers were the subjects of most consults ($n = 276$ and $n = 194$, respectively; Table 3). Marine Corps and Air Force servicemembers accounted for the fewest consultations ($n = 65$ and $n = 21$, respectively).

Injury characteristics

Consultations classified by body region and injury location are listed in Table 4. Over half of all consults stemmed from upper extremity injuries ($n = 305$; 51%), with hand injuries being most common ($n = 197$). Lower extremity injuries were also frequent ($n = 221$; 37%), particularly involving the foot ($n = 72$). Conversely, pelvis injuries were the least common ($n = 2$). When considering the primary diagnosis of the consult (Table 5), fractures comprised 50% ($n = 298$), followed by “other” injuries, non-specific musculoskeletal pain (e.g. overuse conditions), and tendon/ligament injury.

Table 3
Orthopaedic teleconsultation by branch of military service.

Branch of service	2009 (May–December)	2010	2011	2012	Service total
Army	67	58	109	42	276
Air force	6	5	5	5	21
Marines	16	21	18	10	65
Navy	31	35	78	50	194
Contractors	1	3	6	4	14
Noncombatant	2	4	11	1	18
Foreign service	0	1	5	1	7
Not specified	0	0	1	1	2
Year total	123	127	233	114	597

Table 4
Musculoskeletal Injury and Medical Evacuation by Anatomic Location.

Anatomic location	Total consultations	Diagnosed fractures	MEDEVAC	Prevented MEDEVAC
Upper extremity (total)	305	181	33	17
Shoulder/clavicle	32	4	4	3
Arm/elbow	35	7	6	0
Forearm	4	4	0	0
Wrist	37	21	4	3
Hand	197	145	19	11
Lower extremity (total)	221	97	16	6
Hip/thigh	20	4	2	1
Knee	50	6	3	0
Leg	29	13	3	1
Ankle	50	28	4	3
Foot	72	46	4	1
Pelvis	2	2	0	0
Spine/back	47	12	4	3
Other	22	6	3	0
Totals	597	298	56	26

MEDEVAC denotes medical evacuation.

* Other-includes unspecified location of injury or location not encompassed by the above categories.

Consultation disposition

There were a total of 1473 images used in the consultations, with an average of 2.47 images per consult, and a range of 0–44 images used. The average response time was 7.54 h (SD, 10.34; range, 0.05–84.72; Table 6).

Of 59 consultations requesting evacuation during the study period, 56 patients ultimately required evacuation from theatre, with peak activity in 2011 ($n = 22$). Upper extremity injuries comprised the majority of orthopaedic evacuations ($n = 33$), with hand injuries contributing the most of any anatomic region ($n = 19$; Table 4). An additional 255 consultations sought further orthopaedic treatment options, while 283 requested multiple diagnostic, therapeutic, and logistical support. Overall, the telemedicine consult system was able to prevent 26 evacuations for orthopaedic conditions. Prior work has estimated that an individual MEDEVAC costs between \$20,000 and \$113,000 [1,5]. Using the most conservative estimate of \$20,000 per MEDEVAC, the estimated

Table 5
Primary diagnosis and medical evacuations.

Primary diagnosis	2009	2010	2011	2012	Total	Total MEDEVAC	Prevented MEDEVAC
Fractures	58	51	119	70	298	32	14
Pain*	19	13	27	1	60	1	1
Neuropathy/ radiculopathy	5	8	6	4	23	5	2
Tumour	6	7	0	1	14	3	3
Tendon/ligament injury	11	13	16	11	51	7	1
Sprains/strain	10	10	8	1	29	0	1
Infection	4	4	6	0	14	1	0
Joint instability (dislocations)	3	4	2	5	14	1	0
Back pain	1	5	4	4	14	1	0
Other**	6	12	45	17	80	5	4
Totals	123	127	233	114	597	56	26

MEDEVAC denotes medical evacuation.

* Pain-includes main complaint of pain where a specific diagnosis was not encompassed by the other categories (e.g. exertional compartment syndrome, greater trochanter bursitis)

** Other-includes specific diagnosis not encompassed by other categories, and where pain was not the main complaint.

Table 6
Teleconsultation response time by calendar year.

Year	Average (h)	Range (h)	95% CI	Standard deviation
2009	6.61	0.05–56.83	5.03–8.19	8.84
2010	5.29	0.05–45.88	4.06–6.52	6.83
2011	8.21	0.06–52.2	6.84–9.58	10.54
2012	10.03	0.1–84.72	7.54–12.52	2.48
Total	7.54	0.05–84.72	6.7–8.38	10.34

95% CI denotes 95% confidence intervals.

potential cost savings associated with the evacuations that were averted through teleconsultation was \$520,000.

Discussion

While combat-related injuries have appropriately garnered substantial recognition, disease/non-battle injuries among deployed service members received scant attention prior to the Iraq and Afghanistan conflicts and were then referred to as the “hidden epidemic” within military units [6]. Two longitudinal cohort investigations of a U.S. Army Brigade Combat Team found a greater than three-fold incidence of noncombat compared to combat musculoskeletal casualties [2,7]. A remarkable 48% of all musculoskeletal casualties that were medically evacuated from the combat theatre resulted from noncombat injuries [2,7]. Moreover, numerous military servicemembers who incurred non-emergent musculoskeletal injuries were able to be treated non-operatively during their combat deployment and surgery deferred until after its completion [2,8]. The continual, unrelenting physical demands experienced by servicemembers in the combat or deployed setting is evidenced by the reported incidence rates of anterior cruciate ligament disruption and first-time shoulder dislocation that are nearly five times greater than that of the civilian population [2].

To better address the growing issue of managing these ambulatory and acute health concerns in a resource-limited environment, the US military developed the teleconsultation system to enable greater support and interaction from stateside subspecialty-trained physicians to medical personnel in theatre. After the addition of orthopaedic surgical support to the telemedicine system in 2007, a pilot study reported early success in the management of a variety of musculoskeletal conditions, largely from the Iraq theatre of operations [3].

As US military commitments have become more widespread and the teleconsultation concept has been broadly embraced by deployed medical personnel, the current study documents the efficacy of telemedicine in the globalized military network. With nearly 600 consults, the teleconsultation system reflects the presence and tempo of worldwide US military operations. Almost half of all consults originated from Army medical personnel in Southwest Asia, with a large portion stemming from providers in Iraq and Afghanistan. Similarly, peaks in activity occurred in 2011, corresponding to the influx of American forces in Afghanistan. Additionally, a substantial component of consultations derived from the Navy Afloat and military units in the developing world, reflecting the importance of coalition peacekeeping missions and disaster relief. Despite these diverse clinical settings and remote geographic locations, routine orthopaedic teleconsultations were expeditiously addressed in the current study, with an average response time of 7.54 h.

Of all orthopaedic teleconsultations, most were related to injuries of the upper extremity. This is consistent with contemporary reports regarding deployment-related trauma in Iraq, in which extremity injuries comprised the bulk of non-combat [2], as

well as combat-related [9], musculoskeletal wounds. Specifically, the hand was the most commonly involved region, accounting for approximately 33% of the consults placed and 50% of the fractures sustained. Furthermore, medical evacuations for upper extremity injuries were nearly two-fold greater than for lower extremity complaints, and hand injuries comprised 34% of all teleconsultation-directed evacuations for orthopaedic injuries. Prior reports have underscored the prevalence of traumatic, non-combat related hand injuries, accounting for between 4.4% and 17.5% [2,10,11] of all injured patients. Notably, up to 22.6% of deployment hand injuries also required evacuation due to significant soft-tissue injury, fracture, or tendon laceration [11,12]. This finding emphasizes the need for forward treating providers to be well prepared for injuries and fractures of the hand, including clinical evaluation, management, and interdisciplinary coordination with ancillary services such as occupational therapy. While not always acute emergencies, hand injuries that are missed or insufficiently treated can be a significant source of long-term disability and negatively impact occupational performance [11,12]. Due to the manual demands of military servicemembers in a operational setting, including the use of a personal weapon and operation of tactical vehicles, deployed physicians should consider more liberal use of evacuation to the next echelon of care or delay a soldier's return to their unit while an orthopaedic telemedicine consultation is obtained [10].

The epidemiological focus on spine injuries sustained during the current conflicts has steadily increased over the past decade, largely due to the rising incidence of high-energy axial load injuries resulting from a mounted blast mechanism [13–15]. When also considering non-combat etiologies, the prevalence of overuse spine injuries has also increased due to the heavy occupational demands of military service [16,17]. In the current study, spine complaints accounted for 7.9% of all consultations and 7.1% of all medical evacuations. As such, the military should continue to emphasize a heightened awareness of spine-related injuries in active duty servicemembers in both the combat and non-combat deployed environments.

Medical evacuations for deployed military personnel can be very costly, and potentially dangerous. The military teleconsultation system was able to prevent at least 26 medical evacuations based on provider recommendations. Ostensibly, these patients were effectively managed in theatre, limiting time lost to injury, the negative effects on operational readiness, and requirements for replacement personnel. Depending on injury severity, geographic location, and available transportation assets, a single MEDEVAC from theatre has been estimated to cost between \$20,000 and \$113,000 [1,5]. Relying on the lower end figure, the military orthopaedic teleconsultation system provided a potential cost savings of approximately \$520,000. However, actual costs may be significantly higher, as medical evacuation from a non-combat location incurs greater expense in the absence of a routine and well-established evacuation chain. Furthermore, indirect costs are also difficult to account for, particularly when considering operational and manpower costs for naval vessels that must alter course for access to aircraft evacuation or treating medical facilities.

In a time of tight budgetary constraints and increased scrutiny of health care spending, telemedicine has been heralded as an effective means of curtailing unnecessary costs related to musculoskeletal care for the military, as well as the civilian sector. To the best of our knowledge, however, no multi-year assessment of the efficacy of a fully operational teleconsultation system has previously been performed. Our findings seem to indicate that telemedicine may enhance regionalization and leverage the expertise of sub-specialty experts, through reliable and fluid lines of communication, to enhance the delivery of care and mitigate the need for unnecessary travel in remote locations or austere

environments. These results have as much meaning for civilian proponents of a telemedicine system as they do for the US military.

Despite the strengths of this study, certain limitations must be acknowledged. Principal among these is this effort's retrospective design, as well as the lack of clinical follow-up due to de-identification of patient data within teleconsultations in order to ensure appropriate compliance with the provisions of HIPAA. As a result, we were unable to report on the ultimate clinical course and further surgical care after orthopaedic consultation, either when managed locally or after medical evacuation to a military treatment facility. Similarly, subsequent radiographic imaging and the timeline for return to duty were also not available. The findings of this study are also limited to the operational tempo and military environment from which the consultations were derived and generalization to other manners of warfare, such as conventional engagements or large-scale hostilities of sustained duration, may not be appropriate. Nonetheless, it is important to recognize that the results of this work represent some of the best information available regarding the efficacy of telemedicine and its potential impact in a military or civilian setting.

The current US military clinical reach-back teleconsultation system successfully facilitates remote access to subspecialty orthopaedic care and offers timely support for the diagnosis and management of a variety of musculoskeletal injuries arising in a deployed environment. This global telemedicine network effectively diminishes unwarranted medical evacuations, thereby reducing transportation and medical costs and time lost to injury. Secondly, this pathway promotes prompt diagnosis in order to prevent the sequelae of missed or delayed injuries, while coordinating early, definitive treatment when necessary. Further attempts to bolster this mechanism with a real-time interactive platform could dramatically alter the landscape of battlefield orthopaedic care. Additionally, our results would appear to support the expansion of orthopaedic telemedicine in numerous civilian applications including the disaster relief setting and care in underserved areas.

Conflict of Interest

The authors declared that they have no conflict of interest in the authorship and publication of this manuscript.

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