The Military Orthopedics Tracking Injuries and Outcomes Network: A Solution for Improving Musculoskeletal Care in the Military Health System

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ABSTRACT

Introduction:
Musculoskeletal injuries are an endemic amongst U.S. Military Service Members and significantly strain the Department of Defense's Military Health System. The Military Health System aims to provide Service Members, military retirees, and their families the right care at the right time. The Military Orthopedics Tracking Injuries and Outcomes Network (MOTION) captures the data that can optimize musculoskeletal care within the Military Health System. This report provides MOTION structural framework and highlights how it can be used to optimize musculoskeletal care.

Materials and Methods:
MOTION established an internet-based data capture system, the MOTION Musculoskeletal Data Portal. All adult Military Health System patients who undergo orthopedic surgery are eligible for entry into the database. All data are collected as routine standard of care, with patients and orthopedic surgeons inputting validated global and condition-specific patient reported outcomes and operative case data, respectively. Patients have the option to consent to allow their standard of care data to be utilized within an institutional review board approved observational research study. MOTION data can be merged with other existing data systems (e.g., electronic medical record) to develop a comprehensive dataset of relevant information. In pursuit of enhancing musculoskeletal injury patient outcomes MOTION aims to: (1) identify factors which predict favorable outcomes; (2) develop models which inform the surgeon and military commanders if patients are behind, on, or ahead of schedule for their targeted return-to-duty/activity; and (3) develop predictive models to better inform patients and surgeons of the likelihood of a positive outcome for various treatment options to enhance patient counseling and expectation management.

Results:
This is a protocol article describing the intent and methodology for MOTION; thus, to date, there are no results to report.

Conclusions:
MOTION was established to capture the data that are necessary to improve military medical readiness and optimize medical resource utilization through the systematic evaluation of short- and long-term musculoskeletal injury patient outcomes. The systematic enhancement of musculoskeletal injury care through data analyses aligns with the National Defense Authorization Act (2017) and Defense Health Agency's Quadruple Aim, which emphasizes optimizing healthcare delivery and Service Member medical readiness. This transformative approach to musculoskeletal care can be applied across disciplines within the Military Health System.

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INTRODUCTION

Noncombat-related musculoskeletal injuries (MSKI) are the leading cause of morbidity and disability in the U.S. Military.[1–3] MSKI affect more than 800,000 Service Members annually, resulting in 25 million limited duty days, and costing the U.S. Department of Defense $3.7 billion in direct and indirect costs.[2] In 2007, noncombat-related MSKI were

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the leading cause of outpatient clinical visits and the second leading cause of hospitalizations, accounting for 2.1 million injury-related medical visits.[4] For these reasons, it is essential to optimize post-MSKI healthcare and patient outcomes.

The majority of MSKIs within the military setting are treated nonoperatively (i.e., conservatively), but MSKIs that require surgical intervention occur up to 10 times more frequently in military populations, than in the civilian sector.[5–8] Furthermore, orthopedically managed MSKIs commonly result in Service Members being placed on limited duty status for 3 to 12 months, with many Service Members continuing to receive care well past 12 months. This has a marked negative impact on Service Member and military unit readiness, manning, and efficacy,[9,10] while also straining Military Health System resources. Thus, improved patient outcomes following MSKI have wide-ranging potential impact.

The MSKI problem is challenging to address, in part, because it is difficult to systematically assess outcomes that matter to patients, namely function and quality of life. Historically, there have been no Military Health System-wide resources to prospectively track clinically relevant outcomes for patients with MSKIs across the span of a patient's episode of care, military tenure, or across disciplines and clinical settings. This has limited the Military Health System's ability to study long-term impact and improve the efficiency and effectiveness of care. Health systems that strive to deliver value-based care must be learning healthcare systems with the infrastructure in place to capture and process actionable information, and then implement relevant changes. These learning healthcare systems are not possible without the ability to capture and assess patient-reported outcome (PRO) data that inform decisions and improve healthcare delivery.[11]

The Military Health System is charged with providing medical care to America's Military Service Members, eligible retirees, and their families; it manages care for 9.4 million beneficiaries, of which approximately 15% (1.4 million) are active duty military Service Members.[12] To set the Military Health System on a course to become a learning healthcare system, the Military Orthopedics Tracking Injuries and Outcomes Network (MOTION) was established to collect the data necessary to analyze and improve MSKI healthcare. The purpose of this report is to provide the structural framework and design behind MOTION, and highlight how data collected through the MOTION Musculoskeletal Data Portal can be utilized to optimize patient care and outcomes within the Military Health System. We hypothesize that improved data sharing and enhanced patient-provider shared decision making will result in superior patient outcomes as compared to the current standard of MSKI care (i.e., no/minimal examination and sharing of patient outcome data).

METHODS/DESIGN

The MOTION established an internet-based data capture system, the MOTION Musculoskeletal Data Portal. Patients and orthopedic surgeons input case-specific information to build

a comprehensive dataset for each individual and every condition. These data points include global and condition specific PROs and surgeon reported operative case data and can be combined post hoc with data from other existing Department of Defense owned databases. Data are collected in the MOTION Musculoskeletal Data Portal as part of routine standard of care; however, patients can consent to have their data be used for research purposes. Patients who consent to the institutional review board approved observational study are "flagged" within the electronic database. These patients can be selected in separate analyses for the purposes of clinical outcomes research, as opposed to clinical quality assurance and improvement analyses. All study procedures were approved by the Walter Reed National Military Medical Center Institutional Review Board (Study Number 414028) in compliance with all applicable Federal regulations governing the protection of human subjects.

MOTION Primary Objectives

The primary objectives are to:

1. Establish a Military Health System-wide solution to capture and evaluate clinician and patient clinical outcomes for MSKI.
2. Identify factors (e.g., surgical approaches, interventions, demographic information), which improve return to deployment ready status.
3. Develop clinical support tools, including predictive algorithms that provide patients and surgeons with estimates of success or nonsuccess, based on established benchmarks (e.g., symptom/condition chronification, re-injury/revision surgery rates, and time to return-to-duty).
4. Identify the minimal set of questionnaires that provide the necessary clinically important information while reducing patient questionnaire burden.

The MOTION Musculoskeletal Data Portal

In January 2016, MOTION leveraged the lessons learned from previous Military Treatment Facility-level efforts to establish a MSKI-specific PRO data collection platform for implementation within the Military Health System. The primary lesson learned from previous Military Treatment Facility-level efforts was the need to identify a data capture system that had the requisite approvals to be immediately implemented and used across the Military Health System. MOTION selected a Department of Defense-owned and Health Insurance Portability and Accountability Act of 1996 (HIPAA) compliant system to host its data collection system. The system is highly customizable, which allowed MOTION to establish the Musculoskeletal Data Portal as a component of the larger data collection platform. The data collection platform is an entirely internet-based system, obviating the obstacle of installing and

updating a computer program on devices at each data collection site, thereby increasing the availability for data entry beyond the Military Treatment Facility.

Patient Population

Any adult Military Health System beneficiary (18 years of age or older) who is scheduled to receive operative treatment for a specific MSKI within a Military Health System orthopedic clinic is eligible for enrollment into the MOTION Musculoskeletal Data Portal. Individuals enrolled into the MOTION Musculoskeletal Data Portal are given the opportunity to provide informed consent to allow for their data to be used for research initiatives. Patient enrollment into the MOTION Musculoskeletal Data Portal is graphically displayed in Fig. 1.

MOTION Implementation

Concurrent with their orthopedic surgeon standard of care medical management, all patients are provided access to the MOTION Musculoskeletal Data Portal site. Once a patient is entered into the MOTION system, both the patient and surgeon receive relevant questionnaires at standardized time points (Table I). MOTION data can be merged with data from other Department of Defense records (e.g., electronic medical record; deployment history) to better inform the complete assessment of patient outcomes (Table II). The merging of these data will allow investigators to assess the impact orthopedically managed MSKI have on Military Health System resources, Service Member medical readiness, and long-term health outcomes.

Patient and Surgeon Questionnaires

Once an assigned questionnaire is due to be completed, the patient or surgeon is sent an e-mail with a link to the data collection platform portal. Data can be input into the platform via any internet-enabled device. The data collection platform tracks patient and surgeon questionnaire completion compliance in real time. If a questionnaire is not completed in the established time period, a member of the clinical team or research staff attempts to contact the patient or surgeon via telephone or in-person at the next normally scheduled clinical visit.

Patient Questionnaires

MOTION has incorporated a plethora of questionnaires into the data collection platform to comprehensively collect and assess patient outcomes. These questionnaires include traditional validated ("legacy") PROs for assessing patient outcomes following MSKI (e.g., American Shoulder and Elbow Surgeons [ASES] questionnaire; International Knee Documentation Committee [IKDC] questionnaire), general health questionnaires, military-specific readiness questionnaires, and the National Institutes of Health Patient Reported Outcomes Measurement Information System (PROMIS).
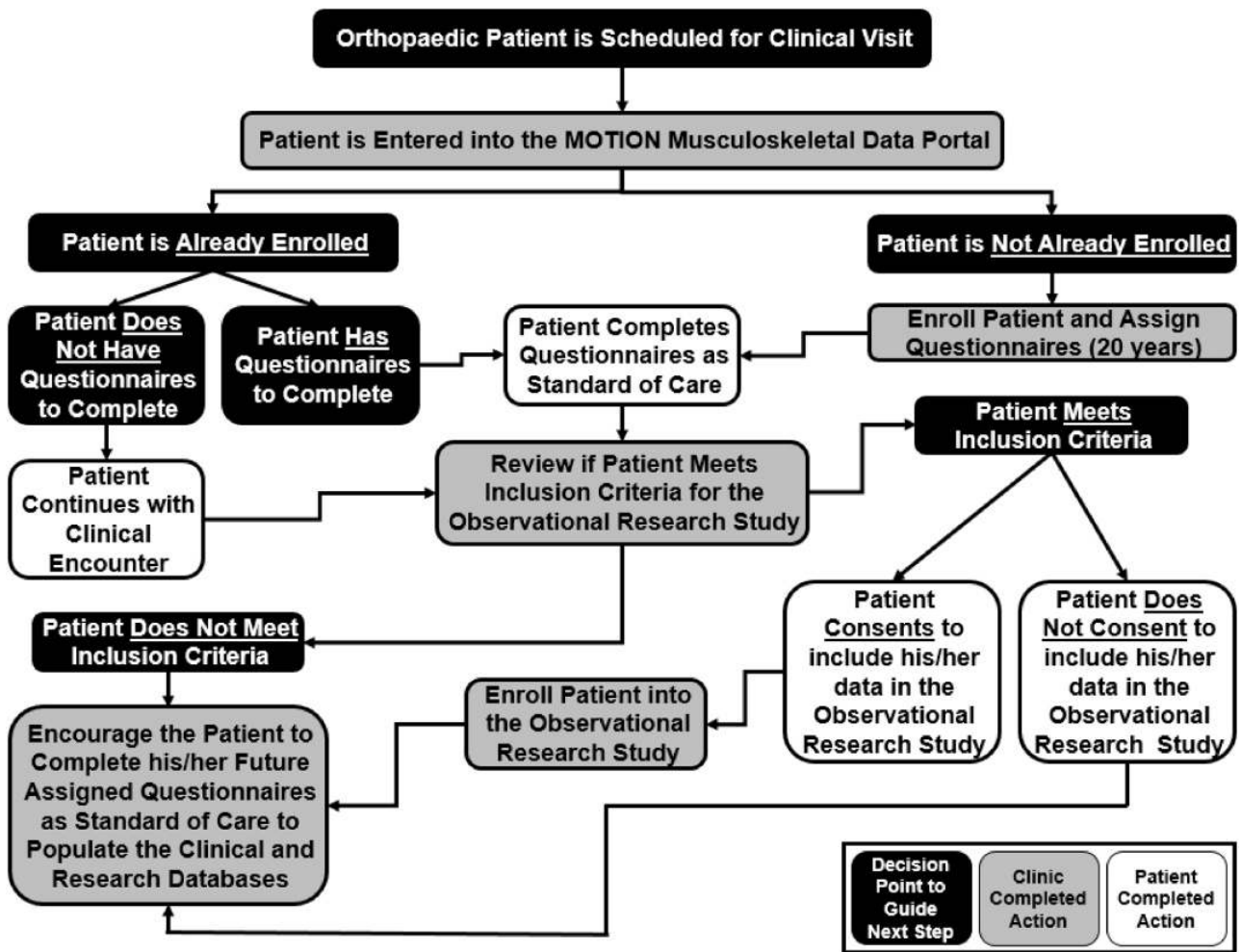
FIGURE 1. Military Orthopaedics Tracking Injuries and Outcomes Network Patient Enrollment Flow-Chart.

PROMIS questionnaires are not condition specific and allow for patient level tracking across the patient's continuum of care.[13] MOTION utilizes the computer adaptive testing versions of PROMIS questionnaires, which reduce patient question burden and increase precision (Table I).[14–18]

Surgeon Questionnaires

Surgeons complete robust, standardized questionnaires (Table I) that provide the structured surgical case data required for data analytics. Surgeon questionnaires are designed to be completed in less than 5 minutes. However, MOTION aims to further optimize surgeon data entry by analyzing the operative data to identify the data fields that provide the most relevant information related to patient outcomes and removing data fields that do not yield clinically impactful information. Optimized data entry will increase questionnaire completion compliance.[19]

Data Analysis Plans

Routine analysis of the nonresearch registry data includes patient enrollment counts and questionnaire completion compliance information for patients and surgeons. All data are stratified by anatomic region, facility, and surgeon. As of April 2020, nine Military Treatment Facilities have enrolled 9,125 patients who were scheduled for one or more orthopedic surgical procedures.

To decrease patient questionnaire burden, one of MOTION early objectives is to reduce the use of anatomic and condition (i.e., legacy) PROs in favor of general physical function and lifestyle impact computer adaptive testing PROs (Objective #4). To this end, we will employ linear and nonlinear regression methodologies to explore the possibility of using various mixtures of computer-adaptive PROMIS questionnaires and demographic information to predict the body region-specific legacy questionnaires identified in Table I. These predictive algorithms will allow the creation of indexes, which approximate the legacy PROs, a known reference point for many surgeons. The goal for each predictive algorithm will be to be within 2.0 times the test-retest reliability of the original legacy measure or attaining 85% predictive accuracy using both within-sample and out-of-sample validation methodologies with an additional goal of having

TABLE I. MOTION Assessment Time Points and Questionnaires

	Assessment time points	Questionnaires
Military Orthopaedics Tracking Injuries and Outcomes Network Surgeons	Immediately after completing the operative case.	*Case Specific Intra-operative Data* • Current Procedural Terminology (CPT) codes • Intra-operative findings • Surgical techniques • Hardware type, quantity, and location • Graft material • Biologics used

MOTION Patients	*Preoperative*
	• up to 4 weeks before the day of surgery
	  6 weeks postsurgery
	• 4 to 8 weeks postsurgery
	  6 months postsurgery
	• 4 to 8 months postsurgery
	  12 months postsurgery
	• 10 to 14 months postsurgery
	  2 years postsurgery
	• 20 to 28 months postsurgery
	  5 years postsurgery
	• 54 to 66 months postsurgery
	  10 years postsurgery
	• 9 to 11 years postsurgery
	  20 years postsurgery
	• 19 to 21 years postsurgery
		General Health Questionnaires
		OSPRO Yellow Flag[25–27,†,§]
		• Brief Resiliency Scale[28,†,§]
		• Therapeutic Alliance[29,30,†,§]
		• DVPRS[31,32,†,§]
		• Deployment readiness specific questions[†,§]
		• VR-12[†]
		PROMIS Computer Adaptive Testing[33–39]
		• Anxiety[†,§]
		• Depression[†,§]
		• Pain Behavior[†]
		• Pain Interference[†,§]
		• Physical Function[†,§]
		• Physical Function Lower Extremity[†]
		• Physical Function Upper Extremity[†]
		• Satisfaction with Social Roles[†]
		• Sleep Disturbance[†,§]
		• Sleep Impairment[†,§]
		• Social Isolation[†,§]

Shoulder Patients

- ASES[40,†,§]
- Marx-Shoulder[41,†,§]
- SANE-Shoulder[42,†,§]
- WOSI[43,44,†,§]

Knee Patients

- IKDC[45,†,§]
- Marx-Knee[46,†,§]
- SANE-Knee[47,†,§]

Hip Patients

- HOOS[48,†,§]
- HOS-ADL[49,†,§]
- IHOT-12[50,†,§]

PROMIS CAT, Patient Reported Outcomes Measurement Information System; OSPRO, Optimal Screening for Prediction of Referral and Outcome; DVPRS, Defense and Veterans Pain Rating Scale; VR-12, Veterans Rand 12 Item Health Survey; ASES, American Shoulder and Elbow Surgeon Score; SANE, Single Assessment Numeric Evaluation; WOSI, Western Ontario Shoulder Instability Index; IKDC, International Knee Documentation Committee Questionnaire; HOOS, Hip disability and Osteoarthritis Outcome Score; HOS-ADL, Hip Outcome Score Activities of Daily Living; IHOT-12, International Hip Outcome Tool.

[†]Indicates the patient reported outcome was used from 2016 to 2018.

[§]Indicates the patient reported outcome was used from 2018 to the time of publication.

relatively uniform error rates across the entire legacy scale.

The MOTION end-goal is to collect and analyze the data that is necessary to enhance MSKI patient outcomes within the Military Health System. Analytics in this area follow three distinct steps: (1) Identify factors which predict favorable outcomes (Objective #2); (2) Develop linear and nonlinear regression models which inform the surgeon if the patient is Green (projected ahead of or on return-to-duty/activity schedule), Yellow (projected marginally behind return-to-duty/activity schedule), or Red (projected substantially behind return-to-duty/activity schedule or at risk of permanent military duty restrictions) (Objective #3); and (3) Develop interactive toolsets which the surgeon can use to see how a patient's future projected status changes with various treatment interventions (Objective #3). Future investigations can then determine how the information/tools generated in Objectives #2 and #3 impact orthopedic clinical practice and patient outcomes.

DISCUSSION

MOTION provides the framework for musculoskeletal care in the military to become a learning system, making it possible to conduct continuous clinical improvement via usable data conveniently available to surgeons.[11] Before the creation of MOTION, the inability to continuously collect and analyze PRO data precluded the fielding of a learning system. In the near-term, MOTION collected data will allow surgeons to better identify patient needs and better personalize treatment options than was previously possible. This

TABLE II. Department of Defense Data Sources for Combination With MOTION Collected Data

Data category	Specific variables (examples)	
Demographics	• age • gender • race • military rank	• military service branch • years of military service • military occupational specialty
Medical Record	• injury history • physical exam findings • diagnosis name • diagnosis code	• radiographic study data • anesthesia data • postoperative rehabilitation • postoperative complications
Military Specific	• deployment history • physical profile status • physical activity history • physical fitness test results	• physical/medical evaluation board outcomes • military discharge • medical disability rating

will culminate in improved patient centered care via real-time feedback and monitoring of individual patient progress and outcomes. Improved patient-centered care allows tailored treatment plans and complimentary interventions (e.g., behavioral health) to enhance patient care and outcomes.[20–22] In the long-term, MOTION collected data will allow healthcare providers and Military Health System leaders to identify leading clinical practices for MSKI management that can be broadly implemented across the Military Health System.

MOTION has accumulated enough data to initiate analyses to answer the objectives described in this article. Initial efforts included identifying common orthopedic surgeon practice patterns for the management of some of the most prolific surgical procedures included in the MOTION database (e.g., anterior cruciate ligament reconstruction). This is an important first step in identifying if military orthopedic surgeons are following evidence based leading practices. MOTION-affiliated collaborators have also focused early efforts on addressing Primary Objective #4 (identify the minimal set of questionnaires that provide the necessary clinically important information while reducing patient questionnaire burden). Under these efforts, MOTION collaborators conducted latent factor analyses of the PROMIS measures within the MOTION patient population and explored relationships between PROMIS measures and the ASES and the SANE. Furthermore, MOTION collaborators examined the possibility of using various mixtures of computer adaptive PROMIS questionnaires and patient demographic information to predict body region-specific legacy questionnaires (e.g., ASES).

These early data analyses are crucial for optimizing data collection efficiency within the clinical setting.

The potential value of MOTION to improve the management of MSKIs was recognized by MSKI healthcare providers and experts (e.g., orthopedic surgeons, physical therapists), and the decision was made to increase the scope of MOTION to include all MSKIs. In May 2018, MOTION augmented the orthopedic surgical focus with the incorporation of selected rehabilitation clinics and nonsurgically managed patients with MSKIs. Military Orthopedics Tracking Injuries and Outcomes Network expansion into the full continuum of care for both surgically and nonsurgically (i.e., conservatively) treated MSKIs goes beyond the original design of the MOTION research initiative that is described in this article; thus, nonsurgically managed patients with MSKIs are not included in this study protocol report. Additionally, as of April 2020 nonsurgically managed patients only account for 5.3% of the total MOTION population ($n_{total} = 9636$, $n_{nonsurgical} = 511$). However, as the number of nonsurgically managed patients with MSKIs increases, this population will enable future investigations into the time course of successful conservative MSKI treatment, unsuccessful conservative treatment resulting in surgery, as well as the success and failure of postsurgical rehabilitation strategies. This significant advancement will require considerable time and investment but has the potential to revolutionize the MSKI medical management in the military and civilian sectors.

The Defense Health Agency recognized MOTION potential value in improving MSKI care and incorporated MOTION as a program of record in December 2018. As part of the incorporation into the Defense Health Agency, MOTION has partnered with the Pain Assessment Screening Tool and Outcomes Registry (PASTOR). Similar to MOTION, PASTOR provides efficient, evidence-based clinical decision support to pain management healthcare providers and the Military Health System as a whole.[23,24] The joint MOTION-PASTOR endeavor was reorganized and renamed the PRO Clinical Record. Each PRO Clinical Record Care Community focuses on a specific patient population (e.g., MOTION focuses on MSKIs), but all communities collect a common set of PRO measures through PROMIS. PROMIS measures are a significant advancement toward the standardized utilization of PROs within the Military Health System.[13] Thus, PRO Clinical Record data has the potential to improve patient-centered care, clinical treatment practices, patient safety, and long-term patient outcomes across medical specialties.

Limitations and Mitigation Strategies

Although there are significant benefits to MOTION, we recognize that our methods are not without limitations. Primarily, these limitations are the result of patient and surgeon questionnaire burden and challenges with questionnaire completion compliance. Currently, MOTION is focusing efforts on optimizing the patient experience by identifying the most

economical suite of adaptive patient questionnaires that will provide the granular data needed in the fewest number of questions. We anticipate that optimizing the patient experience through reduced question burden, as well as patient-specific level outcomes feedback, will also result in improved patient completion compliance for all follow-up time periods.

CONCLUSIONS

Musculoskeletal injuries are the greatest population health dilemma affecting U.S. military Service Members. MOTION was established to collect the data needed to improve military readiness and optimize medical resource utilization through the systematic evaluation of MSKI patient outcomes. MOTION accomplished this goal by leveraging existing U.S. Department of Defense resources to establish the data collection platform required to accurately and efficiently collect patient level outcomes data. This model for systematic enhancement of MSKI care and data collection aligns with ongoing efforts to use "big data" to create transformative approaches to musculoskeletal care that focuses on patient outcome data and can be applied across disciplines within the Military Health System.

CONFLICTS OF INTEREST STATEMENT

MTP is a consultant to and receives royalties from Arthrex, is a consultant to JRF Ortho, and receives royalties from Elsevier. No other authors have reported a competing interest related this manuscript.

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