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The Knee Examination for Video Telemedicine Encounters

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Introduction

Although over the past 2 decades improvements in audio-visual communication technologies have led to an increased use of telemedicine across many health care disciplines [1,27], it had not been widely adopted in orthopedic surgery and other musculoskeletal specialties within the United States until the onset of the COVID-19 pandemic [19]. However, mandated social distancing measures and restrictions on in-person consultations have forced both clinicians and patients to become familiar with web-based videoconferencing platforms for care delivery. To continue providing musculoskeletal care during the pandemic, there has been a dramatic increase in telemedicine visits [2,20]. Previous studies on telemedicine have shown that these visits increase access to care while having lower overall costs and maintaining patient satisfaction [5,9]. With increased access to high-speed videoconferencing platforms, widely available personal computing devices, and patient demand for high-quality, convenient, efficient specialty care, telemedicine is an effective medium for musculoskeletal care that will endure beyond the COVID-19 pandemic [2,19,20,22,24,28]. One particular challenge to the long-term adoption of telemedicine in musculoskeletal specialties has been a widely held perception that remote visits are markedly limited by the inability to perform an in-person physical examination [3,12,13,29,30]. In particular, it has been thought that examination maneuvers requiring manual motor testing for strength, motion assessment, stability, and provocative testing for pain may be difficult to perform remotely [20]. However, in a randomized controlled trial of orthopedic visits in which telemedicine encounters were compared with in-person consultations, physicians rated their ability to examine patients as good or very good in 98% of telehealth visits,

with no significant differences between groups and no adverse safety events [4]. When specifically considering the physical examination of the knee, closer review suggests that most of the examination can actually be successfully performed remotely with some modifications.

The purpose of this commentary is to describe a comprehensive knee physical examination for video telemedicine encounters, including (1) verbal instructions in layman's terms of each examination maneuver, (2) annotated images of each examination maneuver that can be provided to patients via screen share options, and (3) checklists for documentation.

Preparation for Telemedicine Visit

In our experience, before the scheduled encounter, the patient must be provided with information that allows them to become familiar with the specific Internet videoconferencing platform that is being used (eg, Zoom, Skype, and Teams) and should be encouraged to test and verify that their Internet connectivity, video quality, and audio systems are functional for the upcoming virtual visit. Most of these videoconferencing platforms allow for testing each of these parameters prior to a meeting, or in this case, a telemedicine encounter.

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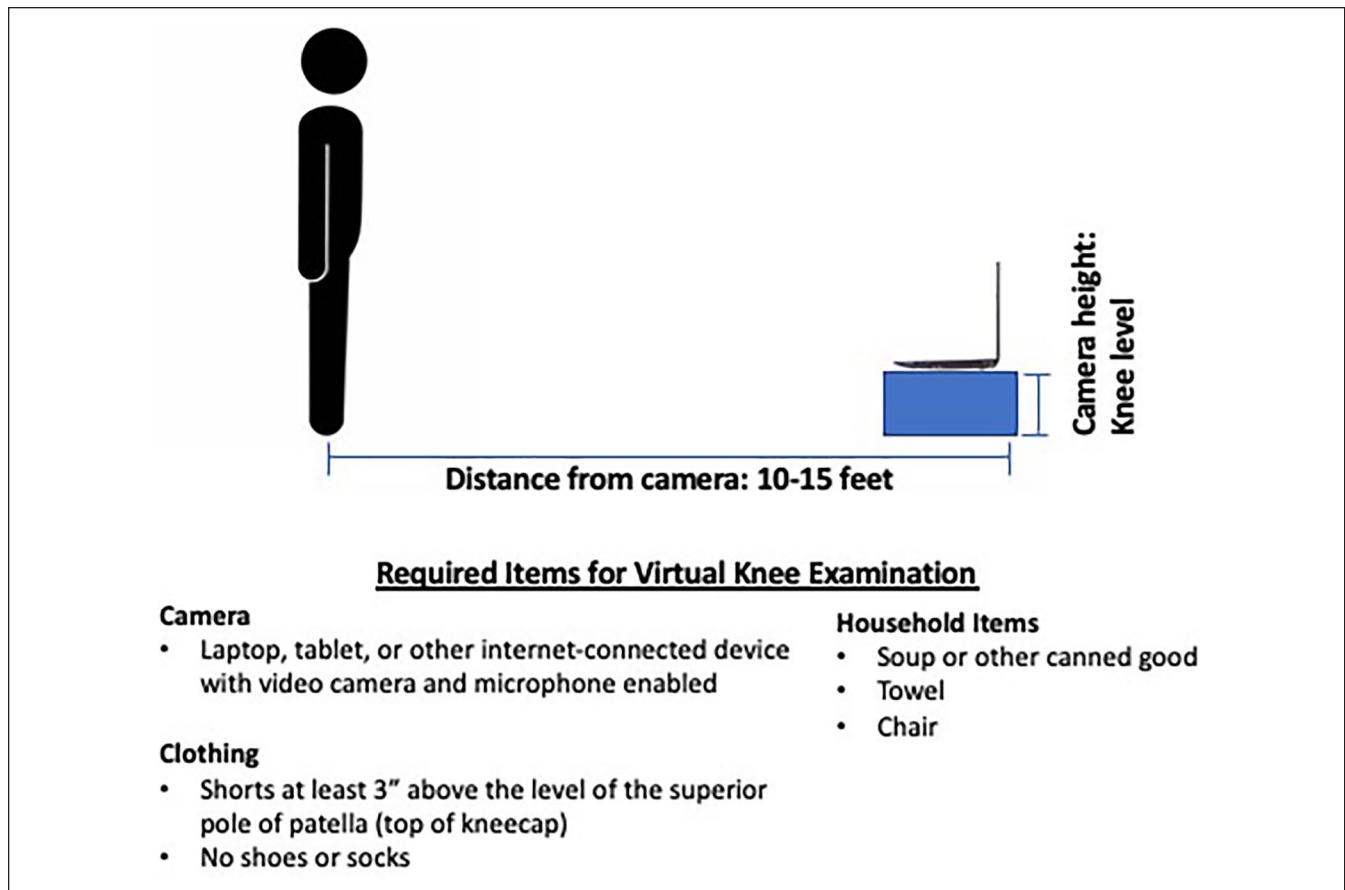


Fig. 1. Schematic of virtual knee examination.

In addition, prior to the virtual visit, we encourage the patient to complete an intake form containing questions about their chief complaint, history of present illness, past medical and surgical history, allergies, home medications, social history, and a complete review of systems. In addition to the virtual examination and medical decision-making, several of these aforementioned intake items must be collected and documented to appropriately bill for the visit. The patient should also review instructions on how to set up their camera to adequately visualize the knee. At the start of the visit, the patient should be seated with their camera centered at their eye level. During the physical examination, the patient will be asked to reposition themselves based on the specific examination maneuver being performed. The required distance and angle of the camera position will vary by the type of camera and the patient position. Finally, the patient should be dressed in appropriate clothing for the virtual visit. We provide the schematic shown in Fig. 1 to patients who are being seen for a knee complaint. This schematic contains guidelines for appropriate clothing, examination space, patient positioning, camera positioning, and any required common household items. In some cases, even when all the aforementioned information has been provided to the patient

ahead of the visit, issues can arise with them connecting to the videoconferencing platform. First, we recommend that a member of the provider's office staff calls the patient and attempts to guide them through these issues. However, it is essential that support from information technology is available for troubleshooting any technical difficulties that cannot be resolved by the provider's office staff.

Virtual Knee Examination

We have divided the knee examination into a basic examination (core knee examination) and pathology-specific special testing [17]. The basic examination includes inspection, palpation, range of motion testing, motor testing, sensory testing, and a peripheral vascular examination [3]. Patients with undifferentiated lower extremity pain with or without low back pain should be assessed for a neurologic etiology. (The lumbar spine examination is covered in a separate article in this special issue of the *HSS Journal*.) Hip or peripheral vascular pathology should also be considered when the pain is difficult for the patient to localize. An assessment for hip pain and restricted motion should be performed on nearly every patient with a complaint of knee pain. (The hip

examination is covered in a separate article in this issue.) Special testing can be performed as needed based on the patient's history and findings on the core knee examination. A PowerPoint document that contains annotated illustrated examples of each knee physical examination maneuver is available as Supplemental Presentation 1. The clinician may choose to demonstrate the examination maneuver to the patient or can share the annotated illustrated examples via screen share options.

Core knee examination. The patient should be asked to position themselves so that their camera will be able to visualize the front, sides, and back of the knee as they turn their body toward the camera during a thorough inspection. This inspection of the bilateral lower extremities should evaluate for coronal and sagittal alignment, muscle atrophy, deformity, prior incisions, scars, effusion, soft tissue swelling, ecchymosis, erythema, skin lesions, or rashes. Gait should be assessed. The patient may be asked to identify the location of maximal pain by pointing to that area and self-palpating. Bilateral range of motion testing should be performed. A virtual goniometer may be used for the evaluation of both alignment and range of motion [7,28]. While bilateral sensory testing and a peripheral vascular examination can be performed by the patient, strength testing requires a remote examiner, such as a family member (Supplemental Table 1 [available online]).

Special testing. Pathology-specific special testing can be categorized into ligament tests, meniscal tests, and patellofemoral joint tests.

Ligament testing. Previous studies have shown that, when performed by an experienced examiner, the lever test is actually more sensitive than other tests, including the Lachman test, for the diagnosis of anterior cruciate ligament (ACL) injury [3,18]. As originally described, the examiner presses down on the distal third of the patient's quadriceps with 1 hand, while the other hand is positioned as a fist beneath the proximal third of the patient's calf [14]. A positive test results in an objective and visual finding—the patient's heel will not raise off the table; it does not rely on subjective determination like the Lachman and anterior drawer tests. We have modified this examination to be performed by the patient independently, with a soup or vegetable can placed beneath the calf, and the patient pressing down on their distal quadriceps muscle. To evaluate for posterior cruciate ligament injury, the posterior sag test [25] and the quadriceps active test [3,6,25] can be performed by the patient independently. Both of these tests should be performed while the patient is supine and the camera is pointed toward the side of the knee (Supplemental Table 2).

Meniscus testing. We have modified the common tests used to assess for meniscal pathology to be performed by

the patient independently, including the bounce test and the hyperflexion test [3,21]. As it was originally described, the Thessaly test can be performed by the patient independently while directly facing the camera (Supplemental Table 3) [3,8,10].

Patellofemoral joint testing. The “J-sign” indicates patellar maltracking and may be observed with the patient facing the camera in a seated position and actively moving their knee back and forth through a range of motion from flexion into extension [3,21,23,26]. Patellofemoral crepitus can similarly be detected by the patient by placing 1 of their hands over the patella while actively moving the affected knee back and forth from flexion into extension. Crepitus may be enhanced by knee extension against resistance, and the patient can be encouraged to do this with the help of a family member. We have modified the patellar apprehension test to be performed entirely by the patient in a seated position with the ankle of the affected extremity crossed over the unaffected leg and a laterally directed force placed on the patella using both thumbs [3,21]. A single-leg squat performed with the patient directly facing the camera can demonstrate valgus and internal rotation collapse that may suggest a correctible neuromuscular imbalance or hip pathology which can contribute to anterior knee pain (Supplemental Table 4) [11].

The maneuvers that comprise the Beighton score (knee and elbow recurvatum, thumb to forearm apposition, and lumbar flexion) can be performed independently by the patient to evaluate for generalized joint hypermobility (Supplemental Table 5) [15].

Implementation of Virtual Knee Examination

The tools provided here offer a comprehensive, standardized approach to the virtual knee examination including office workflow, previsit setup, and physical examination testing. Similar to an in-person new patient consultation, we recommend that the virtual knee physical examination starts with the core knee examination followed by additional pathology-specific special testing as clinically appropriate. The specific special tests performed should be directed by the patient's history of present illness and findings on the core knee examination. The time required to perform an examination can vary based on a variety of factors, but in our experience, the core knee examination as listed requires approximately 5 minutes and a problem-focused examination generally approximately 5 to 10 minutes to complete. Efficiency can be optimized by choosing a sequence of examination maneuvers that minimizes the number of times the patient is asked to move between standing, sitting, and supine positions. Improved standardization of these modified virtual examination tests will result in improved reliability and validity of the virtual examination.

Limitations

An in-office examination performed by an experienced clinician undoubtedly offers a more comprehensive musculoskeletal evaluation compared with a virtual examination including focused palpation in areas consistent with patient's history, tactile recognition of crepitus, accurate strength assessment, and assessment of ligament integrity. At this point, it is impossible to replace the ability of an experienced clinician to perform certain physical examination maneuvers such as the Lachman and pivot shift examinations for ACL injury. In addition to knee ligament assessment, we have found that remote assessment of patellar instability also generally provides more limited diagnostic information compared with an in-person examination. When patients present with a history suggestive of these conditions, we typically perform a virtual physical examination during the initial consultation but have a low threshold to obtain advanced imaging (typically in the form of a magnetic resonance imaging) which may be followed by a subsequent in-person visit for examination. However, by including alternatives such as the lever test for ACL integrity [3,18] and our modification of patellar apprehension testing, we can still obtain useful data that allow for reasonable clinical decision-making. Although we provide our best recommendations regarding optimal positioning of the patient and camera for each examination maneuver, videoconferencing may prevent clinicians from interpreting certain tests with the same accuracy as an in-person examination. A specific example of this is a subtle knee flexion contracture or effusion that is more easily appreciated in person than via videoconferencing. While we attempted to modify as many tests as possible to be performed independently by the patient, certain tests do require a remote examiner. Such tests are often performed by someone who is not trained in performing the musculoskeletal examination, and it is possible that findings may be incorrectly interpreted or reported by the examiner or patient, despite uniform instructions. The sensitivity, specificity, and diagnostic accuracy of the tests that we have included when performed by a patient or by an untrained remote examiner and interpreted by a clinician have yet to be defined but are likely lower than published values for the same tests when they are performed by an experienced examiner in person. It is critical that treatment plans only be formulated when findings of the virtual physical examination corroborate the patient's history and imaging studies. Conflicting findings must prompt an in-person evaluation prior to clinical decision-making [16].

The COVID-19 crisis has forced our society to become increasingly facile with video-based communication platforms. Orthopedists and other providers of musculoskeletal care have found that virtual physical examinations can be performed in a similar manner to in-office visits, albeit with some inherent limitations [22]. Various modifications of physical examination maneuvers, including for evaluation of

the knee, have helped to overcome some of these limitations and allow for a more comprehensive virtual examination. Due in part to high patient and clinician satisfaction, health care savings, improved access to care, and improved time efficiency, we believe that telemedicine in orthopedics will endure beyond the resolution of the current COVID-19 crisis. Future studies will seek to validate the virtual knee examination maneuvers presented here.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Joshua S. Dines, MD, reports relationships with Arthrex Inc, Thieme Inc, Linvatec, Wolters Kluwer Health, American Shoulder and Elbow Surgeons, and the *Journal of Shoulder and Elbow Surgery*, outside the submitted work. Scott A. Rodeo, MD, reports relationships with Advance Medical and Ortho RTI, outside the submitted work. Samuel A. Taylor, MD, reports relationships with DJO Orthopedics and Mitek, outside the submitted work. The other authors declare they have no conflicts of interest.

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