AO FAS AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2020, Vol. 41(8) 1017–1026

DOI: 10.1177/1071100720941020
journals.sagepub.com/home/fai

The Virtual Foot and Ankle Physical Examination

Stephanie K. Eble, BA[1], Oliver B. Hansen, BA[1], Scott J. Ellis, MD[1], and Mark C. Drakos, MD[1]

Abstract

The COVID-19 pandemic has necessitated a rapid and drastic shift for clinicians and patients away from traditional in-person visits and toward internet-based virtual visits. The adoption of telehealth services is likely to persist in some capacity even as in-person visits resume, given the convenience and efficiency of telehealth consultations for patients and perhaps surgeons. A primary challenge of virtual visits, particularly in the field of orthopedic surgery, is the physical examination. However, for the foot and ankle, routine physical examination maneuvers can be completed virtually with little modification given proper patient instruction. We present a comprehensive virtual foot and ankle examination for telehealth visits, including instructions that can be provided to patients verbatim and a corresponding checklist for provider documentation.

Level of Evidence: Level V, expert opinion.

Keywords: virtual physical examination, telehealth, foot and ankle examination

Introduction

The restrictions and social distancing guidelines associated with the present COVID-19 crisis have resulted in a drastic shift away from in-person visits, leading to the rapid adoption of telehealth alternatives. Despite any previously held beliefs on the utility of telehealth services, the crisis has necessitated this dramatic change in the delivery of health care. Previous studies have found telehealth visits to be both convenient and efficient,[1,2,12,14] though prior to the COVID-19 pandemic, the adoption of telehealth in orthopedics was relatively limited, along with corresponding literature on its use in musculoskeletal health.[10] A primary barrier to more widespread adoption of telehealth in orthopedics is related to the belief that a comprehensive and thorough physical examination cannot be performed virtually.

However, particularly for the foot and ankle, we believe that standard physical examination maneuvers can be completed virtually with little modification. J. Lamplot and S. Pinnamaneni have developed a comprehensive checklist and guidelines for shoulder and knee virtual examinations, which we have adapted for use in the foot and ankle (unpublished data, July 2020). With the expectation that telehealth services will continue to be incorporated into physician practices moving forward, these authors provide a list of virtual physical examination maneuvers for the shoulder and knee, specific instructions for clinicians to provide to patients during the visit, and potential frameworks for the implementation of virtual visits in practice. Thus, we present a guide for the virtual foot and ankle examination, including detailed guidelines for patients, instructions that can be read verbatim by providers to administer the virtual physical examination, and a corresponding checklist for medical record documentation.

Preparation for Telehealth Visit

In preparing for the telehealth visit, the patient should complete previsit forms detailing the chief complaint, history of present illness, medical and operative history, allergies, medications, social history, and a review of systems. Height and weight should also be provided. If possible, patients should take and record their temperature if an at-home thermometer is available, pulse rate if available on a fitness watch, and blood pressure if a sphygmomanometer is available, as these metrics increase the complexity of documentation necessary for both billing and comprehensive patient care. Before the telehealth visit begins, the patient should

[1]Hospital for Special Surgery, New York, NY, USA

Corresponding Author:
Stephanie K. Eble, BA, Department of Orthopaedic Foot and Ankle Surgery, Hospital for Special Surgery, 535 East 70th St, New York, NY 10021, USA.
Email: stephanieeble97@gmail.com

Table 1. Patient Guidelines for Appropriate Dress and Instructions for Setting up the Camera.

For patients (intended to be provided *before* the telehealth visit)
Recommended Devices: A portable laptop or tablet is preferable for use during the telehealth visit, as it is stable and the camera can be easily tilted as needed. A mobile phone can also be used, though it may be difficult to position properly unless a family member or friend is available to hold the phone in position.
Patient Clothing: Both ankles and knees should be exposed. Wear gym shorts that end at least 3 inches above the knee. Shoes and socks off.
Examination Space: 10 to 15 feet of open space should be available to allow you to move for gait analysis.
Lighting: The brightest area in the room should be behind the camera, not facing it.
Patient Position: Begin seated and with your camera at eye level. During the physical examination you will be asked to reposition yourself and your camera as described below, based on the body part being examined.
Camera Repositioning (when instructed to do so during the examination):
Standing: Camera should be placed at shin level with knees to feet visible on the video. You will need 10 feet of space to walk. The camera should also be movable to give an overhead view of the feet.
Seated: Sitting on a stool/high chair with feet not touching the floor. The camera should be placed on a table at shin level with knees to feet visible on the video.
Please test out the positioning and camera images prior to the visit. The required distance and angle of the camera position will vary with the type of device.

dress appropriately, based on the provided guidelines, and refer to instructions for setting up the camera, including initial positioning and making preparations for repositioning during the examination (Table 1). The camera setup, including video and audio, should be tested prior to the start of the visit, as the required distance and angle of the camera will vary based on device. The patient should begin the visit seated with the eyes at camera level. During the visit, they will be asked to move and reposition the camera according to physician instructions during the physical examination (Figure 1).

Foot and Ankle Examination

The foot and ankle examination includes a core examination, consisting of inspection, palpation, range of motion testing, strength testing, and neurovascular assessment. Additional tests, such as those for flatfoot, cavovarus foot, hallux rigidus, and Achilles rupture conditions, can be added based on the suspected pathology. Table 2 provides a comprehensive list of each examination to be performed, a checklist for medical record documentation, and corresponding verbal instructions for clinicians to provide to patients during the virtual examination.

Core Foot and Ankle Examination

Inspection. Initial examination of bilateral lower extremities should evaluate for alignment, atrophy, deformity, incisions, scarring, rash, swelling, ecchymosis, and erythema. This examination should include both standing and seated positions, with camera views from the front, side, and back of the foot and ankle. The plantar aspect of the foot should also be examined for ulcers, abrasions, and skin breakdown. It is particularly important to have good lighting for the inspection portion of the examination.

Palpation. The patient should be asked to use one finger to point to the area of maximal pain or discomfort, including any areas on the plantar aspect of the foot. Figure 2 provides examples for Achilles tendon, peroneal tendon, and plantar fascia pathologies. In the foot and ankle, many of the structures causing pathology are superficial and can be easily palpated and identified by the patient during the virtual examination.

Range of motion. The patient's gait should be evaluated, and range of motion (ROM) testing should be performed assessing for symmetry and pain of the ankle (plantarflexion, dorsiflexion), hindfoot (inversion, eversion), and metatarsophalangeal (MTP) joints (flexion, extension). Range of motion assessment can be assisted with the use of a web-based goniometer.[17] Several goniometer applications have been developed for smartphones. These include applications that use pictures and subsequent placement of markers to calculate ROM or applications that rely on the device's internal accelerometer and spatial positioning to assess angles in real time.[21] The current literature suggests moderate to strong correlation between ROM measured by these applications and ROM measured in-person using a universal goniometer.[20,21]

ROM assessment can be done both actively (asking patients to move the affected joint with their own muscle power) or passively (asking the patient or family member or friend to manipulate the joint of interest manually), though patients may have trouble accurately assessing their own range of motion. They may inadvertently tense or activate muscles during these movements, which can interfere with the measurement.

Strength. The assessment of strength remains one of the largest challenges of the virtual foot and ankle examination. A patient's ability to walk on their tip toes indicates 4/5 strength in ankle plantarflexion, but it can be difficult to

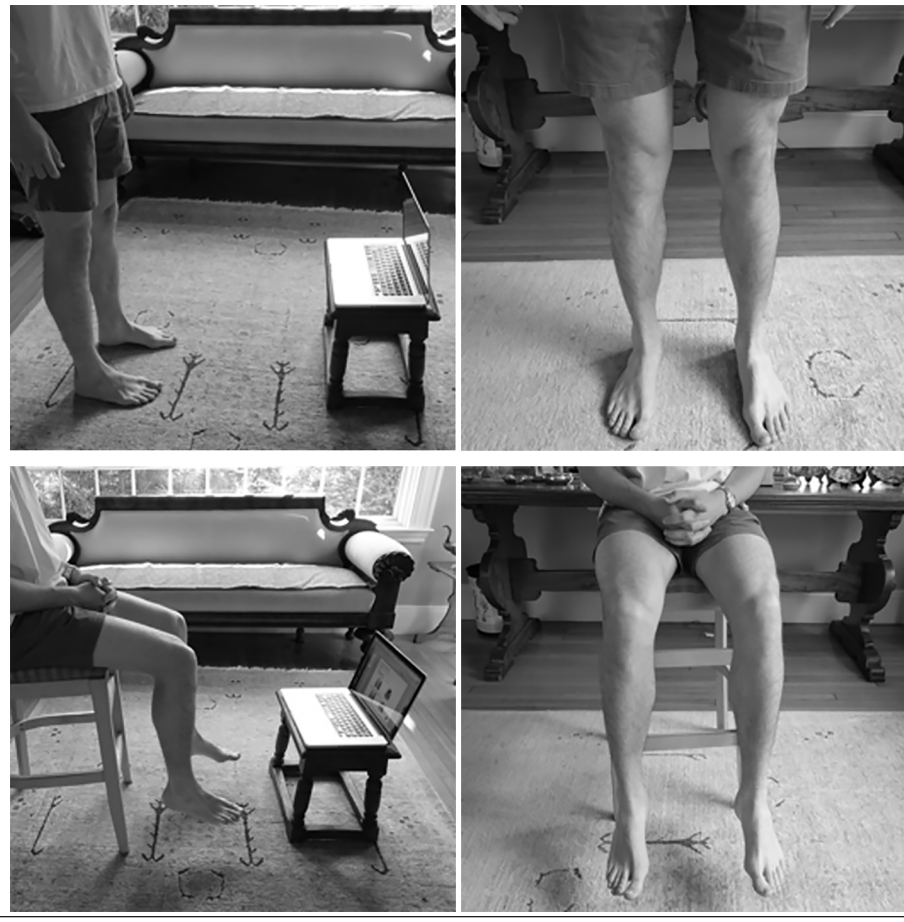

Figure 1. Examples of (top) standing and (bottom) seated patient setup to be used when asked by the provider to reposition.

detect asymmetries between legs during virtual examination. A family member or friend should assist, if possible, in the strength assessment, performing tests on both sides at the same time, and then reporting on strength of the affected side as well as symmetry. Strength tests may also be affected by inadvertent tensing or activating of different muscles.

Neurovascular. Though pulses cannot be palpated by the provider, perfusion and capillary refill can be assessed. It is also possible to differentiate between rubor associated with Charcot foot, which will resolve with elevation, and that associated with infection, which will not resolve with elevation. Patients should be asked to touch their skin on both the affected and unaffected sides and to report if they have the same sensation bilaterally. Of note, sensory feedback from the patient's own fingers touching the skin is a limitation of this self-administered neurovascular evaluation.

Special testing.

Pathology-specific testing includes tests for suspected flatfoot, cavovarus foot, hallux rigidus, and Achilles rupture pathologies. There are many pathologies that affect the foot and ankle, such that it would be impossible to include every examination in this review; however, this approach can be tailored as needed to investigate additional diagnoses. Inevitably, certain tests can only be performed accurately by a trained health care provider in person, but much can be done virtually.

Flatfoot. A standard heel raise test can be performed with the patient's lower legs positioned such that both hind feet and heels are in view of the camera. The patient should be asked to perform a heel raise bilaterally and then unilaterally. A negative test is denoted by the individual's ability not only to bring the heel off the ground, but also to invert the hindfoot in the process.[4]

Cavovarus foot. The Coleman block test can be performed by asking the patient to place a stack of magazines under the heel and lateral side of the foot with both hind feet and heels in view of the camera. The degree of correction with the stack placed under the heel can then be assessed.[9]

Table 2. Foot and Ankle Virtual Examination Template, Including a List of Each Examination to Be Performed, a Checklist for Medical Record Documentation, and Corresponding Verbal Instructions for Clinicians to Provide to Patients During the Virtual Examination.

Examination	Documentation	Verbal Instructions for Patient
Vital signs (provided on patient intake form if possible)		
Height and weight	☐ Height: _____ ☐ Weight: _____	
Temperature	☐ Temp: _____ ☐ Location: _____	
Heart rate (HR)	☐ HR: _____	
Blood pressure (BP)	☐ BP: _____/_____	
Gait		
Standard walking (heel to toe)	☐ Antalgic ☐ Coxalgic ☐ Trendelenberg ☐ Flexed knee ☐ Stiff knee ☐ Varus thrust ☐ Valgus thrust	"Walk directly away from the camera for at least four steps. Turn around and walk directly back toward the camera for at least four steps. Make sure you are in view of the camera while walking."
Toe walking	☐ Adequate calf/Achilles strength ☐ Weakened calf/Achilles	"Walk directly away from the camera on your tip toes for at least four steps. Turn around and walk back towards the camera on your tip toes."
Heel walking	☐ Adequate ankle dorsiflexion strength ☐ Weak ankle dorsiflexion strength	"Walk directly away from the camera on your heels for at least four steps. Then walk back towards the camera on your heels while staying in view of the camera throughout."
Inspection/palpation		
Hindfoot alignment (posterior view)	☐ Neutral ☐ Mild varus ☐ Severe varus ☐ Mild valgus ☐ Severe valgus	"Stand facing away from the camera so that the doctor can see the back of your legs and heels, from your feet to your knees."
AP foot alignment (from above)	☐ Neutral ☐ Mild abduction ☐ Severe abduction ☐ Mild adduction ☐ Severe adduction	"Stand and hold the camera over your feet so that the doctor can see your ankles and feet from above."
Tenderness	☐ Locate area of concern	"Point with one finger to the area of maximal tenderness while positioning the camera so that the doctor can see that area."
Skin integrity	☐ Dorsal surface integrity ☐ Plantar surface integrity	"While sitting, raise your foot so that the doctor can see the bottom surface. Then place your foot down and position the camera so that the top surface is visible."
Range of motion		
Dorsiflexion and plantarflexion	Active ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful Passive ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful	"While seated, position the camera so that the doctor can see the side of your foot. The foot being examined should be the one closest to the camera. Bend your knee to a 90-degree angle. First, using your own muscle power, bend your foot as far towards your shin as possible with your toes pointing up, then point your toes as far towards the ground as possible. Now manually manipulate the foot through the same motion, either yourself or with assistance from a family member or friend."
Gastroc tightness (compare to bent knee PF and DF above)	☐ Normal tightness ☐ Mild tightness ☐ Severe tightness	"Remain seated and perform the same motion as before, but with your knee straight. You may need to reposition the camera for the doctor to see your foot and ankle."

(continued)

Table 2. (continued)

Examination	Documentation	Verbal Instructions for Patient
Inversion and eversion	Active ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful Passive ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful	"Sit with the camera facing the front of your feet and ankles. First, using your own muscle power and trying to keep your toes facing forwards, rotate your foot as far inwards as possible, then as far outwards as possible. Now manually manipulate the foot through the same motion, either yourself or with assistance from a family member or friend."
Strength tests (assisted by an examiner)		"To complete the following tests, you will need someone to help provide resistance as you complete the described motions. This will give us a sense of your strength. Position the camera for each exercise so that the doctor can see your feet and ankles."
Ankle dorsiflexion strength	Remote Examiner ☐ Unable ☐ Very weak ☐ Somewhat weak ☐ Symmetric	"The examiner will place his/her hands on the top of each foot. The examiner will resist as you attempt to bend your ankles up such that your toes point toward your face, as if you are easing off of the gas pedal. The examiner will test both ankles at the same time and describe the strength as 'very weak,' 'somewhat weak,' or "same as other side."'
Ankle plantarflexion strength	Remote Examiner ☐ Unable ☐ Very weak ☐ Somewhat weak ☐ Symmetric	"The examiner will place his/her hands on the bottom of each foot. The examiner will resist as you attempt to press your feet down, as if you are pressing down on the gas pedal. The examiner will test both legs at the same time and will describe the strength as 'very weak,' 'somewhat weak,' or "same as other side."'
Big toe strength	Remote Examiner ☐ Unable ☐ Very weak ☐ Somewhat weak ☐ Symmetric	"The examiner will place his/her hands on the top of each big toe. The examiner will resist as you attempt to point your big toes toward your face. The examiner will test both big toes at the same time and will describe the strength as 'very weak,' 'somewhat weak,' or "same as other side."'
Eversion strength	Remote Examiner ☐ Unable ☐ Very weak ☐ Somewhat weak ☐ Symmetric	"The examiner will place his/her hands on the outside border of each foot. Resist the examiner as he/she pushes on the outside border of each foot. The examiner will test both legs at the same time and will describe the strength as 'very weak,' 'somewhat weak,' or "same as other side."'
Inversion strength	Remote Examiner ☐ Unable ☐ Very weak ☐ Somewhat weak ☐ Symmetric	"The examiner will place his/her hands on the inside border of each foot. Resist the examiner as he/she pushes on the inside border of each foot. The examiner will test both legs at the same time and will describe the strength as 'very weak,' 'somewhat weak,' or "same as other side."'
Circulation		
Foot perfusion (visual)	☐ Adequate perfusion visually ☐ Inadequate perfusion visually	"While seated, turn your foot so that the doctor can see the bottom surface. Then face the top surface of your foot to the camera."
Foot perfusion (temperature)	☐ Symmetric ☐ Cooler ☐ Hotter	"Does your foot feel the same temperature on both sides?"
Capillary refill	☐ <2 seconds ☐ >2 seconds	"Position the camera so that your doctor can see your toes. Press the soft pad of your big toe or toenail until it turns white. Then, release your thumb and allow it to pink back up. How long did it take to pink back up?"

(continued)

Table 2. (continued)

Examination	Documentation	Verbal Instructions for Patient
Pitting edema	☐ None ☐ Mild ☐ Moderate ☐ Severe	"Make sure your lower leg is in view of the camera. Using two fingers, press down on the front of your shin just above your ankle."
Calf pain	☐ Pain ☐ No pain	"Squeeze your calf. Does this cause you pain?"
Homan	☐ Negative ☐ Positive	"Use a belt to pull your ankle up as if you are stretching your calf. Does this cause you pain?"
Neuromuscular		
Numbness or tingling	☐ Numbness absent ☐ Tingling absent ☐ Numbness reported ☐ Tingling reported	"Do you feel any numbness or tingling in your foot or ankle? If so, point to the area where the sensation occurs. Position the camera so that the doctor can see this area."
Individual nerves:		"We are going to test sensation in some specific locations. Please use your other hand to touch. . . ."
SPN	☐ Normal ☐ Numbness ☐ Painful touch	" . . . the top of both feet."
DPN	☐ Normal ☐ Numbness ☐ Painful touch	" . . . the webspace between your big toe and the second toe."
Tibial	☐ Normal ☐ Numbness ☐ Painful touch	" . . . the bottom center of both feet."
Sural	☐ Normal ☐ Numbness ☐ Painful touch	" . . . the outside of both feet."
Saphenous	☐ Normal ☐ Numbness ☐ Painful touch	" . . . the inside of both calves."
Condition-specific tests		
Flatfoot: heel raises	☐ Normal ☐ Heel off ground but no inversion ☐ No heel off ground	"Stand and position the camera so your lower legs and feet are in the frame and you are facing away from the doctor so that they can see your heels. You should be positioned against a wall and can place your hands on the wall for balance. While standing on both feet, lift up so you are on your toes. Now repeat this exercise standing on one foot, taking the other leg completely off the floor with the knee bent at 90 degrees so that your foot is behind you. Finally, repeat on the other side."
Cavovarus foot: Coleman block test	☐ Correction to neutral ☐ No correction to neutral	"Stand and position the camera so your lower legs and feet are in the frame and you are facing away from the doctor so that they can see your heels. Stand on a stack of magazines or something of similar height such that your heel and the outside of the foot are on top of the stack, and your first, second, and third toes hang freely off the edge of the stack."
Hallux rigidus: Big toe ROM	Active ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful Passive ROM ☐ Normal ROM ☐ Limited ROM ☐ Motion painful	"Position the camera so that your toes are visible while seated. Bend your big toe up and down through its full range of motion. Describe any sensations of pain, clicking, or grinding that may arise while doing this."

(continued)

Table 2. (continued)

Examination	Documentation	Verbal Instructions for Patient
Achilles rupture: Thompson test	☐ Normal ☐ Pathological	"This test will require an assistant. Lie face down on the floor, a couch, or a bed with your knees bent 90 degrees so that your feet are in the air. Position the camera so your lower leg and foot are visible to the doctor. Relax your muscles completely while the assistant squeezes and releases your calf muscles. Do your toes become pointed during squeezing?"

Abbreviations: AP, anteroposterior; DF, dorsiflexion; DPN, deep peroneal nerve; PF, plantarflexion; ROM, range of motion; SPN, superficial peroneal nerve.

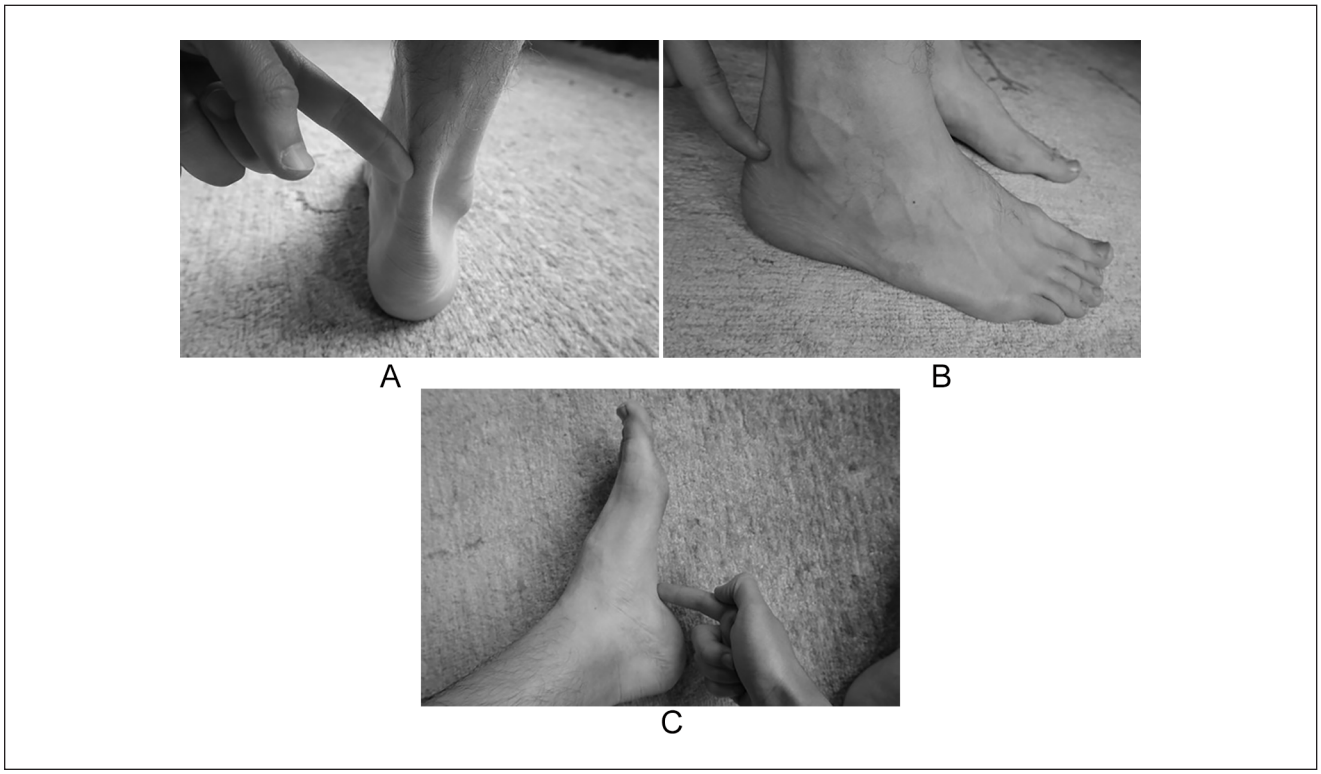

Figure 2. Images demonstrating a single finger used to identify the (A) Achilles tendon, (B) peroneal tendon, or (C) plantar fascia.

Hallux rigidus. A hallux rigidus ROM test can be performed with the patient's involved toe in view of the camera, though it is subject to the same limitations mentioned previously for ROM testing. The patient should be instructed to both actively then passively bend the big toe up and down through its full range of motion, reporting any sensations of pain, clicking, catching, or grinding.[7]

Achilles rupture. The Thompson test can be performed with an assistant. The patient should lie prone on the floor, a couch, or a bed with feet hanging freely off the edge, and the camera should be positioned so that the affected lower leg is in view. A family member or friend should gently squeeze the midcalf and watch for ankle plantarflexion, equal to the opposite leg (denoting a negative or normal test).[18]

Postoperative foot and ankle examination

For patients in the first 6 weeks postoperatively, the core foot and ankle examination can be utilized, though when patients are non–weight bearing, maneuvers involving placing weight on the foot are avoided and strength testing is somewhat limited. The purpose of this examination is to identify any concerns that would require additional in-person follow-up and evaluation. For postoperative patients, the provider should instruct the patient to adjust camera positioning to allow for full visualization of the incision site. Wound healing, erythema, drainage, ecchymosis, and rash should be evaluated. Range of motion on the involved side can also be compared to the contralateral side and should be noted accordingly on the provider checklist. A

virtual goniometer may be helpful in assessing range of motion and can be used across multiple visits to track progress in range of motion.[17]

Implementation of Virtual Physical Examination

We recommend performing the core foot and ankle examination followed by any appropriate special tests. Three workflows may be used, as described by J. Lamplot and S. Pinnamaneni for shoulder and knee virtual examinations (unpublished data, July 2020). The 3 options are summarized below:

1. *Examination Reveal*: The provider instructs the patient to perform the physical examination for the first time during the initial telehealth visit. Though this method avoids any work to be done by the clinician before the visit, it requires more time during the visit to explain the maneuvers to patients.
2. *Comprehensive Preview:* The provider may review the patient intake form before the telehealth visit to generate a differential diagnosis and may then send video demonstrations of both the core examination and any relevant special tests to the patient to be reviewed and potentially practiced before the telehealth visit. J. Lamplot and S. Pinnamaneni report that, in their experience, patients tend to become overwhelmed when this model is implemented and exhibit the same familiarity with the examination protocols as the "Examination Reveal" group (unpublished data, July 2020). However, because the number of tests for the foot and ankle is relatively low, the concern may prove less relevant in implementing this workflow for a virtual foot and ankle examination.
3. *Core Examination Preview:* The provider may send video demonstrations of only the core examination maneuvers to the patient before the telehealth visit, while any special testing is performed during the visit with guidance from the provider. This alternative avoids the overwhelming volume of information for patients in the "Comprehensive Preview" model, but the patient's familiarity with the basics of the examination allow for more efficient use of time during the telehealth visit.

Benefits of Telehealth

The benefits of telehealth, particularly for applications in musculoskeletal health, have started to be explored in the literature. One randomized controlled trial comparing telehealth and in-person visits for follow-up after orthopedic trauma reported that telehealth patients spent less time for their visits on average, and no telehealth patients took time off work for their appointment, compared to 55.6% of patients who had in-person visits.[12] One retrospective study reported similar findings with respect to the time efficiency of telehealth appointments for patients, with an average wait time of 13 minutes for virtual visits vs 41 minutes for subsequent in-person visits.[16] Atanda et al report a similarly large difference in average wait times, 2 minutes for telehealth vs 33 minutes for in-person, as well as average visit times, 15 minutes vs 68 minutes on average.[2] Though patients report significant time saved for telehealth appointments given the nature of a virtual visit, studies have suggested that for clinicians, telehealth requires more flexibility, and potentially more preparation and overall time spent,[12,16] though to date the literature has not explored these points in detail.

In addition to saving time for patients during a single visit, telehealth services may also prevent further future utilization of resources. When comparing telehealth and in-person visits following total hip or total knee arthroplasty, Sharareh and Schwarzkopf report significantly fewer unscheduled clinic visits and clinic calls in the telehealth group, although they evaluated patients during the initial postoperative period when they had limited mobility and may have been less likely to seek an in-person clinic visit.[13] Future research is needed to corroborate these findings. When further evaluating the economic costs between telehealth and in-person visits for fracture care, another study found that both direct and indirect costs were lower for telehealth.[14] Other authors also support the cost-effectiveness of telehealth, suggesting that on average families saved 85 miles and $50 in costs, along with $24 in labor costs per telehealth visit.[2] Given the convenience, efficiency, and cost-saving benefits of telehealth, these services have consistently produced overall patient satisfaction rates around 90% in the existing literature.[2,12,14,15]

Several authors have proposed that telehealth services may be best used in a postoperative setting.[1,6,13] Abel et al compared in-person and virtual visits completed 24 hours apart for patients who underwent arthroscopic knee surgery. These authors observed strong agreement between in-person and virtual visits in their documentation of range of motion, incision characteristics, and effusion size.[1] Other authors have similarly found that virtual physical examinations, as well as assessment of wounds and nerve symptoms, largely agreed with in-person assessment, and that postoperative wound complications following upper extremity procedures were easily identified on a telehealth platform.[1,6,19] When comparing in-person and virtual postoperative visits, the literature generally reports no difference in postoperative complication rates between groups, suggesting that virtual visits most often do not cause providers to miss a complication requiring further intervention.[1,13] However, if a concern is identified during a virtual postoperative visit, subsequent in-person follow-up and additional use of resources may be needed to address the

issue, which represents an inefficiency of virtual visits. One study evaluating postoperative care also reported difficulty with virtually assisting patients in removing their own sutures, which over one third of patients were unable to do, again requiring an additional in-person follow-up.[19] In addition to suture removal, postoperative visits may require cast application or change, immediate issue of prescriptions, and urgent wound care, along with any necessary written consents, which would require in-person visits.

Limitations of Telehealth

We acknowledge that some providers and patients still consider in-person evaluation and physical examination to be optimal. However, we believe that the guidance and checklist provided for virtual foot and ankle examinations allow for accurate and efficient virtual assessment. Particularly with respect to the foot and ankle, many of the standard examinations can be performed relatively easily and accurately by the patient, though the possibility of misinterpretation of results remains a concern. We have outlined a protocol for patients with regard to camera placement, angle, and lighting. Reported rates of patient satisfaction with video and audio quality are high in the existing literature, with one study reporting sufficient video quality for 87.5% of patients and sufficient audio quality for 100% of patients.[12] Nevertheless, the virtual assessment may not lead to the same interpretation as an in-person examination. As such, treatment plans should be based on a combination of virtual physical examination findings, imaging, and patient history. Subsequent in-person visits should follow if findings on the virtual physical examination conflict with other available information.

In addition to potential reluctance from providers to adopt telehealth more widely, some patients may be unable or unwilling to transition away from in-person visits. First, patients may be unable to access a device or reliable Internet connection to participate in telehealth consultations. Certain populations, particularly elderly patients or patients with technological barriers to accessing care, may be unable to participate in telehealth services. Several existing studies have evaluated the utility of telehealth only in pediatric or younger populations.[1,14] Some patients may otherwise be uncomfortable with virtual visits, as evidenced by randomized control trials that have assigned patients to telehealth or in-person visits, with around 10% to 20% of patients declining to participate citing a lack of computer access, significant problems warranting in-person consultation, or preference for an in-person visit.[3,8,11] This preference may be shared by many patients and providers, as in-person discussions likely foster stronger patient-provider relationships, which allows patients to develop more trust in their providers and potentially helps in avoiding misunderstandings. One study reported that one-third of patients and nearly one-half of physicians preferred in-person visits, in part to establish a stronger personal connection between patient and provider.[5]

Future Directions for Telehealth

Given the present need for telehealth solutions as a result of COVID-19 restrictions and social distancing guidelines, patients and providers have experienced the relative benefits and limitations of virtual visits. The demand for telehealth services is likely to persist beyond the resolution of the current crisis, and this transition can be aided by a reliable framework for the implementation of telehealth services. Although many studies have focused on telehealth in remote or rural settings, we also see potential benefits of its use in densely populated areas where parking may be expensive, or congestion may make transit difficult. However, the convenience and other benefits of telehealth must be tempered by the potential loss of accuracy from virtual examinations. Often, an experienced clinician will seek the tactile assessment of an in-person examination, which has been honed and mastered through years of repetition. A trained clinician is best equipped to detect subtleties that might otherwise be undetected by the patient during a virtual examination. Furthermore, telehealth is currently limited with regard to stability testing for the ankle, as well as many other joints. At the very least, telehealth in orthopedics may be best suited as a screening tool, with further in-person visits, advanced imaging, or surgical consultation to follow as needed. Subsequent radiographic follow-up can be done at a location convenient for the patient, with images then forwarded to the treating physician. Telehealth also presents an opportunity for many different types of providers, including physician assistants, nurse practitioners, athletic trainers, and physicians, to consult and triage patients effectively, in the process improving access to care and perhaps even accelerating the appropriate consultations for a specific patient.

Telehealth may also prove particularly useful for postoperative care, as several authors have explored following orthopedic surgery.[1,6,13,19] Postoperative visits requiring a short physical examination, review of imaging, and discussion between patient and provider can be done effectively through a virtual visit, and one study suggests that this alternative may even improve patient satisfaction with the quality of their care.[13] We also see a potential use for telehealth visits preoperatively, where details of the planned surgery can be reviewed, giving patients and providers the opportunity to discuss the plan of care without requiring an additional in-person visit.

Conclusion

With the dramatic increase in virtual health care visits as a result of the COVID-19 pandemic, both patients and providers have experienced the merits and drawbacks of

adopting more routine use of telehealth services. Because of the convenience and efficiency associated with virtual visits, we expect that patient interest in telehealth services will likely persist. Though virtual visits do not allow for a traditional in-person physical examination by the provider, a critical component of musculoskeletal evaluation, a standard foot and ankle physical examination can still be achieved virtually with modification. We have detailed both a core examination and special pathology-specific tests, along with a provider checklist and verbal instructions for patients. We believe that this standardized guidance will allow for a reliable virtual examination whereby a provider can extract many of the same findings that would historically be found through an in-person examination. Further work is required to assess the accuracy of the findings during virtual examinations, as well as which findings should be used as indicators for further workup, subsequent in person visits, or appropriate triage to ensure the highest quality of care.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Stephanie K. Eble, BA, https://orcid.org/0000-0002-6425-5112
Oliver B. Hansen, BA, https://orcid.org/0000-0003-3736-6797
Scott J. Ellis, MD, https://orcid.org/0000-0002-4304-7445

Supplemental Material

A supplemental video for this article is available online.

References

1. Abel KC, Baldwin K, Chuo J, et al. Can telemedicine be used for adolescent postoperative knee arthroscopy follow-up? *JBJS J Orthop Physician Assist* 2017;5(4):e26.
2. Atanda A, Pelton M, Fabricant PD, Tucker A, Shah SA, Slamon N. Telemedicine utilisation in a paediatric sports medicine practice: decreased cost and wait times with increased satisfaction. *J ISAKOS*. 2018;3(2):94.
3. Buvik A, Bergmo TS, Bugge E, Smaabrekke A, Wilsgaard T, Olsen JA. Cost-effectiveness of telemedicine in remote orthopedic consultations: randomized controlled trial. *J Med Internet Res*. 2019;21(2):e11330-e11330.
4. Deland JT. Adult-acquired Flatfoot Deformity. *J Am Acad Orthop Surg*. 2008;16(7).
5. Donelan K, Barreto E, Sossong S, et al. Patient and clinician experiences with telehealth for patient follow-up care. *Am J Manag Care*. 2019;25(1):40-44.
6. Grandizio LC, Foster BK, Klena JC. Telemedicine in hand and upper-extremity surgery. *J Hand Surg*. 2020;45(3):239-242.
7. Ho B, Baumhauer J. Hallux rigidus. *EFORT Open Rev*. 2017;2(1):13-20.
8. Kane LT, Thakar O, Jamgochian G, et al. The role of telehealth as a platform for postoperative visits following rotator cuff repair: a prospective, randomized controlled trial. *J Shoulder Elbow Surg*. 2020;29(4):775-783.
9. Krähenbühl N, Weinberg M. Anatomy and biomechanics of cavovarus deformity. *Foot Ankle Clin*. 2019;24(2):173-181.
10. Loeb AE, Rao SS, Ficke JR, Morris CD, Riley LH 3rd, Levin AS. Departmental experience and lessons learned with accelerated introduction of telemedicine during the COVID-19 crisis. *J Am Acad Orthop Surg*. Published online April 14, 2020:10.5435/JAAOS-D-20-00380. doi:10.5435/JAAOS-D-20-00380
11. Marsh J, Bryant D, MacDonald SJ, et al. Are patients satisfied with a web-based followup after total joint arthroplasty? *Clin Orthop Relat Res*. 2014;472(6):1972-1981.
12. Sathiyakumar V, Apfeld JC, Obremskey WT, Thakore RV, Sethi MK. Prospective randomized controlled trial using telemedicine for follow-ups in an orthopedic trauma population: a pilot study. *J Orthop Trauma*. 2015;29(3):e139-e145.
13. Sharareh B, Schwarzkopf R. Effectiveness of telemedical applications in postoperative follow-up after total joint arthroplasty. *J Arthroplasty*. 2014;29(5):918-922.e1.
14. Sinha N, Cornell M, Wheatley B, Munley N, Seeley M. Looking through a different lens: patient satisfaction with telemedicine in delivering pediatric fracture care. *J Am Acad Orthop Surg Glob Res Rev*. 2019;3(9):e100-e100.
15. Soegaard Ballester JM, Scott MF, Owei L, Neylan C, Hanson CW, Morris JB. Patient preference for time-saving telehealth postoperative visits after routine surgery in an urban setting. *Surgery*. 2018;163(4):672-679.
16. Sultan AA, Acuña AJ, Samuel LT, et al. Utilization of telemedicine virtual visits in pediatric spinal deformity patients: a comparison of feasibility and patient satisfaction at a large academic center. *J Pediatr Orthop*. Published online March 2020. doi:10.1097/bpo.0000000000001553.
17. Tanaka MJ, Oh LS, Martin SD, Berkson EM. Telemedicine in the Era of COVID-19: the virtual orthopaedic examination. *J Bone J Surg Am*. Published online April 2020. doi:10.2106/jbjs.20.00609.
18. Thompson T. A test for rupture of the tendo Achilles. *Acta Orthop Scand*. 1962;32:461-465.
19. Tofte JN, Anthony CA, Polgreen PM, et al. Postoperative care via smartphone following carpal tunnel release. *J Telemed Telecare*. 2018;26(4):223-231.
20. Vohralik SL, Bowen AR, Burns J, Hiller CE, Nightingale EJ. Reliability and validity of a smartphone app to measure joint range. *Am J Phys Med Rehabil*. 2015;94(4):325-330.
21. Wang KY, Hussaini SH, Teasdall RD, Gwam CU, Scott AT. Smartphone applications for assessing ankle range of motion in clinical practice. *Foot Ankle Orthop*. 2019;4(3):2473011419874779.