George G.A. Pujalte (Orcid ID: 0000-0002-7537-7457)

[Category: Review]

Foot Evaluation Via Telephone and Video Virtual Medical Visits

Andres I. Applewhite, MD

George G.A. Pujalte, MD

Keri Denay, MD

Mitchell J. Odom, MD

Azael Arizpe, MD

Shirley Albano-Aluquin, MD

Anja M. Kinaszczuk, DO

Amiethab Aiyer, MD

Author Affiliations: Department of Family Medicine (Drs Applewhite, Pujalte, and Kinaszczuk) and Department of Orthopedics and Sports Medicine (Dr Pujalte), Mayo Clinic, Jacksonville, Florida; Department of Family Medicine (Drs Denay and Odom), University of Michigan, Ann Arbor, Michigan; Department of Orthopaedics (Drs Arizpe and Aiyer), University of Miami, Miami, Florida; and Department of Rheumatology (Dr Albano-Aluquin), Penn State Milton S. Hershey Medical Center, Hershey, Pennsylvania.

Corresponding author: George G.A. Pujalte, MD, Departments of Family Medicine, and Orthopedics and Sports Medicine, Mayo Clinic, 4500 San Pablo Rd, Jacksonville, FL 32224 (Pujalte.george@mayo.edu Phone: 904-953-6722 Fax: 904-953-0625).

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Abstract

Telemedicine, also known as telehealth, has a very important role in our society by allowing providers to treat patients who don't have easy access to a health-care facility. Additionally, the COVID-19 pandemic has created challenges such as limited social interactions. Telemedicine is a practical and efficient strategy to deliver health care despite social distancing. However, musculoskeletal diseases, in general, are challenging problems to address via telemedicine because diagnoses rely on physical examination; nevertheless, a well-planned virtual consultation for musculoskeletal foot problems may yield successful results. This is especially true if physicians have a well-planned guide with questions, instructions, and examination maneuvers on which to rely during the consultation. With this narrative review, we seek to deliver a guide, with suggestions, questions, and interpretations of answers included, to help physicians who are novices in the practice of telemedicine have successful virtual encounters with patients suffering from foot musculoskeletal ailments.

Keywords: COVID-19; evaluation; foot; telemedicine; telephone

Introduction

The COVID-19 pandemic has changed our lives in multiple important ways. Social distancing has mandated a reevaluation of the way physicians effectively handle the increasing patient load (Wosik et al., 2020). An effective strategy to approach this is by conducting medical evaluations virtually (by telephone or video call), which is known as *telemedicine* or *telehealth* (He et al., 2020). Virtual medical visits are not only useful during times of social distancing, but also offer healthcare access to people living in far away or underserved areas (Rutledge, Haney, Bordelon, Renaud, & Fowler, 2014). Furthermore, there is a certain monetary and psychological cost involved in waiting times, time off work, and transportation associated with in-person visits, which may be alleviated by virtual consultations. A Norwegian study evaluating the cost-effectiveness of telemedicine in orthopaedic consultations found that for 300 consultations, the cost savings amounted to approximately €18,616 ($22,576) (Buvik, Bergmo, et al., 2019).

It is estimated that 40% of the US population suffer from foot problems (Ho & Baumhauer, 2017). Patients would benefit greatly if more physicians learn to effectively examine and manage these problems through virtual consultations. Foot evaluations present unique challenges because it is a relatively small body area with many anatomic components. There are 26 bones, 33 joints, and more than 100 ligaments, tendons, and muscles in each foot (Coughlin, Saltzman, & Anderson, 2014). However, the advantage of foot evaluations is that a lot of anatomic components commonly suffering injury are located superficially and may therefore be recognizable when patients point out location of maximal discomfort. Through a properly executed video medical visit, practitioners may successfully perform full evaluations and recommend management plans. Furthermore, as technology improves, telemedicine will become increasingly precise and efficient. Interestingly, a systematic review by Hazenberg et al (2020)

looked into the feasibility, effectiveness, costs, and limitations of prototype devices used for diabetic patients. The aim was to prevent, assess, monitor, and manage diabetic foot pathology via telemedicine. Results suggested that some of these devices showed promising results (Hazenberg et al., 2020).

Patient satisfaction is extremely important. Even with the benefits of telemedicine, some patients may be unwilling to engage in virtual visits due to a variety of reasons. However, some studies suggest that after patients partake in a virtual visit, satisfaction levels are comparable to in-person consultations (Howard & Kaufman, 2018). A study conducted at the University Hospital of North Norway evaluated the personal satisfaction of 389 orthopedic patients based on self-filled surveys after having either a traditional doctor's visit or a telemedicine video visit. Results indicated that both groups had the same percentage of positive contentment-level. Furthermore, 89% expressed a preference for video-assisted consultation for their next appointment (Buvik, Bugge, Knutsen, Smabrekke, & Wilsgaard, 2019).

To accomplish a telemedicine visit effectively, physicians need to have an in-depth understanding of foot anatomy, injury mechanics, classical findings, and be familiar with current management guidelines. Also, they need to thoroughly and systematically approach every case to ensure details are not missed, as these can lead to incorrect diagnosis. Though many physical examination maneuvers and special tests may be performed virtually, some are simply not possible. If during an encounter the physician considers the case merits a face-to-face evaluation, the patient should be scheduled for an in-office appointment.

The intention of this paper is to serve as a guide for executing a virtual medical visit for patients with musculoskeletal foot problems. This is not an exhaustive guide that covers every possible foot concern, but rather a template for how a virtual encounter should be carried out,

while covering some common foot lesions. Every encounter should be tailored to each specific case and guided by patient answers.

Proper Setting for Consultation

Before starting the telemedicine visit, patients must comply with a few conditions to maximize benefits. The patient should wear shorts that end above the knee and wear no shoes or socks. This allows ample exposure of the foot, ankle, and knees. A portable tablet or laptop with tilting capabilities and a camera should be used. A mobile phone may also be utilized; however, it may be difficult to stabilize and tilt it (a person assisting the patient may help do this). The room should be large enough to allow the patient to take at least 4-6 steps for gait evaluation. The area should be well-lit with the camera oriented in the correct direction for proper visualization, ensuring no strong backlight (e.g., from a window or lightbulb) disturbs the video. Different camera angles, heights and positions will be required throughout the evaluation. Finally, for the seated part of the examination, a stool high enough to allow free movement of feet (no contact with the ground) will be ideal. Preferably, a checklist with requirements would be given to the patient a few days prior to the appointment to allow proper preparation.

History Taking

As with any medical consultation, the first step should be to obtain a comprehensive history of the patient's background and events that resulted in seeking medical attention. Details of the chief complaint, previous injuries, social, medical and surgical history, allergies, and current medications should be carefully questioned, as well as a review of each organ system. Finally, measurements such as height, weight, and vital signs may be taken by the patient and

reported to the physician as part of a comprehensive medical evaluation and billing purposes if sphygmomanometer, scale, and thermometers are available. It is helpful to obtain information regarding the type and age of footwear most commonly used by the patient, as this could yield clues pertaining to the source of pain (Dufour et al., 2009). It is also important to question patients regarding use of walking aid (i.e., walker or cane). Associated symptoms should always be inquired as well. Fever, sweating profusely during the night, and loss of weight may be related to an infection or a malignant process. If there is swelling present on both feet, it is likely a systemic problem such as kidney or heart disease, or a circulatory problem. Neurological symptoms such as weakness or numbness are commonly related to problems in the spinal cord or peripheral neuropathy. If a traumatic event took place, it is essential to ask about any swelling or bruising at the time of injury and later.

The Telephone Visit

Telephone visits without the visual aid of a camera require an especially thorough, careful, and thoughtful questioning process. After initial history is obtained, specific questions and diagnostic test maneuvers may be employed via verbal instructions at the discretion of the physician. The physician should always use terms the patient easily understands and rephrase when the patient does not or is providing ambiguous or unhelpful responses. **Table 1** presents a set of possible questions to ask the patient, examples of tests that can be performed, and possible interpretation of patient responses. To be as consistent as possible, it helps to frame questions while maintaining standardized anatomic positioning in mind. This should be explained to the patient. If the patient has access to a portal or web-based health care system, they may be able to take pictures of their foot or ankle and upload them for the physician to review.

The Video Visit

Like any other medical consultation, beginning the patient interview with questions about course, onset, duration, intensity, exacerbating and relieving factors, and associated symptoms as part of their history will help the clinician formulate subsequent targeted questions. After taking a thorough history, examination of the foot consists of inspection, palpation, range of motion testing, strength testing, and neurovascular assessment. As part of the inspection, it is crucial to note the wear marks on both the sole and heel of the patient's footwear, for this can yield useful information. For example, early lateral, proximal, and mid shoe wear, indicate a supination deformity, whereas wear on the medial border indicates a pronation deformity (Coughlin et al., 2014; Dufour et al., 2009). The patient should also be asked about the use of insoles and walking aids.

Inspection

The physician should closely evaluate the quality of the skin as well as any deformities, injuries, abrasions, ulcers, scars, edema, ulcers, discoloration, atrophy, ecchymosis, and misalignments. This is especially important in patients with diabetes mellitus due to the increased risk of developing ulcers (Schaper et al., 2016). For the physician to completely inspect the feet, several different views with repositioning of the camera will be involved with the patient standing and sitting. Lighting is crucial during this part of the consultation. **Table 2** shows some suggestions on how to guide the patient through inspection during a virtual encounter.

Video of Patients Ankle and Feet – Dorsal and Plantar View

The patient should start by placing the camera on the floor, or a few inches from it, and expose both feet and ankles side by side. Careful evaluation of the skin and any deformities should take place for they may yield important clues. The tripod-like structure of the foot (i.e., center of calcaneus, head of fifth metatarsal, and head of first metatarsal) should be cautiously evaluated for they support the weightbearing axis of the leg and are important pressure points. Plantar ecchymosis for example could be indicative of a Lisfranc injury and should be evaluated with radiographic imaging in the setting of trauma (Moracia-Ochagavia & Rodriguez-Merchan, 2019).

Video of the Patient's Ankle and Feet – Lateral View

From this angle, physicians may evaluate the medial and lateral aspects of each foot, as well as the arches and the way they contact the floor. In a cavovarus deformity, elevation of the medial arch and a short medial column will be evident (Krahenbuhl & Weinberg, 2019). Also, movement of the hallux will easily be visible for evaluation of range of motion. Limitation of hallux range of motion could be a sign of hallux rigidus and will be evident when comparing to the contralateral side (Ho & Baumhauer, 2017).

Video of the Patient's Ankle and Feet – Posterior View

From this view hindfoot and ankle alignments may also be evaluated, which should be neutral to slightly valgus under normal conditions. Only the fourth and fifth toes should be visible from this angle. If more are seen, referred to as *too many toes sign*, increased heel valgus in the setting of an adult acquiring flat foot may be present; however, it is important to compare

both sides of the foot as this could also be caused by the legs being externally rotated. At this point, the patient should be asked to stand on their tiptoes if possible. Both ankles should fall into a varus alignment if there is normal subtalar movement (Krahenbuhl & Weinberg, 2019). Furthermore, in the setting of flat feet, if an arch forms medially when standing on tiptoes, this is a sign that the flat foot deformity is flexible (Alazzawi, Sukeik, King, & Vemulapalli, 2017). If the patient is unable to assume a posture on tiptoes, there may be an Achilles tendon injury and further tests should be performed.

Video of Patients Lower Limb – Frontal View

This first view requires the patient to stand up straight and face the camera with feet together. The camera may be raised to about knee level to expose an ample view of patient's feet, ankles, and knees. This will allow the physician to do a general inspection of the lower limbs before focusing more closely on the feet and ankles. Patient should be asked to do a slow 360° turn on their longitudinal axis to appreciate lower limbs from the sides and posteriorly as well. Any obvious large areas of skin change anywhere on the leg should be visible. Also, misalignment of the heel, more easily appreciated from this view, may be due to varus or valgus angulations and may cause foot problems. For example, the heel pad being visible from the front of the patient, referred to as *peek-a-boo sign*, may indicate varus angulation (Alazzawi et al., 2017). Physicians should ask patients to walk away and towards the camera (several times if necessary) while carefully examining gait. If possible, patients should be asked to repeat this walk on their tiptoes and again on their heels, as each of these maneuvers may yield different clues. **Table 3** shows some gait patterns and common related pathologies (Alazzawi et al., 2017;

Gandbhir, Lam, & Rayi, 2020; Pirker & Katzenschlager, 2017; Ruzbarsky, Scher, & Dodwell, 2016; Sharma, Sinha, Narang, Chouhan, & Gupta, 2020).

Palpation

The physician must rely on asking patients to palpate their own body. It is important to ask the patient to show with 1 finger where the pain is worst to narrow down the anatomic culprit (Alazzawi et al., 2017). An advantage of foot evaluations is that there is relatively little space between bone and skin, so the outline of some underlying anatomic structures may be observed. Further, with a good knowledge of foot anatomy, it is conceivable for the physician to pinpoint the offending structure by the patient's indication of maximal discomfort site. **Table 3** shows common pain locations, the underlying anatomic structures, and possible causal pathologies (Alazzawi et al., 2017; Berman, Tafur, Ahmed, Huang, & Chang, 2017; Besse, 2017; Bowes & Buckley, 2016; Drakos, Fiore, Murphy, & DiGiovanni, 2015; Lui, 2017; Munir, Tafti, & Morgan, 2020; Tu, 2018; Wentzell, 2018). **Table 2** shows some suggestions on how to guide the patient through palpation during a virtual encounter.

Range of Motion

The physician must direct the patient through a full range of motion evaluation (flexion, extension, abduction, adduction, inversion and eversion of foot as well as exploration of metatarsophalangeal and interphalangeal joints), several times if necessary, looking for asymmetries, pains, or clicks. If a helper or proxy examiner is present, they may move the patient's joint to explore passive ROM, as these are more reliable than active movements which may interfere with measurements (Eble, Hansen, Ellis, & Drakos, 2020). Several mobile

telephone–based joint angle measurement tools (i.e., goniometers) have proven to be reliable and accurate. These may be used on several articulations, including the ankles and toes (Mourcou, Fleury, Diot, Franco, & Vuillerme, 2015). **Table 2** shows some suggestions on how to guide the patient through range of motion testing during a virtual encounter.

Strength Testing

Two important challenges of a virtual foot evaluation are strength testing and neurovascular assessment. If a family member or proxy examiner is available, the physician may instruct them to oppose different foot bilateral movements simultaneously and report if a notable difference in resistance is appreciated. If no assistant is available, patients may be asked to execute maneuvers such as standing on their tiptoes (which would indicate a 4/5 in strength in plantar flexion muscles). They may also be instructed to attempt resisting foot movements with their hands and compare sides; however, these techniques yield limited information. **Table 2** shows some suggestions on how to guide the patient through strength testing during a virtual encounter.

Neurovascular

For vascular assessment, it is less reliable for patients to palpate their pulses; however, perfusion and capillary refill of toenail beds can be easily explored with appropriate instructions. While assessing integrity of sensory nerves is challenging, the patient may be asked to gently stroke different parts of the foot with an instrument, such as a pencil, preferably with their eyes closed (to eliminate visual input) and compare with the opposite limb. **Table 2** shows some

suggestions on how to guide the patient through neurovascular assessment during a virtual encounter.

Radiographic Considerations

Radiographic studies are a very important compliment if findings from a telemedicine visit are suggestive of osseous injury. Patients may have studies done locally and uploaded into a virtual imaging system, or physically mailed to the treating physician to be analyzed. Imaging results can help guide management, particularly if the etiology is not completely clear based on telephone or video evaluation alone.

Limitations of Telemedicine

Some people, both physicians and patients, may not be inclined to engage in telemedicine for a variety of reasons. However, a carefully planned and executed virtual medical visit may offer a multitude of benefits and yield very successful results. Many physical examination tests normally performed during a foot evaluation may be executed by patients on themselves or a proxy examiner under the direction of a physician, nevertheless it is possible that patients execute or interpret the results of a specific maneuver incorrectly, which may ultimately lead to incorrect diagnosis. This misfortune can be minimized if an exhaustive patient history is considered carefully with a thorough physical examination, including multiple maneuvers, and imaging if available. If a video visit results inconclusive, patients should be encouraged to schedule an in-person appointment.

Telemedicine only works well if the technology used is at least adequate (e.g., stable internet and software, suitable cameras, speakers and microphones) and if the patients are

familiar with the technology. These two factors are sometimes limiting in isolated places or third world countries, and more commonly with geriatric patients. However, as technology improves and becomes more accessible, each new generation is more adept to using it.

Patient satisfaction is an extremely important factor of any medical visit. Though many studies comparing patient satisfaction between cohorts of patients assigned to traditional in-person visits versus cohorts assigned to telehealth show patient satisfaction to be the same on both groups, this may not be the case for all. Many physicians and patients prefer traditional in-person visits for they foster stronger relationships, which ultimately encourage more trust in patients towards their providers.

Conclusion

There is real value in telemedicine that extends beyond times of pandemics. By mastering the skill of performing virtual evaluations, we can extend the reach of medical care to cover people who live in remote areas. It's crucial to have a guide and follow a specific sequence during telehealth visits. This allows the physician to be thorough and effective. Almost half of the US population suffers from foot ailments; therefore, it is important to have an effective method of conducting foot evaluations in a virtual fashion. Despite traditional in-person visits having many benefits, virtual visits fill a very specific but important need in today's healthcare system. Telemedicine should not be thought of as a replacement for traditional in-person visits, rather it is another instrument in the toolbox that physicians may use. Lastly, it is important to consider radiologic imaging if the findings from the evaluation indicate an osseous injury or if etiology is not completely clear based on telephone or video evaluation alone.

References

Alazzawi, S., Sukeik, M., King, D., & Vemulapalli, K. (2017). Foot and ankle history and clinical examination: A guide to everyday practice. World J Orthop, 8(1), 21-29. doi:10.5312/wjo.v8.i1.21

Berman, Z., Tafur, M., Ahmed, S. S., Huang, B. K., & Chang, E. Y. (2017). Ankle impingement syndromes: an imaging review. Br J Radiol, 90(1070), 20160735. doi:10.1259/bjr.20160735

Besse, J. L. (2017). Metatarsalgia. Orthop Traumatol Surg Res, 103(1S), S29-S39. doi:10.1016/j.otsr.2016.06.020

Bowes, J., & Buckley, R. (2016). Fifth metatarsal fractures and current treatment. World J Orthop, 7(12), 793-800. doi:10.5312/wjo.v7.i12.793

Buvik, A., Bergmo, T. S., Bugge, E., Smaabrekke, A., Wilsgaard, T., & Olsen, J. A. (2019). Cost-Effectiveness of Telemedicine in Remote Orthopedic Consultations: Randomized Controlled Trial. J Med Internet Res, 21(2), e11330. doi:10.2196/11330

Buvik, A., Bugge, E., Knutsen, G., Smabrekke, A., & Wilsgaard, T. (2019). Patient reported outcomes with remote orthopaedic consultations by telemedicine: A randomised controlled trial. J Telemed Telecare, 25(8), 451-459. doi:10.1177/1357633X18783921

Coughlin, M. J., Saltzman, C. L., & Anderson, R. B. (2014). Mann's surgery of the foot and ankle. Amsterdam: Elsevier Saunders.

Drakos, M. C., Fiore, R., Murphy, C., & DiGiovanni, C. W. (2015). Plantar-plate disruptions: "the severe turf-toe injury." three cases in contact athletes. J Athl Train, 50(5), 553-560. doi:10.4085/1062-6050-49.6.05

Dufour, A. B., Broe, K. E., Nguyen, U. S., Gagnon, D. R., Hillstrom, H. J., Walker, A. H., . . . Hannan, M. T. (2009). Foot pain: is current or past shoewear a factor? Arthritis Rheum, 61(10), 1352-1358. doi:10.1002/art.24733

Eble, S. K., Hansen, O. B., Ellis, S. J., & Drakos, M. C. (2020). The Virtual Foot and Ankle Physical Examination. Foot Ankle Int, 41(8), 1017-1026. doi:10.1177/1071100720941020

Gandbhir, V. N., Lam, J. C., & Rayi, A. (2020). Trendelenburg Gait. In StatPearls. Treasure Island (FL).

Hazenberg, C., Aan de Stegge, W. B., Van Baal, S. G., Moll, F. L., & Bus, S. A. (2020). Telehealth and telemedicine applications for the diabetic foot: A systematic review. Diabetes Metab Res Rev, 36(3), e3247. doi:10.1002/dmrr.3247

He, D., Gu, Y., Shi, Y., Wang, M., Lou, Z., & Jin, C. (2020). COVID-19 in China: the role and activities of Internet-based healthcare platforms. Glob Health Med, 2(2), 89-95. doi:10.35772/ghm.2020.01017

Ho, B., & Baumhauer, J. (2017). Hallux rigidus. EFORT Open Rev, 2(1), 13-20. doi:10.1302/2058-5241.2.160031

Howard, I. M., & Kaufman, M. S. (2018). Telehealth applications for outpatients with neuromuscular or musculoskeletal disorders. Muscle Nerve, 58(4), 475-485. doi:10.1002/mus.26115

Krahenbuhl, N., & Weinberg, M. W. (2019). Anatomy and Biomechanics of Cavovarus Deformity. Foot Ankle Clin, 24(2), 173-181. doi:10.1016/j.fcl.2019.02.001

Lui, T. H. (2017). Arthroscopic Repair of Superomedial Spring Ligament by Talonavicular Arthroscopy. Arthrosc Tech, 6(1), e31-e35. doi:10.1016/j.eats.2016.08.034

Moracia-Ochagavia, I., & Rodriguez-Merchan, E. C. (2019). Lisfranc fracture-dislocations: current management. EFORT Open Rev, 4(7), 430-444. doi:10.1302/2058-5241.4.180076

Mourcou, Q., Fleury, A., Diot, B., Franco, C., & Vuillerme, N. (2015). Mobile Phone-Based Joint Angle Measurement for Functional Assessment and Rehabilitation of Proprioception. Biomed Res Int, 2015, 328142. doi:10.1155/2015/328142

Munir, U., Tafti, D., & Morgan, S. (2020). Morton Neuroma. In StatPearls. Treasure Island (FL).

Pirker, W., & Katzenschlager, R. (2017). Gait disorders in adults and the elderly : A clinical guide. Wien Klin Wochenschr, 129(3-4), 81-95. doi:10.1007/s00508-016-1096-4

Rutledge, C. M., Haney, T., Bordelon, M., Renaud, M., & Fowler, C. (2014). Telehealth: preparing advanced practice nurses to address healthcare needs in rural and underserved populations. Int J Nurs Educ Scholarsh, 11. doi:10.1515/ijnes-2013-0061

Ruzbarsky, J. J., Scher, D., & Dodwell, E. (2016). Toe walking: causes, epidemiology, assessment, and treatment. Curr Opin Pediatr, 28(1), 40-46. doi:10.1097/MOP.0000000000000302

Schaper, N. C., Van Netten, J. J., Apelqvist, J., Lipsky, B. A., Bakker, K., & International Working Group on the Diabetic, F. (2016). Prevention and management of foot problems in diabetes: a Summary Guidance for Daily Practice 2015, based on the IWGDF Guidance Documents. Diabetes Metab Res Rev, 32 Suppl 1, 7-15. doi:10.1002/dmrr.2695

Sharma, A., Sinha, S., Narang, A., Chouhan, D. K., & Gupta, S. (2020). Waddling Gait: A complication of valproate therapy and a thought beyond vitamin D deficiency. Sultan Qaboos Univ Med J, 20(1), e104-e108. doi:10.18295/squmj.2020.20.01.016

Tu, P. (2018). Heel Pain: Diagnosis and Management. Am Fam Physician, 97(2), 86-93. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/29365222

Wentzell, M. (2018). Conservative management of a chronic recurrent flexor hallucis longus stenosing tenosynovitis in a pre-professional ballet dancer: a case report. J Can Chiropr Assoc, 62(2), 111-116. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/30305767

Wosik, J., Fudim, M., Cameron, B., Gellad, Z. F., Cho, A., Phinney, D., . . . Tcheng, J. (2020). Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inform Assoc, 27(6), 957-962. doi:10.1093/jamia/ocaa067

Legends

Figure 1. A, Inspection of lower limb. B, Examination of hindfoot for injuries. C, Exploration of plantar fasciitis.

Figure 2. A, Continued exploration of plantar fasciitis (notice toes are being passively dorsiflexed). B, Examination of flexor tendon integrity. C, Examination of extensor tendon integrity (notice toes are actively trying to extend against resistance of hand).

Figure 3. A, Examination of lateral border of foot for injuries. B, Examination of midfoot joints integrity. C, Continued examination of midfoot joints integrity.

Figure 4. A, Continued examination of midfoot joints integrity. B, Continued examination of midfoot joints integrity. C, Exploration of 1st proximal and medial metatarsal, sesamoid bones, and tendons of flexors of hallucis brevis muscles integrity.

Figure 5. Ankle joint planes of motion.

Table 1. Foot Evaluation Questions/Instructions by Telephone

Clinician's questions	**Interpretation**
"If you look at the soles of the shoes you wear most often, can you describe to me the wear pattern on it?"	Attempt to correlate wear pattern description to any possible misalignment.
"Do you use any insoles and walking aids"	Interpret answer
"Are you able to describe where on your foot it hurts the most?"	Attempt to correlate patient's description to anatomic structures
"Stand in front of a mirror so you can see your whole feet, ankles, knees and a few inches above. Examine carefully and compare your lower limbs. Looking at your feet next to each other, are there any differences in size or color? Is there any bruising or swelling?" **Figure 1A**	Possible trauma, infection, ligamentous injury or inflammatory (i.e., gout) Ask about fevers, inverted or everted injuries, falls, or other traumatisms
"Looking at your feet next to each other while you are standing, does the big toe on the painful foot point in towards the other toes on that same foot more than compared to your other foot?"	Possible hallux valgus
"Take one hand and cup the heel bone. Squeeze the sides of the heel bone. Does this reproduce your pain?" **Figure 1B**	Possible calcaneal injury or stress fracture
"Use your thumb and press over the bottom of your heel up toward the inside; is there any specific point or area on the bone that is painful?" **Figure 1C**	Possible plantar fasciitis
"Grab your toes and pull them back so they point up towards your head. Does this cause pain over the bottom of your heel or arch?" **Figure 2A**	Possible plantar fasciitis
With your foot muscles, try to extend your toes toward you and at the same time place your hand on top of your toes and oppose this movement by pushing them away from you. Does this cause pain?" **Figure 2B**	Possible flexor tendon pathology
Now try the opposite. Try to flex your toes down toward the floor against the resistance of your hand pulling them back up toward you. Does this cause pain?" **Figure 2C**	Possible extensor tendon pathology
"On the outside (lateral) edge of the foot, press along the bone in the midportion of the foot that leads to the small toe. Is there any pain over the length of the bone?" **Figure 3A**	Possible fifth metatarsal injury or stress fracture Possible peroneus brevis tendinopathy
"With one hand, hold the ankle steady, and with the other hand grab the midfoot (the area of the foot in front of the ankle, but before the toes begin) and rotate or twist. Does this cause pain?" **Figure 3B**	Possible midfoot injury, such as a Lisfranc injury
"With one hand, hold the ankle steady and with the other hand grab the midfoot and move the bones of the midfoot up and down. Does this cause pain?" **Figure 3C**	Possible midfoot injury, such as a Lisfranc injury
"Squeeze the midfoot as if you are trying to compress the bones of the midfoot together. Does this cause pain or make a clicking or popping noise?" **Figure 4A**	Possible midfoot injury, such as a Lisfranc injury
"Squeeze the foot right where the toes begin. Does this cause pain or clicking?" **Figure 4B**	Possible Morton neuroma Possible midfoot injury (depending on where the patient squeezed)

"Press along the ball of the foot before the big toe begins. Is there a specific point that reproduces your pain?" **Figure 4C**	Possible sesamoid injury or stress fracture
"Are you able to safely stand on your tiptoes for 2-3 seconds? If so, are you able to safely take 4-6 steps on your tiptoes?"	Testing for balance, gastrocnemus and achilles tendon integrity and strength, ankle flexibility, posterior impingement, midfoot and metatarsophalangeal joints integrity, and S1/S2 nerve function.
"Are you able to safely stand on your heels for 2-3 seconds? If so, are you able to safely take 4-6 steps on your heels?"	Testing for balance, anterior leg compartment (tibialis anterior, extensor hallucis longus, extensor digitorum brevis, fibularis tertius) integrity and strength, ankle flexibility, anterior impingement, plantar fasciitis/heel problems, and L4/L5 nerve function.
"Do you feel any numbness or pain in any part of your foot, ankle, legs or buttocks?"	Correlate possibly affected nerve with respective dermatome location described by patient.
"Using a light object such as a pen or pencil, close your eyes and lightly brush the top of your foot. Now try your other foot. Do they feel the same?"	Superficial peroneal nerve
"Repeat this on the space between your 1st and 2nd toe."	Deep peroneal nerve
"Repeat this on the middle of the plantar surface of your feet."	Branches of the tibial nerve
"Repeat this on the lateral surface of your feet."	Branches of the sural nerve
"Repeat this on medial surface of your feet."	Saphenous nerve
"Press on your 1st toenail with your fingers for 2 seconds, and then quickly release it. How long did you see it took for your white toenail to become red again? Repeat contralateral side". Compare sides.	Normal capillary refill time should be less than 2 seconds.
"Press the skin in front of your shin bone firmly with your index finger, and then quickly let it go. Did it leave an indentation on your leg? Repeat contralateral side".	No evidence of pitting edema should be present.
"Do you have any pain in your foot, calf, or thigh when you exercise (such as walking up a steep hill or a flight of stairs) and relieved by rest?"	No intermittent claudication should be present.
"Using a rope or belt, pull the front of your foot up (dorsiflexion) as if you were stretching your calf muscle. Does this cause pain?"	Homan sign should be negative.

Table 2. Foot Evaluation Questions/Instructions by Video

Clinician's Instructions	Interpretation
Inspection	**Assessing the Following**
"Please show me the soles of the shoes you use most often".	Inspect wear pattern.
"Do you use any insoles and walking aids"	Consider answer with overall case
General inspection: "Place the camera on the floor or a few inches from it and show me your feet from all angles". (Physician must instruct patient to expose feet and carefully inspect anterior, dorsal, lateral, posterior, medial and plantar surfaces of feet one at a time).	Meticulously inspect the quality of the skin, lack of hair (circulation changes), nails, deformities, injuries, abrasions, ulcers, scars, edema, ulcers, discoloration, atrophy, ecchymosis, and misalignments.
"Take 4-6 steps away from the camera, turn around, and take 4-6 steps towards the camera". Repeat this step as many times as necessary.	**Table 4** shows some gait patterns and common related pathologies.
"Can you safely stand on your tip-toes for 2-3 seconds? Can you now take 4-6 steps towards the camera but on your tiptoes"	Gastrocnemus and achilles tendon integrity and strength, ankle flexibility, posterior impingement, midfoot and metatarsophalangeal joints integrity, and S1/S2 nerve function.
"Can you safely stand on your heels for 2-3 seconds? Can you now take 4-6 steps towards the camera but on your heels"	Anterior leg compartment (tibialis anterior, extensor hallucis longus, extensor digitorum brevis, fibularis tertius) integrity and strength, ankle flexibility, anterior impingement, plantar fasciitis/heel problems, and L4/L5 nerve function.
"Take a few steps back and stand so I can see your entire foot, ankle, and a few inches above your knee" **Figure 1A**	Misalignments such as varus or valgus.
"Grab the camera and show me your feet from above".	Foot deformities such as hallux valgus
Range of Motion	**Normal Values**
Have the patient show you on camera doing active movements of plantar flexion, dorsiflexion, inversion, and eversion of both feet by explaining the movements one at a time and comparing sides. Also have them flex and extend the toes. If a proxy examiner is present, the physician should instruct them to repeat these movements on the patient with their feet relaxed (passive movements) and compare sides. Several goniometer apps are available to help measure these angles. **Figure 5**	**Ankle Joint** Dorsiflexion 0 to 20 degrees Plantar flexion 0 to 50 degrees Inversion 0 to 35 degrees Eversion 0 to 15 degrees (Anatomic structures of the hip joint responsible for internal and external rotation of foot) **Metatarsophalangeal Joints** Flexion 0 to 30 degrees Extension 0 to 80 degrees **Interphalangeal Joints** Flexion 0 to 50 degrees Extension 50 to 0 degree
Palpation	**Possible Interpretation if Pain is Reproduced**

"Using one finger, indicate the point of maximal pain or discomfort"	(see **Table 3**)
"Take one hand and cup the heel bone. Squeeze the sides of the heel bone. Does this reproduce your pain?" **Figure 1B**	If pain is reproduced (especially also when patient runs/jumps/walks), possible calcaneal injury or stress fracture
"Use your thumb to press down over the bottom of your heel; is this point painful?" **Figure 1C**	Possible plantar fasciitis
"Grab your toes and pull them back so they point up towards your head. Does this cause pain over the bottom of your heel or arch?" **Figure 2A**	Possible plantar fasciitis
With your foot muscles, try to extend your toes toward you and at the same time place your hand on top of your toes and oppose this movement by pushing them away from you. Does this cause pain?" **Figure 2B**	Possible flexor tendon pathology
Now try the opposite. Try to flex your toes down toward the floor against the resistance of your hand pulling them back up toward you. Does this cause pain?" **Figure 2C**	Possible extensor tendon pathology
"On the outside (lateral) edge of the foot, press along the bone in the midportion of the foot that leads to the small toe. Is there any pain over the length of the bone?" **Figure 3A**	Possible fifth metatarsal injury or stress fracture Possible peroneus brevis tendinopathy
"With one hand, hold the ankle steady, and with the other hand grab the midfoot (the area of the foot in front of the ankle, but before the toes) and rotate or twist. Does this cause pain?" A proxy examiner may be useful during this maneuver. **Figure 3B**	Possible midfoot injury, such as a Lisfranc injury
"With one hand, hold the ankle steady and with the other hand grab the midfoot and move the bones of the midfoot up and down. Does this cause pain?" A proxy examiner may be useful during this maneuver. **Figure 3C**	Possible midfoot injury, such as a Lisfranc injury
"Squeeze the midfoot as if you are trying to compress the bones of the midfoot together. Does this cause pain or make a clicking or popping noise?" **Figure 4A**	Possible midfoot injury, such as a Lisfranc injury
"Squeeze the foot right where the toes begin (at the level of bases of toes). Does this cause pain or clicking?" **Figure 4B**	Possible Morton neuroma or midfoot injury (depending on where the patient squeezed)
"Press along the ball of the foot before the big toe begins. Is there a specific point that reproduces your pain?" **Figure 4C**	If this reproduces pain in the medial part of the ball of foot, possible sesamoid injury or stress fracture
Strength Test	
This section is ideally be done with another person as a proxy examiner. Though it is possible to attempt maneuvers on oneself, it requires a certain level of agility, flexibility and strength, and will provide limited data. A commonly used scale to measure strength is the Medical Research Council Manual Muscle Testing scale: **Grade 0 -** No contraction **Grade 1 -** Flicker or trace of contraction **Grade 2 -** Active movement with gravity eliminated **Grade 3 -** Active movement against gravity **Grade 4 -** Active movement against gravity and resistance	

Grade 5 - Normal power	
Maneuver	**Muscles Tested**
Have the examiner place one hand on top of patient's midfoot and resist the patient trying to dorsiflex (from a seated position with the foot not contacting the ground). Repeat on contralateral side.	Tibialis Anterior
Similarly, the examiner places one finger on top of the 1st toe and resists the patient trying to dorsiflex it. Repeat contralateral side.	Extensor hallucis longus
The examiner now places hand on top of toes 2-5 and resists patient from dorsiflexing them. Repeat contralateral side.	Extensor digitorum longus
Have the examiner place one hand under the patient's foot and resist the patient trying to plantarflex. Repeat on contralateral side.	Muscles of posterior leg compartment
Similarly, the examiner places one finger under the 1st toe and resists the patient trying to plantarflex it. Repeat contralateral side.	Flexor hallucis longus
The examiner now places hand under toes 2-5 and resists patient from plantarflexing these. Repeat contralateral side.	Flexor digitorum longus
Have the examiner push medially against lateral border of foot, while patient attempts to evert foot while in plantar flexion	Peroneal longus and peroneal brevis
Neurovascular Assessment	
"Do you feel any numbness or pain in any part of your foot, ankle, legs or buttocks?"	Correlate possibly affected nerve with respective dermatome
"Using a light object such as a pen or pencil, close your eyes and lightly brush the top of your foot. Now try your other foot. Do they feel the same?"	Superficial Peroneal Nerve
"Repeat this on the space between your 1st and 2nd toe."	Deep peroneal nerve
"Repeat this on the middle of the plantar surface of your feet."	Branches of the Tibial Nerve
"Repeat this on the lateral surface of your feet."	Branches of the Sural Nerve
"Repeat this on medial surface of your feet."	Saphenous Nerve
"Position the camera so I can see your toes. Press on your 1st toenail with your fingers for 2 seconds, and then quickly release it. How long did you see it took for your white toenail to become red again? Repeat contralateral side". Compare to what you saw on the screen as video may be delayed.	Normal capillary refill time should be less than 2 seconds.
"Press the skin in front of your shin bone firmly with your index finger, and then quickly let it go. Did it leave an indentation on your leg? Repeat contralateral side".	No evidence of pitting edema should be present.
"Do you have any pain in your foot, calf, or thigh when you exercise (such as walking up a steep hill or a flight of stairs) and relieved by rest?"	No Intermittent claudication should be present.

"Using a rope or belt, pull the front of your foot up (dorsiflexion) as if you were stretching your calf muscle. Does this cause pain?"	Homan sign should be negative.

Table 3. Patient Localization of Pain, Anatomic Site of Pain, and Possible Underlying Pathologies

Where is the pain located?	Specific anatomic location	Common pathologies
"The front of my ankle"	Anterior ankle, localized at tibiotalar joint	Degenerative osteoarthritis, syndesmotic injury, anterior ankle impingement (Berman et al., 2017), tibiotalar osteophyte (Berman et al., 2017), ankle joint capsule injury (e.g., violent and excessive plantar flexion)
"The inside of my foot"	Medial and posteromedial midfoot	Lisfranc injury, pes planus, pes cavus, medial ankle impingement, subtalar degenerative changes, middle facet coalition, peroneus longus insertional tendinopathy (Alazzawi et al., 2017), navicular fracture, spring or deltoid ligament (Lui, 2017), tibialis posterior insertional tendinopathy, flexor hallucis longus pathology, or tarsal tunnel syndrome
"The outside of my foot"	Lateral midfoot	Stress fracture of distal fibula, anterior talofibular ligament injury, lateral ankle impingement, sinus tarsi syndrome, tarsometatarsal synovitis (fourth/fifth), cuboid fracture, painful os peroneum syndrome, calcaneal fracture, malunion fracture
"The top of my foot"	Dorsal surface of the midfoot	Degenerative disease, post traumatic arthritis, tarsal bones stress fracture, ligament injury (i.e., Lisfranc injury), tibialis anterior or peroneal brevis insertional tendinopathy, osteoarthritis
	Dorsal surface of the metatarsals (forefoot)	Metatarsalgia, metatarsal fracture (including stress injuries), Morton's neuroma, stress fracture, Freiberg disease, metatarsophalangeal joint synovitis, nail pathology
"The bottom of my foot/underneath my foot"	Plantar surface	Plantar fasciitis, flexor digitorum longus tendonitis, sesamoiditis (Alazzawi et al., 2017), metatarsalgia (Besse, 2017), Morton neuroma (Munir et al., 2020), plantar plate disruption (Drakos et al., 2015)
"My heel"	Calcaneus/posterior pian	Insertional Achilles tendonitis, calcaneus fracture, plantar fasciitis/rupture, posterior ankle

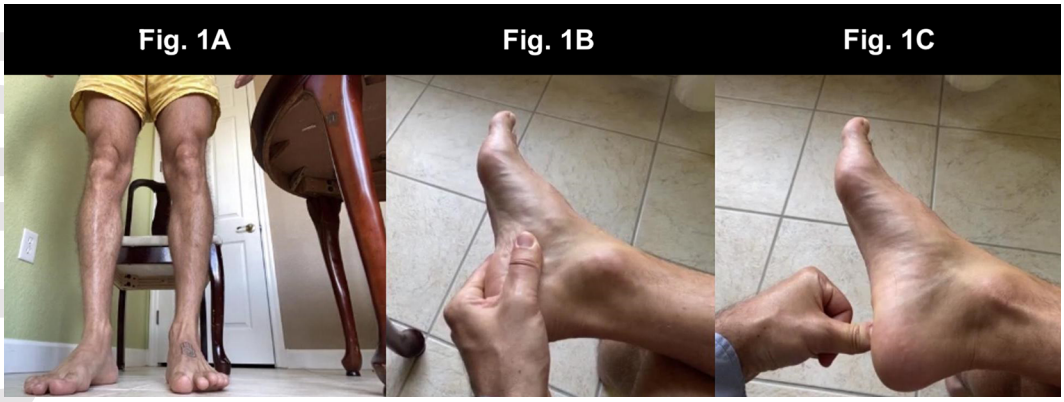
		impingement, os trigonum pathology, osteophyte, malunion fracture, tarsal tunnel syndrome, foreign body reaction, first branch of lateral plantar nerve entrapment (Tu, 2018), fat pad atrophy/contusion
"My big toe"	First toe (MTP, PIP, and DIP)	Hallux valgus/rigidus, inflamed bunion, sesamoiditis, sesamoid fracture, turf toe, fracture of the phalanx, flexor hallucis longus insertional tendonitis (Wentzell, 2018), gout, callus, arthritis
"My toes"	Second to fourth toes (MTP, PIP, and DIP)	Hammer toe, claw toe, mallet toe (Alazzawi et al., 2017), fracture of the phalanx, Morton neuroma (Munir et al., 2020)
"My little toe"	Fifth toe (MTP, PIP, and DIP)	Inflamed bunionette, fracture of the phalanx, callus, fifth metatarsal fracture (Jones fracture) (Bowes & Buckley, 2016), peroneus brevis insertional tendinopathy

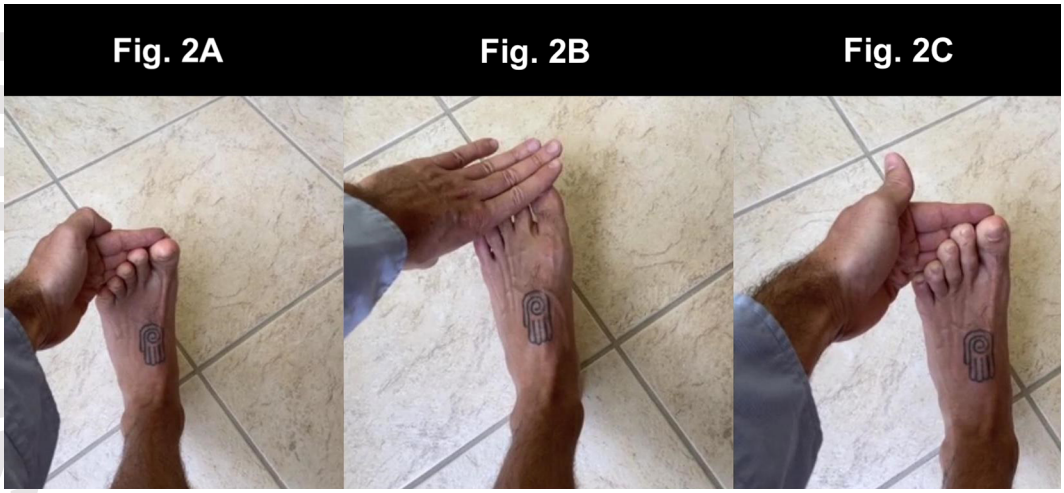
Abbreviations: DIP, distal interphalangeal; MTP, metatarsophalangeal; PIP, proximal interphalangeal.

Table 4. Gait Patterns and Common Underlying Pathologies

Gait pattern	**Common underlying pathologies**
Trendelenburg gait	Gluteus medius/minimus weakness, superior gluteal nerve injury (L4-S1) (Gandbhir et al., 2020)
Lurching (Rocking horse) gait	Gluteus maximus weakness (Alazzawi et al., 2017), inferior gluteal nerve injury (L5-S2)
Myopathic (waddling) gait	Developmental hip dysplasia (Sharma et al., 2020), muscular dystrophy (Sharma et al., 2020), bilateral hip abductor injury (Gandbhir et al., 2020)
High steppage gait	Foot drop, common peroneal nerve injury, dysfunction of the anterior compartment dorsiflexors
Antalgic gait	Pain on weightbearing (Alazzawi et al., 2017), ankle sprains, stress fractures, plantar fasciitis, degenerative osteoarthritis (Pirker & Katzenschlager, 2017)
Knee hyperextension gait	Femoral nerve pathology, spinal cord pathology (Alazzawi et al., 2017), radiculopathy (Alazzawi et al., 2017), quadriceps muscle weakness (Pirker & Katzenschlager, 2017)
Tip toeing (equinus) gait	Leg length discrepancy (Alazzawi et al., 2017; Ruzbarsky et al., 2016), abnormal dorsiflexion or, plantar contractures (Alazzawi et al., 2017)
Scissor gait	Muscular spasticity, abnormal bilateral adductor hypertonia (Pirker & Katzenschlager, 2017)
Ataxic gait	Cerebellar disorder (Pirker & Katzenschlager, 2017), dorsal columns lesión (Pirker & Katzenschlager, 2017)
Equinovarus gait Quadriceps gait	Congenital talipes equinovarus (club foot) (Pirker & Katzenschlager, 2017)

	Radiculopathy or spinal cord pathology (Pirker & Katzenschlager, 2017)
Hemiplegic (circumductory) gait	Spastic muscles





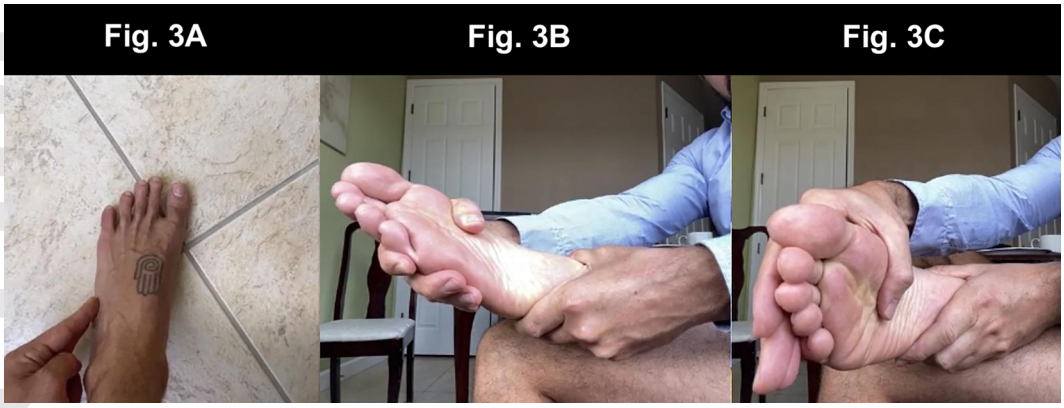


Fig. 4A Fig. 4B Fig. 4C

Fig. 5