



Point-of-care radiology service at the US Open Tennis Championships

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Abstract

Professional tennis tournaments have onsite sports medicine physicians who oversee the athletes' overall health during competition, including musculoskeletal injury and general illnesses. The medical team is composed of orthopedic and non-operative sports medicine physicians. Frequently, the tournament doctors require imaging to localize and grade musculoskeletal injuries and to make decisions regarding treatment, safe training, and return to match play. The most versatile and readily available imaging modality to evaluate for acute musculoskeletal injury is point-of-care ultrasonography. In 2015, a dedicated radiology service was created at the US Open by bringing in a musculoskeletal radiologist who would perform ultrasounds in a formal and consistent manner. In addition, the radiologist was tasked with onsite radiography as well as review of all MRI examinations done at the imaging center. This article describes how this radiology service was implemented, what types of studies were performed and the advantages of having an onsite musculoskeletal radiologist at the tournament. This service allowed the medical team to provide the comprehensive and efficient medical care required in a major professional tennis event. It also showed the value of having the in-person expertise of the musculoskeletal radiologist in the sports medicine team. This same model could be applied to other professional sporting events.

Keywords Musculoskeletal radiology · Point-of-care ultrasound · US Open · Tennis tournaments · Sports medicine

Introduction

The professional tennis tour takes place over 11 months of the year in all continents. It consists of over 100 combined men and women events as well as four Grand Slam tournaments. These international tournaments bring in the top tennis players from all around the world. All tour level events have onsite sports medicine physicians who oversee the tennis athletes' overall health during competition, including

musculoskeletal injury and general illnesses. Previous studies have found acute musculoskeletal injuries to be more common than chronic overuse injuries [1–3]. Frequently, the tournament doctors require imaging to localize and grade musculoskeletal injuries and to make decisions regarding treatment, safe training and return to match play [4–7]. The most commonly used imaging modalities to evaluate musculoskeletal injuries in sports medicine are radiography, ultrasonography and magnetic resonance imaging (MRI).

A quick, effective and relatively inexpensive imaging tool to look for musculoskeletal injury in tournaments is point-of-care ultrasonography, given the technology's high sensitivity to superficial soft tissue injury, portability and all-around availability. Many tournament doctors have incorporated ultrasound exploration as part of their physical examination, but there is variability in skill sets and scanning confidence. Proper technique for ultrasound scanning and a good knowledge of anatomical landmarks are key elements to identify the injured tissue and make an accurate diagnosis. Most musculoskeletal radiologists are well-trained to perform these examinations.

Mount Sinai Hospital has been the official medical services provider of the US Open since 2013, with both

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orthopedic and non-operative sports medicine physicians who provide care for the athletes onsite as well as access to the entirety of the medical services available at the main hospital. In 2015, a dedicated radiology service was created at the tournament by adding a musculoskeletal radiologist to the onsite medical team. The plan was to offer quick, consistent and formal point-of-care ultrasound examinations that would help the medical team triage injuries and make rapid clinical decisions regarding the athlete's treatment and safe play. The service also included onsite radiography and a PACS workstation to access and interpret MRI, and occasional CT examinations done in the hospital. The onsite PACS facilitated the sharing and discussion of important imaging findings with the tournament physicians and the tennis athlete's team. The radiography equipment was used to evaluate for fractures after acute trauma and to screen for acute lung disease in athletes with respiratory symptoms.

In summary, the purpose of creating an onsite radiology service at the US Open was to provide quick and effective radiological examinations that would streamline the ability to provide comprehensive medical care for the athletes. In this article, we describe how this service was implemented, what types of studies were performed and the advantages of having an onsite musculoskeletal radiologist at the tournament.

Radiology service implementation

All imaging equipment was brought in to the stadium a few days before the event started to have time to test and optimize the machines. One of three musculoskeletal radiologists was scheduled to be at the stadium every day of the tournament, including qualifying week. Daily hours were adjusted depending on the week of the tournament and number of players remaining in competition. The radiologist was in charge of managing the following imaging modalities:

Ultrasonography

Two portable, laptop ultrasonography systems mounted on carts were brought in to the player treatment area. The units were fitted with a full musculoskeletal software package and broad-range, high-frequency transducers (up to 18 MHz). All examinations provided images with morphological measurements and labels. Power Doppler analysis was routinely done to evaluate for tissue hyperemia. Dynamic ultrasound maneuvers were commonly performed to evaluate muscle contraction, tendon movement and joint laxity. Contralateral asymptomatic side comparison images were included in some examinations. On rare occasions, vascular studies were requested to evaluate for deep venous thrombus in both upper and lower extremities. Between two to three

ultrasound-guided steroid injections and joint fluid aspirations were performed every year.

Given the time constraints to evaluate the athletes, all sonograms were focused to the region of pain. On occasions, the examinations were abbreviated by recording video sweeps of the region of interest in two orthogonal planes, later extracting still images for measurements and labels.

Magnetic resonance imaging

When ultrasound was not sufficient to provide a final diagnosis to explain the athlete's symptoms, or when intra-articular injuries or stress fractures were clinically suspected, the athletes were referred to MRI. All MRIs were done off-site at Mount Sinai Hospital. The tournament radiologist monitored the MRI examinations from the stadium PACS workstation to troubleshoot artifacts and adjust the imaging protocol if the injury was not clearly shown in the images.

Radiography

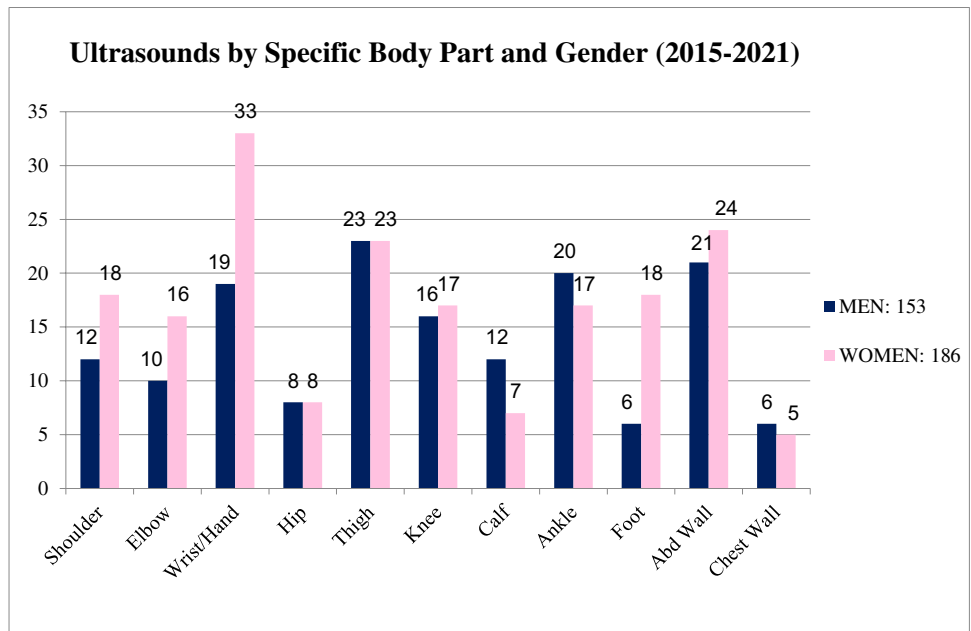
A portable X-ray machine was operated in a separate room following standard radiation safety protocols. The room did not require shielding since it was a portable system. Tennis athletes who sustained trauma during match play got a radiographic examination to evaluate for acute osseous injury. Athletes who had minor respiratory symptoms got a screening chest radiograph to assess for lung opacities or other cardiopulmonary findings.

Service utilization and injury trends

A total of 339 ultrasounds were performed between 2015 and 2021 with a yearly average of 49. Concordant with published tennis literature, the most common injuries were seen in muscles and tendons [8–10]. The most commonly ordered regions for muscle strains were the thighs and abdominal wall. The majority of muscle injuries were minor strains (grade 1). As expected in racquet sports, there was adaptive asymmetry of the rectus abdominis muscles in all athletes with muscle hypertrophy contralateral to the racquet arm [11]. All injuries were seen on the hypertrophic side.

Categorized by body region, women athletes utilized sonography more often than men for all upper extremity examinations, specifically the hand/wrist, and for the foot in the lower extremity (Fig. 1). Conversely, men athletes utilized sonography more often than women for the calf and ankle. The numbers are very similar for both men and women when imaging the thigh, knee and chest/abdominal wall. The most ordered joint ultrasounds were the wrists, ankles, and knees. Follow up MRI was needed in 40 athletes (11.8%) when ultrasound was inconclusive or

Fig. 1 Most ordered ultrasound body regions were the wrist/hand, thigh, abdominal wall, knee and ankle



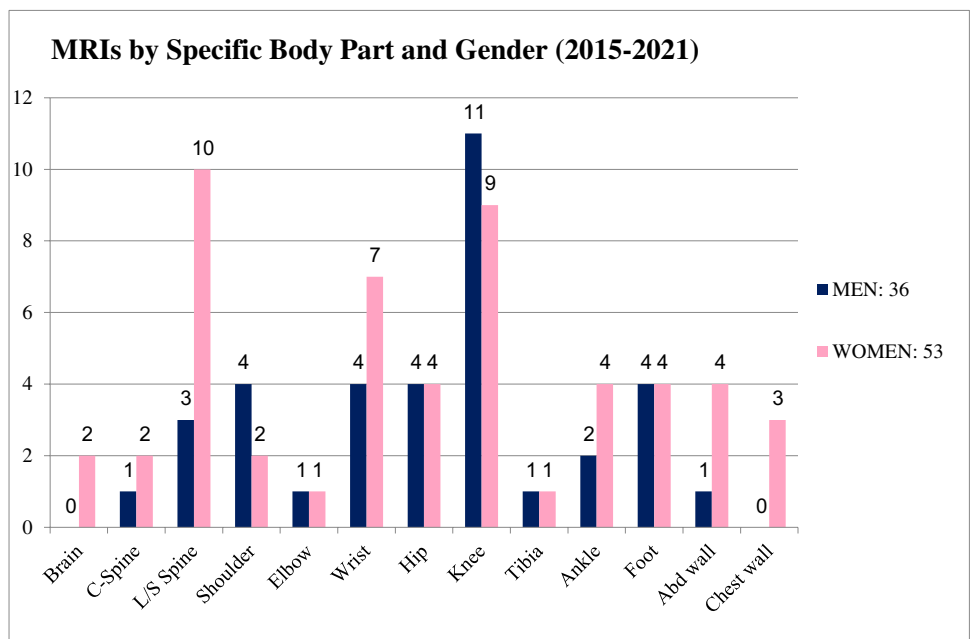
non-diagnostic. Most of these cases had articular cartilage and bone stress injuries.

A total of 89 MRIs were performed between 2015 and 2021 with a yearly average of 11. Women athletes utilized MRI more often than the men for lumbar spine and wrist examinations (Fig. 2). Men athletes utilized MRI more often than women for knee examinations. Cartilage contusion, bone bruises, stress fractures, meniscal/labral tears and joint sprains were commonly encountered injuries in the professional tennis players. The most commonly

ordered joint MRI for all athletes were the wrists and knees. Bone stress injuries were common MRI findings in the feet, knees and wrists.

Onsite radiography was the least utilized imaging modality of the three. The most commonly ordered radiographs were the feet/ankles, hands/wrists and chest examinations. All radiographic studies were negative for fractures or lung disease. Some chronic osseous abnormalities were seen in the feet/ankles, likely related to old ligamentous avulsion injuries.

Fig. 2 Most ordered MRI body regions were the knee, lumbar spine, and wrist



Discussion

The implementation of an onsite musculoskeletal radiology service in the US Open improved efficiency of the tournament medical service by avoiding the need to send tennis athletes offsite for additional tests. This service offered three main benefits. First, there was streamlining of the treatment workflow with faster turnaround times, from presentation of symptoms at player arrival to final assessment and treatment plan. Second, there was improved communication between the medical team members and the radiologist, with less chances for lost information. This improved the radiological interpretations, making them more accurate and relevant to the clinical concern. Third, there was better consistency of radiological reports by having a single point person in charge of all imaging modalities. Specifically, athletes who were sent out for an MRI after an ultrasound scan could be monitored by the same radiologist, who could adjust the imaging protocol to the area of concern and tie together the sonographic and MRI findings.

The regional distribution of injuries in the radiological studies was concordant with published epidemiological reviews of both professional tennis and other competitive sports injuries [2, 5, 6, 9, 10, 12, 13]. As published in previous radiological literature, ultrasound examinations were diagnostic for muscle and tendon injuries [14, 15]. MRI examinations provided final diagnosis for intra-articular disease and bone stress injuries [16]. However, given the inherent, high tissue-contrast sensitivity of MRI, there were asymptomatic abnormalities that likely represented chronic injury or physiologic alterations related to high-performing athletes. Special attention was required to make a clear distinction between acute and chronic findings as well as separate clinically relevant and incidental discoveries before communicating the results to the medical team.

Although radiography was not used as much, it provided valuable information to clear for acute lung disease in athletes with respiratory symptoms and exclude bone fractures following acute trauma.

Future improvements for the onsite radiology service include the integration of images and reports into the electronic medical record systems of the professional tennis associations to enhance medical communication between tournaments and have quick access to old examinations for direct comparison.

In addition to onsite radiography and ultrasonography, a stadium MRI machine would integrate all three sports imaging modalities in one place. The expense for an onsite MRI would be better justified in Grand Slam or Masters tournaments that have a greater number of tennis players and larger budgets. The immediate availability of MRI

would make it easier and more convenient for more of the injured athletes to get scanned before leaving the tournament. A cost effective solution would include a mobile high field MRI unit installed on a trailer that could park next to the stadium for the duration of the tournament. These mobile MRI units require an initial capital investment in the form of preparation of a parking platform with specific electrical hookups. Tournament sponsors could help facilitate this project.

Conclusion

The US Open point-of-care radiology service was a valuable addition to the tournament medical group, providing the comprehensive and effective medical care needed in a major professional tennis event. It helped to streamline the treatment workflow for the athletes in a more efficient and timely manner. This same model could be applied to other professional sporting events.

Permissions

The US Open Data was obtained with permission of the USTA and is referenced in this article courtesy of the USTA with the provision of physician services by Mount Sinai Hospital.

Declarations

Conflict of interest The authors declare no competing interests.

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