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Transperineal Sonography Evaluation of Muscles and Vascularity in the Male Pelvic Floor

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Abstract

Idiopathic chronic male pelvic pain is difficult to diagnose and treat. Currently, diagnosis relies on subjective symptoms; objective measures of neuromuscular mechanisms have not been investigated. Sonographic imaging has been used to investigate these neuromuscular mechanisms in the female pelvic floor, but neither research nor books describe sonography evaluation of the male pelvic floor. The purpose of this study was to develop and evaluate a perineal sonographic technique for the examination of the male pelvic floor muscles. Anatomic landmarks were identified with images collected from two subjects, one with intermittent reports of pelvic pain and one with no history of pain in the pelvic region. A description of the equipment settings, the examination protocol, and the resulting comparative image analysis is included. A validated protocol such as this may be useful in documenting differences in the soft tissue structures between asymptomatic individuals and patients with chronic pelvic pain to aid in diagnosis and treatment. This is the first known study to report sonographic findings of the individual muscles in the male pelvic floor, and additional research is needed to validate the techniques that have been deemed feasible.

Keywords

chronic pelvic pain syndrome, sonography, musculoskeletal, Doppler

Pelvic health issues are commonly associated with women; however, pelvic health evaluation and treatment should not be limited to females as there are numerous male pelvic floor disorders that require investigation. Pelvic disorders are a significant cause of decreased quality of life caused by voiding dysfunction, sexual dysfunction, and pain. Prostatitis is a frequently used diagnosis for a variety of pelvic disorders in men and has four classifications: acute prostatitis (type I), chronic bacterial prostatitis (type II), chronic prostatitis/chronic pelvic pain syndrome (type III), and asymptomatic inflammatory prostatitis (type IV). Chronic prostatitis/chronic pelvic pain syndrome (CP/CPPS) accounts for up to 95% of all prostatitis diagnoses[1] and is the most frequent urology diagnosis in men younger than 50 years.[2]

Although the pathophysiology of some prostatitis diagnoses can be linked to bacterial infections and inflammation, the etiology of CP/CPPS is unknown. Metabolic, neurobehavioral, and neuromuscular factors have been suggested as contributory to the pain and dysfunction associated with CP/CPPS.[3,4] Treatments to reduce and regulate tension of the pelvic floor muscles have shown promise in reducing symptoms in patients with CP/CPPS,[5–7] but little is known about the morphology of neuromuscular structures in the region and how it is related to the pathology that is being treated.

Clinical evaluation for male pelvic floor disorders currently relies primarily on subjective patient reports and evaluation of symptoms. The National Institutes of Health Chronic Prostatitis Symptom Index (NIH-CPSI) was introduced in 1999 as an objective questionnaire to standardize the diagnosis of CP/CPPS, as well as to serve as an outcome measure for treatment efficacy.[8] The NIH-CPSI divides CP/CPPS into three domains: urination, pain, and quality of life. Although the NIH-CPSI can inform the practitioner about the end effect of the disorder, there is a need for screening technology that can identify patient-specific physiological mechanisms[9] and determine their

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relation to physiological and structural changes in the tissues.

Supplementing these subjective questionnaires with objective sonographic imaging may be a useful technique for investigating neuromuscular dysfunction in the pelvic floor, a primary contributing factor. Sonographic imaging is widely used to examine the female pelvic floor, including structural imaging (e.g., prolapse quantification) and functional imaging (e.g., levator muscle contraction) in both 2D[10] and 3D.[11] Imaging of the female pelvic floor has provided objective evidence for the diagnoses and treatment of difficult disorders. Only three studies could be identified that attempted to evaluate the male pelvic region, primarily focused on gross observations of the relationship of structures to each other.[12–14] Because of the success and wide utilization of sonographic imaging of the female pelvic floor, it is possible that with more foundational studies, sonographic imaging could also be useful for advancing clinical practice in the diagnosis and treatment of male pelvic floor disorders.

The addition of point-of-care sonographic imaging could provide valuable objective information related to the neuromuscular structures in the male pelvic floor to aid in differential diagnosis and recommendations for treatment. Because so few research or educational images exist that identify the individual muscles and structures of the male pelvic floor and because numerous differences exist between the anatomy of the male and female pelvic floors, there is a need to document the sonographic appearance of the male pelvic floor. The purpose of this study was to determine the feasibility of obtaining images of the soft tissue structures of the male pelvic floor using transperineal sonography with a linear probe and establish musculoskeletal techniques to provide preliminary images in this region.

Methods

This feasibility study was completed to develop a standardized evaluation protocol for future research. Because of the preliminary and novel nature of this investigation, a repeated, single-subject design was used. Two subjects were individually scanned using the same protocol to optimize the sonographic equipment, to develop image acquisition techniques with both 2D and 3D transducers, and to create a map of the pelvic region with identifiable anatomical landmarks. Data for this feasibility study were collected in a research laboratory as preliminary data for a funded research protocol. The university's institutional review board approved this research.

Subject Positioning

Two research team members were scanned for this feasibility study. Subject A was a 33-year-old man with intermittent reports of chronic pelvic pain. The protocol was repeated with subject B, a 40-year-old man with no history of pain or other diagnosis in the pelvic region. At the time of data collection, neither subject indicated having pain or discomfort in the pelvic region. After disrobing from the waist down, each subject lay supine on a height-adjustable evaluation table with a pillow under his head and the lower body covered with a sheet. The subject was placed in a modified lithotomy position with the feet flat on the table instead of in stirrups. During image acquisition, the subject assisted by holding the penis and scrotum out of the way to expose the perineum. Each transducer was covered with a latex-free probe cover, and a generous amount of coupling gel was applied directly to the perineal region to reduce noncontact artifacts due to hair in the region.

Equipment and Technique

A Logiq E9 (GE Healthcare Ultrasound, Milwaukee, Wisconsin) was used to collect images for this preliminary report. Data were obtained with an 11-MHz linear-array transducer. Equipment settings were optimized for both transducers in subject A, and these same settings were used initially for subject B. Optimal image acquisition in both subjects was obtained with an initial dynamic range of 72, speckle reduction imaging of 2, frame averaging of 1, line density of 3, and time gain compensation controls vertically aligned in the center with overall gain at 50. During scanning, subject variability required slight modification of gain controls and modification of dynamic range between 72 and 78. To enhance images throughout all depths, three focal points were equally placed from superficial to deep, and coded harmonic imaging was used throughout image acquisition. To acquire boney landmarks, virtual convex mode was used and a depth of up to 5.5 cm was required.

With the orientation marker to the subject's right, the 11-MHz transducer was placed on the perineum approximately midway between the anus and the attachment of the scrotum. The region was explored by moving the transducer in an anterior-posterior direction along the central perineum; equipment settings were adjusted for optimal resolution of various tissues and structures based on the echogenicity of the individual subject.

Following optimization, anterior-posterior and left-right dynamic sweeps were completed and cine clips were stored for analysis. For the anterior-posterior sweep, the transducer was placed at the base of the scrotum centered over the bulb of the penis. The transducer was moved posteriorly from the base of the scrotum to the anus through the perineal region. The bulb of the penis was maintained in the center of the image throughout the sweep. A slight anterior angling of the probe beam was required near the end of the sweep to reduce artifact due to the angle of the posterior pelvic floor. Still images were acquired at one-quarter, one-half, and three-quarters of the total distance from the base of the scrotum to the anus to represent the anterior, mid, and posterior perineal structures, respectively.

For the left-right dynamic sweep, the orientation marker of the transducer was placed posteriorly and the transducer was centered over the most posterior point where the urethra was fully within the bulb of the penis. The transducer was then moved from the left perineal margin to the right perineal margin. The transducer was moved at a rate of 1 cm per second, and the researcher repeated the each of the sweeps until the transducer was maintained in a consistent orientation to the pelvic structures for the duration of the sweep.

Color Doppler images were obtained at the anterior, mid, and distal perineal locations to observe vasculature within the region. Color Doppler images were obtained at a frequency of 6.2, gain of 20.0, and pulse repetition frequency of 1.6. Published anatomical references for vascularity in the perineum were not helpful in determining the specific orientation or location of vessels running through the region. Therefore, initial Doppler imaging was conducted in multiple scanning planes. Cross-sectional acquisition of vessels was best obtained with the transducer placed with the orientation marker to the subject's right. Doppler investigation began at the anterior location at the base of the scrotum, and the transducer was moved posteriorly with intermittent pauses at one-quarter, one-half, and three-fourths of the distance. Images were acquired for interpretation when a mirrored (left-right) pair of vessels could be resolved and identified within these locations.

Image Analysis

A sonographic applications specialist with 30 years of experience as a sonographer and an experienced musculoskeletal sonographic researcher collaborated to complete this study. Consensus was reached between these individuals at each stage of the research process; two researchers with experience in treatment of male pelvic floor disorders provided additional input. Sonographic images were initially interpreted during the live scanning sessions for identification of appropriate scanning planes required to capture the structures of interest.

Following data acquisition, the images were reviewed by the research team to ensure consensus on identification of the structures within each image. The team identified the bulb of the penis and the urethra in each of the cine clips and the static images. Wrapping around the superficial surface of the bulb of the penis, the bulbospongiosus muscle is a bipennate muscle with a central tendon. The ischiocavernosus muscles are a pair of muscles that run along the lateral borders of the perineum and were therefore expected to lie laterally and slightly deep to to the bulb of the penis. The third muscle of the pelvic region, the two superficial transverse perineal muscles, create the posterior border of the perineum with lateral attachments on the ischial tuberosity and medial attachment to the perineal body just anterior to the anus. Finally, the research team attempted to identify the neurovascular structures within the perineal images.

Results

The team was able to confidently identify the bulb of the penis and the urethra in all images that were generated throughout the various protocols, and the bulbospongiosus and ischiocavernosus muscles were observed in all cross-sectional views. Image acquisition in the anterior perineum (i.e., one-quarter of the distance between the base of the scrotum and the anus) allowed for visualization of the bulb of the penis, the bulbospongiosus muscles, and the ischiocavernosus muscles superficial to the inferior pubic rami as they approach the pubic symphysis (Figure 1). Although the relative positioning of these structures was noted to be the same between both subjects, it was noted that the bulbospongiosus muscles tracked more laterally in the healthy subject (B), whereas these muscles remained more medial along the superficial surface of the bulb of the penis in subject A. Review of the cine clip through the region confirmed that the bulbospongiosus muscles remained connected to the central tendon along the bulb of the penis for the entire length in the subject with intermittent pain, whereas the more anterior portions of these muscles were completely separated in the subject with no pelvic pain.

Analysis of the images from the mid-perineal region approximately halfway between the base of the scrotum and the anus indicated only slight differences between the subjects. In this view, both muscles could be seen in their superior and lateral positions relative to the bulb of the penis, and the urethra could be clearly noted within the deep borders of the bulb (Figure 2). The central cord of the bulbospongiosus muscle could be clearly visualized in both subjects; however, in the subject with intermittent symptoms (A), this muscle was noted to have a much flatter appearance with an angled central tendon resulting in an asymmetrical appearance. During image acquisition, positioning of the transducer was adjusted numerous times to ensure that the muscle and tendon were not being observed at an angle, and each time a similar image was obtained. In contrast, imaging in the mid-region from subject B was noted to be more symmetrical.

Identification of the muscle structures in the posterior perineal region was challenging. The team members were

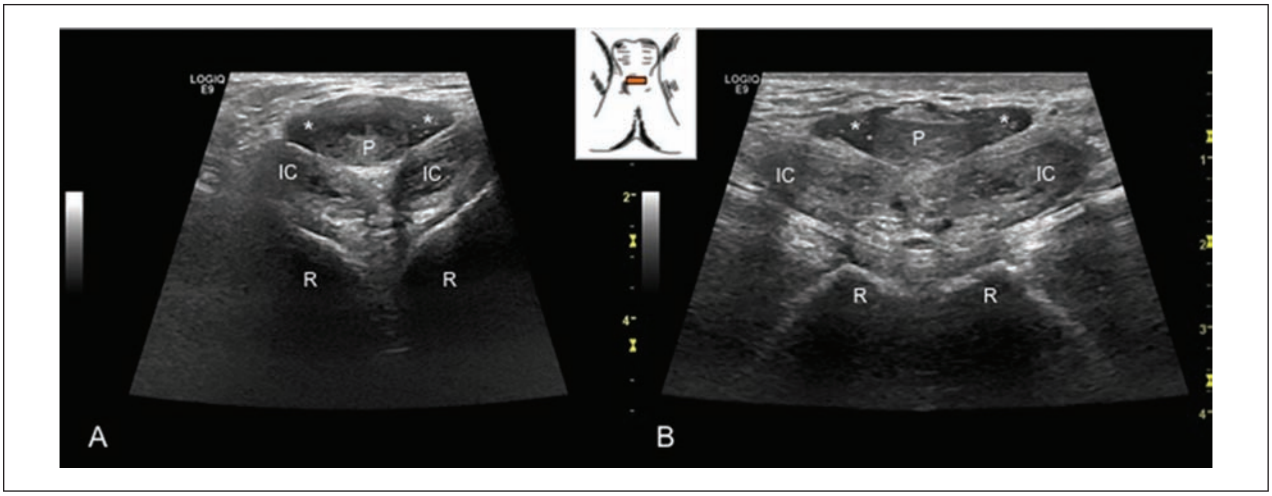

Figure 1. Sonographic images from subjects A and B in the anterior perineal region (one-quarter the distance from the base of the scrotum to the anus). The two bulbospongiosus muscles (asterisks) are seen laterally to the bulb of the penis (P) in the near field. The ischiocavernosus muscles (IC) lie deep to these structures but superficial to the inferior pubic rami (R) near the pubic symphysis.

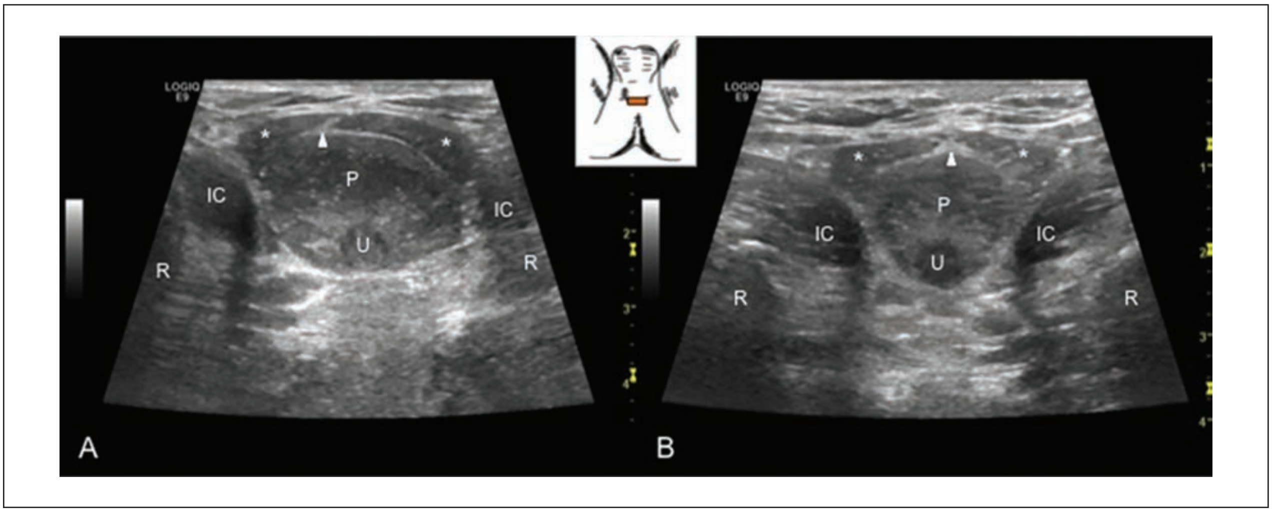

Figure 2. Sonographic images from subjects A and B in the mid-perineal region (half the distance from the base of the scrotum to the anus). The two bulbospongiosus muscles (asterisk) wrap superficially around the bulb of the penis (P) and connect to the midline raphe/central tendon (arrowhead). The ischiocavernosus muscles (IC) follow the pubic arch, sitting next to the inferior pubic rami (R) visualized at the deep lateral borders of the virtual convex image. The urethra (U) can be visualized deep in the bulb of the penis.

unable to come to consensus in the identification of the perineal body and the medial connection of the superficial transverse perineal (STP) muscles. Review of multiple anatomy reference books and models resulted in conflicting notations of the position and directionality of the STP muscles. Some references indicated an anterior-posterior direction of travel as the muscle fibers moved away from the perineal body and others indicating an anterior-posterior direction as the muscles traveled toward the perineal body from the lateral ischial tuberosities. This led to significant difficulty in confirming the exact location of this muscle on the sonographic images due to an inability to place the transducer in the correct scanning plane. To better locate these muscles, the transducer was shifted laterally to capture the ischial tuberosities. Although these muscles lie superficially along the posterior border of the region, consensus was reached that the STP was likely the deeper of the muscles noted on the image due to the directionality of the muscle fibers (Figure 3).

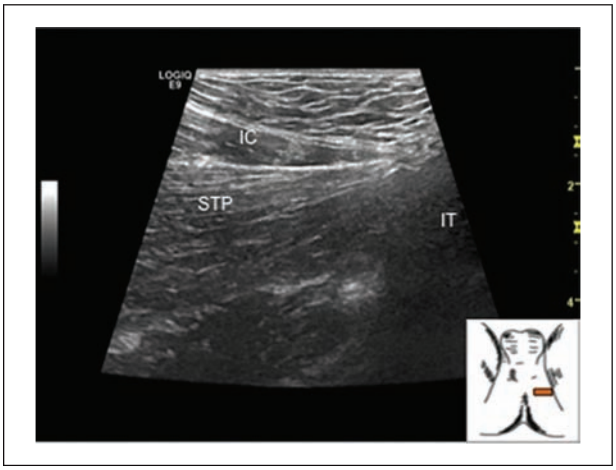

Figure 3. Sonographic image of the left margin of the posterior perineal region depicting the ischiocavernosus muscle (IC) in the near field and the superficial transverse perineal muscle (STP) in the far field as they converge and attach onto the ischial tuberosity (IT). Note: Exact orientation and location of the muscle structures in this image require further validation.

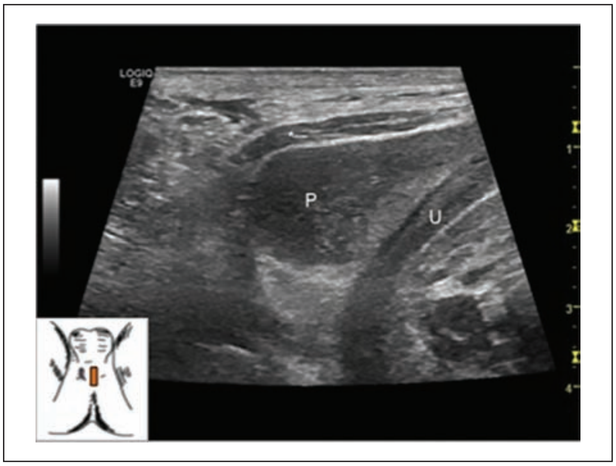

Figure 4. Longitudinal view of the central perineum demonstrating the bulbospongiosus muscle (asterisk) in the near field and the urethra (U) in the far field as each relate to the bulb of the penis (P). The transducer was placed with the orientation marker to the patient's posterior such that the left of the image is toward the anus and the right of the image toward the scrotum.

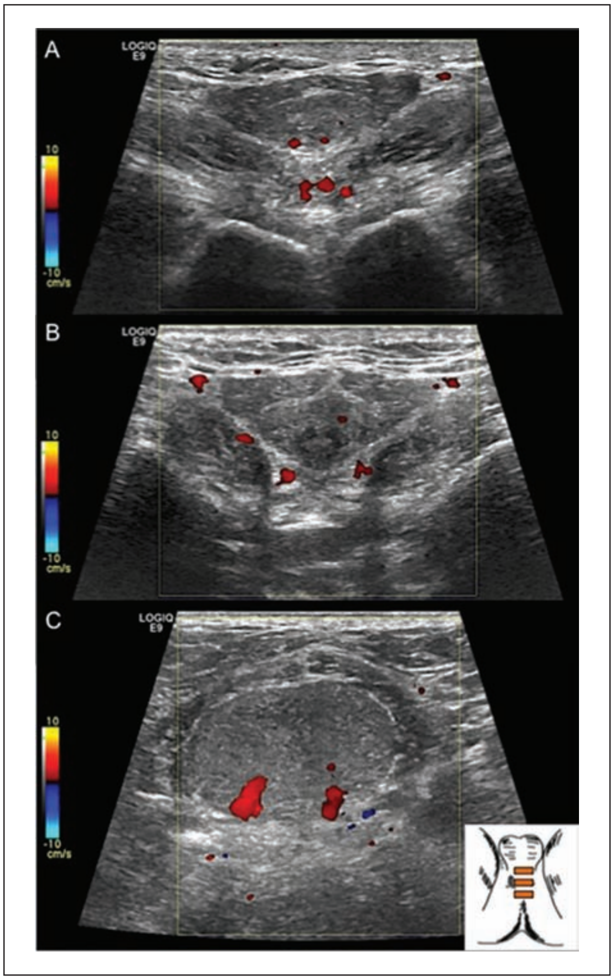

Figure 5. Doppler images were collected to evaluate vasculature in the anterior (A), mid (B), and posterior (C) perineal regions surrounding the bulb of the penis. Mirrored pairs of vessels can be noted within the interperineal membranes. Validation studies are needed to determine normal vascularity in the region and identify each of these vessels.

Images in the longitudinal plane of view were most useful in identification of structures within the middle of the perineal region. Scanning in this plane allowed for the visualization of the urethra entering the bulb of the penis along with a longitudinal view of the bulbospongiosus muscle (Figure 4). The cine clip feature was useful in being able to move frame by frame through the central region of the perineum to see the lateral borders of each of these structures. The central cord of the bulbospongiosus muscle was able to be interrogated as the transducer passed from left to right across the midline with the muscle bellies noted wrapping around the bulb of the penis on either side of the central cord.

Interrogation of the perineal region using color Doppler resulted in multiple sets of vessels surrounding the bulb of the penis. Similar to the problems noted in identification of the STP, the research team was unable to come to consensus for the specific identification of these vessels in the anterior, mid, and posterior regions of the perineum (Figure 5).

Discussion

We have demonstrated that it is feasible to use a perineal approach to obtain sonographic images of the muscles in the male pelvic floor. Once equipment is optimized and patient positioning is standardized, image acquisition in this region can be completed successfully given the limitations of musculoskeletal imaging (e.g., anisotropy). The techniques described in this study can be useful in advancing the clinical evaluation and treatment of neuromuscular conditions of the male pelvic floor provided that further validation research is completed.

The approach and equipment used in this study are highly innovative and have resulted in images that begin to fill a major gap in current literature. Only three previous studies using sonography to evaluate the male pelvic region have been identified. Previous studies have demonstrated the ability to observe and measure the relative relationship and movement of the urinary bladder and pelvic floor muscles using either an abdominal or a perineal approach with a low-frequency curvilinear transducer.[12–14] This technique and equipment appear to be adequate for visualizing the relative relationship and movement of the structures in the evaluation of urinary incontinence. However, higher resolution images are needed for the individual observation and measurement of muscles, nerves, and blood vessels.

Idiopathic pelvic pain likely involves a neuromuscular component, requiring the use of higher frequency transducers and new techniques. Evaluation of global morphology with sonography has led to the identification of more acute anorectal and levator plate angles created by the pelvic floor muscles in men with CPPS versus controls.[12] Although this structural difference could be important in determining etiology, the observation of individual muscle morphology, fascicle patterns, and muscle contractions may be more useful in clinical diagnosis and treatment. The use of a higher frequency, linear transducer in our study resulted in images with higher resolution, which allowed for identification of the individual muscles, their fascicular patterns, and tendon attachments. These higher resolution images showed some variation between our subjects in the echogenicity, size, and relative positioning of the soft tissue structures that may not have been as easily observed in a lower resolution image.

The use of high-frequency musculoskeletal sonographic techniques described in our protocol has potential for enhancing diagnosis and treatment for individuals with idiopathic pelvic pain. The anatomical landmarks provided by our scanning protocol create a foundation upon which further research can be completed to describe both normal and abnormal tissue pathologies. Differences in the relative positioning, size, and shape of each structure could be important information and add to the noted difference in angles of the pelvic floor structures previously identified.[12] In addition, other physiological tissue abnormalities that could be related to CPPS can be evaluated, including the observation of edema and swelling using Doppler techniques, the entrapment or swelling of nerves, and the development of fibrous or scar tissues in the region.

Diagnostic techniques used in other areas of musculoskeletal dysfunction should be considered and researched in this patient population. The pain syndrome may be related specifically to abnormal activation patterns in the pelvic floor muscles. Sonographic techniques may be useful in identifying myofascial trigger points[15] by measuring and evaluating fascicular patterns[16] or through the use of elastography to identify various tissue tensions.[17] Observation of the muscles over a given time period in their resting state could identify twitches or spasms, and various sonographic techniques could be used to determine how the muscles respond to voluntary contraction. Evaluation of how these muscles respond in both patients and healthy controls may lead to a better understanding of the disorder and allow for the development of more focused treatments for the regulation of the muscles involved.

Although sonography is primarily used for diagnosis and medical intervention situations, the ability to see real-time dynamic movement of tissues can potentially be of significant use in rehabilitation for CPPS. The ability to identify abnormal muscle regulation patterns from nerve or blood flow pathologies could be useful information in a clinical screening protocol to best target rehabilitation treatments. As a treatment tool, sonography may assist a therapist or clinician in targeting the treatment or in noting if the treatment is being effective in reducing the pathological state. Dynamic movement of muscles may be a useful biofeedback tool for training patients in exercise or relaxation techniques. Each of these uses requires additional investigation and evaluation for effectiveness.

One challenge in collecting and analyzing images in this region was determining the orientation and relative position of structures in the images due to the coronal scan plane. Although scanning in a coronal plane is used in neonatal cranial sonography and for scanning the plantar surface of the foot, most musculoskeletal sonography does not use this plane for scanning. Most of the structures were noted to be oriented at off-angles to each other. Therefore, once the team was able to determine the relative positions of the structures within the scan plane, a second challenge was to minimize anisotropy.

The overall lack of published sonographic images of the male pelvic floor and conflicting notation of the orientation of the structures within this region in reference books limited the interpretation of some images in this study. The most challenging was identification of the STP both during the live-scan session and in image analysis. Because reference books presented with conflicting information and only two subjects were scanned for this preliminary study, the team was unable to reach consensus for the identification of the STP. Owing to the inability to consistently obtain an image of the STP and a general lack of knowledge of its true orientation, image acquisition with a 3D probe may provide valuable information for improved scanning techniques and image interpretation. The lack of published information created a similar limitation in a lack of consensus for the identification of the neurovascular structures. It is clear that additional research is necessary to better identify and describe the location and orientation of the STP and all the neurovascular vessels in the male pelvic floor.

Although some qualitative differences were noted between the two subjects in this study, conclusions regarding the diagnostic or clinical relevance of these differences cannot yet be determined. However, the results of this study are imperative to provide a foundation, as this is one of the first publications providing images identifying individual muscles of the pelvic floor using a transperineal technique in the male. The interpretation of the images requires validation either through comparative imaging or cadaveric studies before significant data analysis can be completed. For now, the basic protocol described in this study may be limited to use as a screening tool. More advanced techniques and protocols may be required for the reduction of artifacts and to increase the reliability and accuracy for the interrogation of individual structures. Validation and development of advanced techniques can then be useful in the comparative analysis of normal and abnormal structures in clinical and research applications.

Conclusions

Transperineal sonography can be used to collect images of the structures of the male pelvic floor. Although the techniques used to collect the preliminary images in this report require rigorous validation, there is potential for the use of sonographic imaging in a clinical population. Additional research is necessary to enhance this screening protocol for the evaluation and measurement of specific structures within the male pelvic floor that may include scanning techniques such as elastography and 3D analysis. Further studies are needed to identify diagnostic measurements and other characteristics of disorders in the soft tissue structures in this region. Continued investigation of image analysis techniques that relate to screening, diagnosis, and biofeedback is warranted to advance the clinical utility of point-of-care sonography for male pelvic floor disorders.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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