THE ROLE OF MUSCULOSKELETAL IMAGING IN GOLF

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INTRODUCTION

Medical imaging can help accurately diagnose and provide treatment interventions for the >66 million people that play golf globally. This is important as the research suggests that each year 16-41% of amateur golfers will sustain an injury, while this can reach 90% of professional golfers. Golfers can also sustain injuries away from the golf course, and accurately diagnosing an issue can help these people to play, and to minimise disruption to their golfing performance (everyone wants to play their best!).

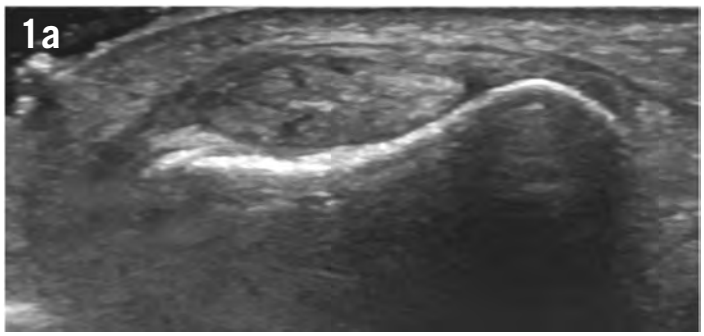
This article discusses imaging modalities, including X-ray, ultrasound, and magnetic resonance imaging (MRI), their utility in golf, and considerations related to injury patterns in golfers. We provide illustrative case examples and describe imaging in the professional game.

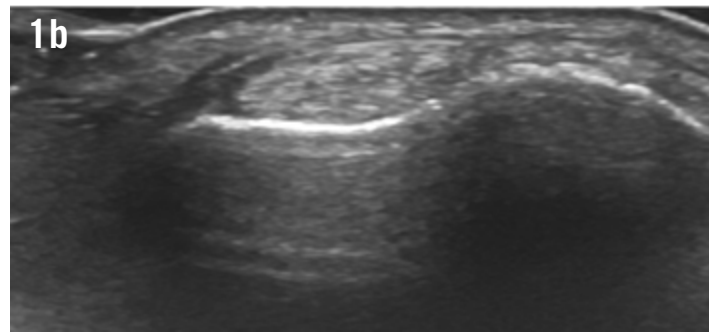
X-RAY

X-ray is available in many clinics and hospitals, and is predominantly used to look at bone and joints. Golf is a sport played by all ages and is particularly popular with older adults. For amateur golfers presenting with ongoing lower back (lumbar) or neck (cervical) pain in the absence of neurological symptoms, then conventional X-ray is often used to provide information on the degree and anatomy of degenerative change particularly around the facet joints, and to exclude other conditions. Although golf is a relatively infrequent cause of hip or knee pain, many people who play golf have osteoarthritis in these joints, and imaging can help confirm this, and support a rehab, injection or operative management strategy. Stress fractures are a well-recognised cause of pain, particularly in professional golfers where the repeatability of the swing biomechanics and increased load compared to amateurs renders them at more risk. The ribs, lumbar spine and wrist are the frequently affected areas, with rib stress fractures, pars defects and stress fractures of the hamate most common. Radiographic assessment is the first line investigation of both the areas and requires specialist views with oblique radiography of lumbar spine and carpal tunnel views of the hamate for radiographic assessment. Sensitivity can be limited, and MRI may be needed if clinical suspicion remains and X-ray is normal.

ULTRASOUND

Diagnostic ultrasound is portable, non-invasive, and is often provided on site at professional events. This portability helps provide precise imaging of muscles, tendons, ligaments, joints and other tissues on site—providing the athlete, the treating physio and clinician immediate answers. Golfers are typically precise and data-informed individuals and generally value being able to see the exact diagnosis in front of them. Point of care diagnostic ultrasound is used in the professional population to look for tendinopathy, tenosynovitis, synovitis, joint hypervascularity, and to provide dynamic imaging to assess for example for extensor carpi ulnaris instability caused by a sub-sheath tear, or for dynamic impingement at the shoulder. In amateur golfers, where elbow injuries are relatively more prevalent than in professionals, ultrasound is often used to diagnose common flexor and common extensor tendinopathy. Ultrasound is also often used—in clinic, hospital or at events—to guide diagnostic (for example using local anaesthetic) or therapeutic injection (Figures 1).





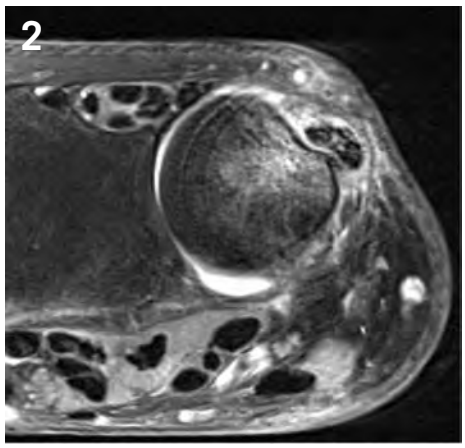


Figure 1: Professional golfer with overuse lead wrist ulna-sided wrist pain. Ultrasound demonstrates thickening of the extensor carpi ulnaris tendon with hypoechoic heterogenous echotexture (a) compared to the asymptomatic other side (b). Extensor carpi ulnaris pathology is much more common in the lead wrist of professional golfers.

Figure 2: Professional golfer with lead wrist sudden onset ulna border pain following a traumatic event. This demonstrates subluxation of the extensor carpi ulnaris tendon with subsheath distruption with bone marrow oedema and tendon sheath inflammatory pain.

MRI

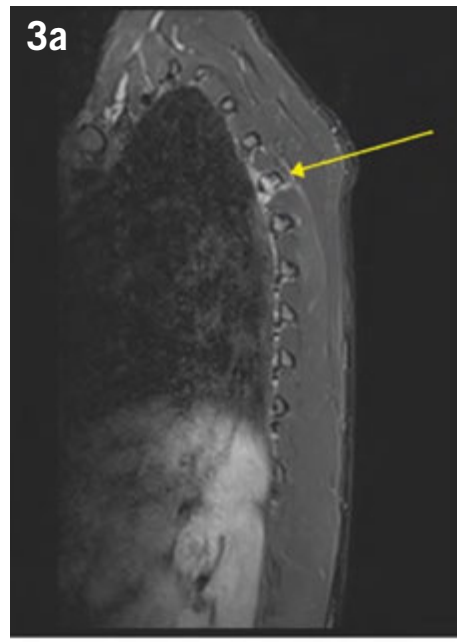
MRI can produce detailed imaging of body tissues (e.g. Figure 2). It is of great value in areas where there is limited acoustic access for ultrasound assessment. It is also more sensitive for inflammatory change than ultrasound though lacks the dynamic element of ultrasound and the ability to link findings with symptoms. Spinal (particularly lumbar, and cervical region) pain is a frequent presentation in golfers. For those that have neurological symptoms such as radiating pain, or altered sensation, power, or reflexes, an MRI is usually indicated. It can assess for any encroachment on the spinal canal, nerve roots, and for evidence of disc protrusion. It can also comment on the facet joints, muscles, ligaments and adjacent structures.

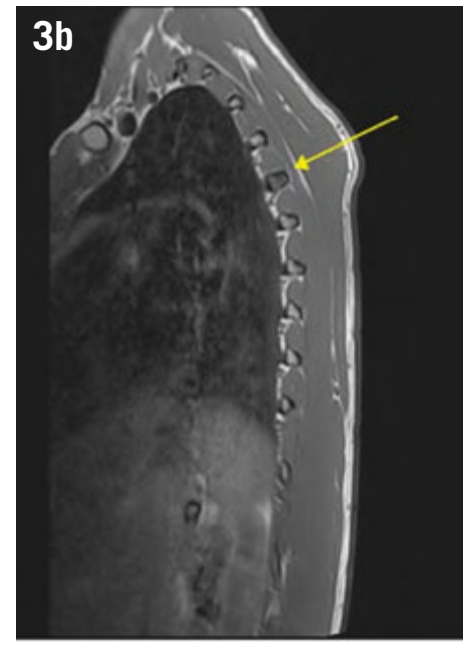
MRI is also the investigation of choice when looking for stress reactions of bone—with the hook of hamate, and the postero-lateral ribs being common sites in golfers. Computerised tomography (CT) scans can further characterise bony fractures (Figure 3).

CASE EXAMPLES

Hand/wrist

A high-level right-handed golfer who is also a new father presents with pain on the radial/thumb side of their right (trail) wrist. The onset follows a change at the top of his backswing, creating more radial deviation,





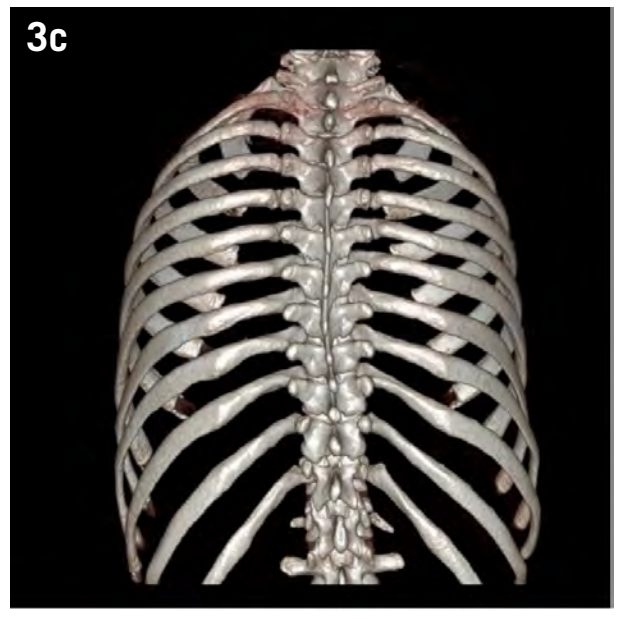


Figure 3: 27 year old professional golfer with acute on chronic left sided chest wall pain preventing competitive golf. MRI demonstrates bone marrow oedema (b) with low T1 signal (a) inkeeping with established bone stress. CT of the same player (c) showed normal appearances of the ribs in keeping with bone stress without structural failure (fracture).

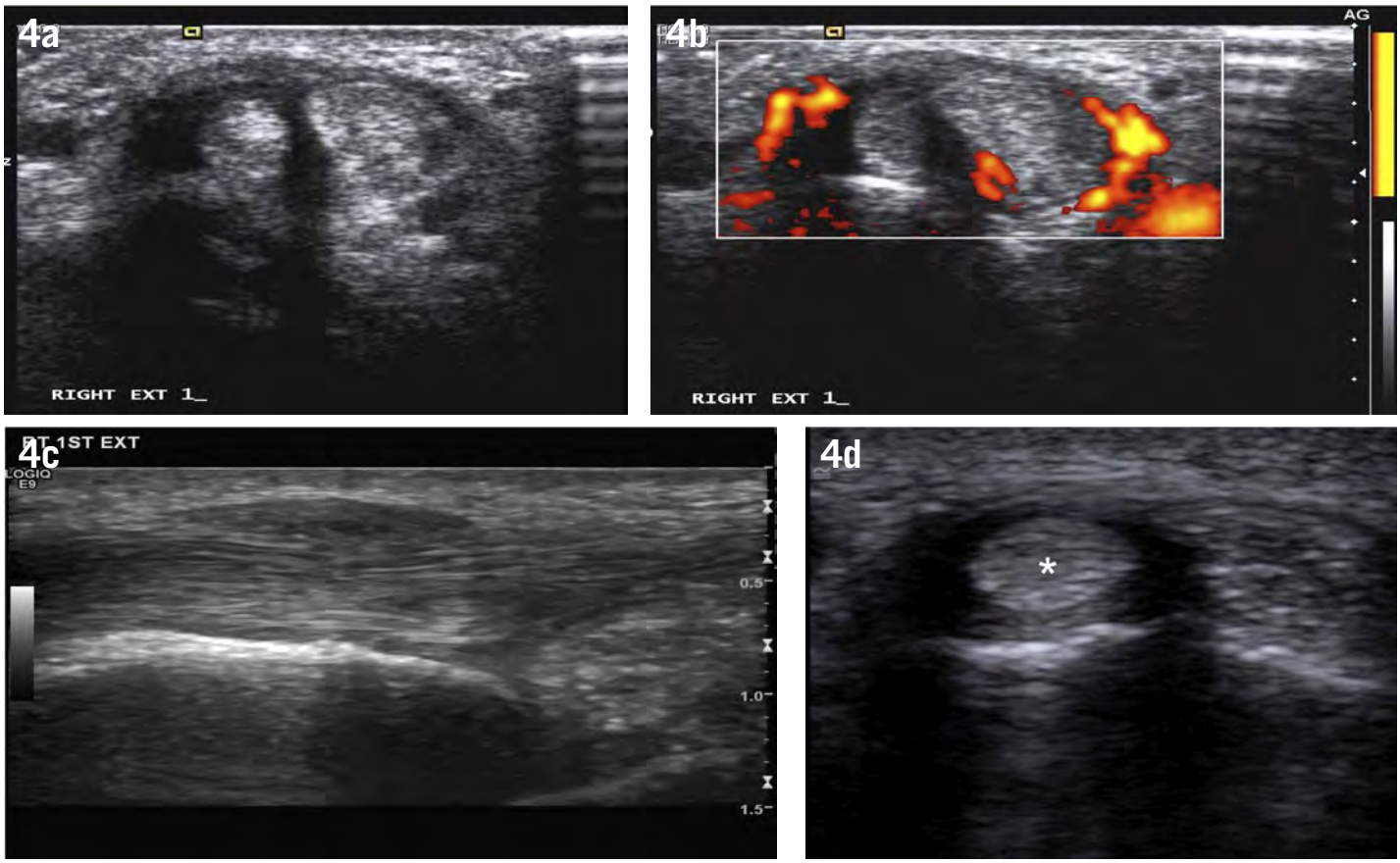


Figure 4: (a) Transverse ultrasound image demonstrating the typical grayscale ultrasound findings of hypoechoic thickening of the tendon sheaths of extensor compartment 1, predominantly involving the extensor pollicis brevis. This thickened tissue demonstrates vascularity on power doppler (b). (c) shows longitudinal scan of a different patient showing thickening of the extensor compartment 1 retinaculum resulting in stenosis of the compartment. (d) The ultrasound scan shows typical appearances of a double tunnel extensor compartment 1 with a ridge demonstrated in the underlying radius and persisting tenosynovitis in the extensor pollicis brevis portion of the compartment.

and the transition into the downswing is now painful, as well as lifting his daughter.

Examination by the physiotherapist, and sport and exercise medicine physician found tenderness over extensor compartment 1, with an abnormal Finkelstein's test. A diagnostic ultrasound showed tenosynovitis in extensor compartment 1, with some tendinopathy of abductor pollicis longus, and extensor pollicis brevis. The images below of the 1st extensor compartment shows thickening and fibrosis of the sheath seen as a low reflectivity halo around the tendon, and neovascularity (Figure 4).

Symptoms were partially improved with physiotherapy exercises (isometrics followed by eccentrics) ice, splinting and topical and oral anti-inflammatory medication. Following consultation and Therapeutic Use Exemption (TUE) approval, a guided injection of the tendon sheath with local anaesthetic and glucocorticoid was performed. In view of the thickening of the retinaculum, needling of this structure was performed to try to disrupt and release the retinaculum. We find 'ultrasound guided' injections are more accurate and provide the golfer with more confidence than 'landmark guided'/non-ultrasound guided injection. In the case of extensor compartment 1, a 'double tunnel' can lead to ongoing symptoms, with 24-77% of persons having a 'double tunnel'. Following this, the player avoided practice for 48 hours, temporarily went back to their previous swing mechanics, and was able to resume a successful season.

Other common imaging findings around the wrist include extensor carpi ulnaris tenosynovitis, tendinopathy (Figure 1) or subluxation (Figure 2), dorsal rim synovitis and dorsal ganglions. Bony injury such as carpal bossing and hook of hamate stress reaction, as well as cartilage damage, are best visualised by MRI, which also well visualises the adjacent soft tissues, plus or minus CT scanning (Figures 5 and 6).

Shoulder

Shoulder arthritis is reasonably common in the general population, and this can impact persons ability to play golf. Conventional X-ray is often used to differentiate glenohumeral joint arthritis from 'frozen shoulder'/adhesive capsulitis.

Regarding injuries sustained playing golf, impingement and rotator cuff tendinopathy/tear are the most frequent injuries seen. We share the case of a golfer in his 20s, who presents with pain, loss of range of movement and loss of power in the lead shoulder. Examination was consistent with cuff pathology. Point of care ultrasound was suggestive of subacromial bursitis, and rotator cuff tendinopathy plus or minus tear. An MRI showed quite dramatic fluid signal within the rotator cuff tendon, consistent with tendinopathy and tear, with subacromial subdeltoid bursal fluid (Figure 7).

Imaging normalised over the course of his rehabilitation, and the player remains in the world's top 100. In general around the shoulder, x-ray can assist looking for acromioclavicular and glenohumeral joint arthritis, which are common issues

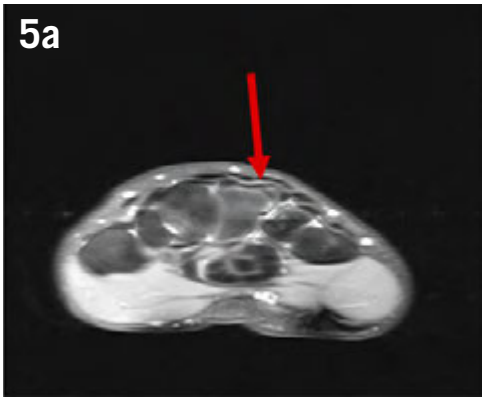
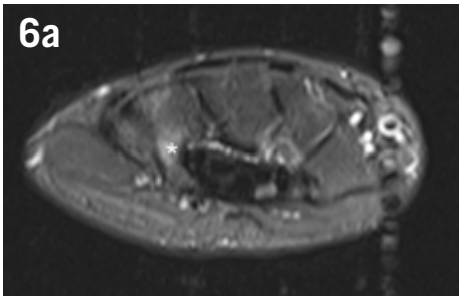
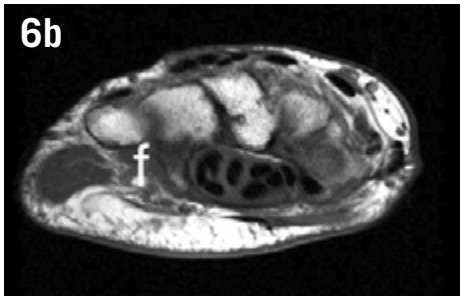
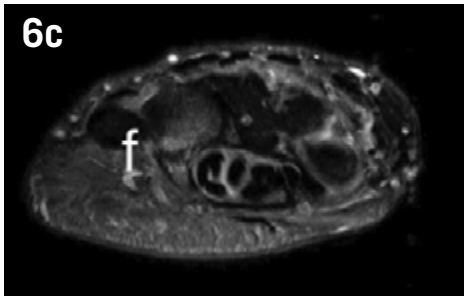
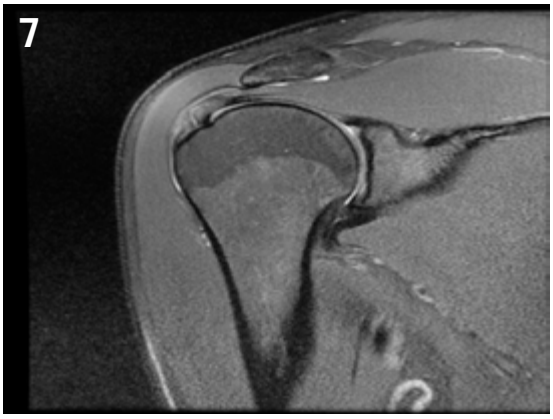


Figure 5: Professional golfer with dorsal wrist pain. (a) demonstrated typical fluid sensitive fat saturated MR appearances of dorsal prominence of the distal capitate in keeping with carpal boss formation. There is bone and soft-tissue oedema centred around an undisplaced transverse fracture (red arrow) of this carpal boss. (b) is a surface rendered CT reformat of the same golfer demonstrating the carpal boss and fracture (red arrow).









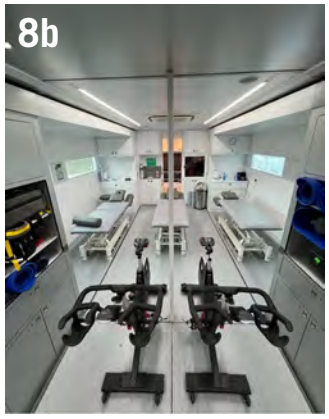


Figure 6: Professional golfers with ulna border wrist pain in their non-dominant (leading) wrist. Figure 6a demonstrates the early features of bone stress with bone marrow oedema without a linear component (*) in the hook of hamate. Figure 6b and c demonstrate the appearances as structural failure progresses to fracture.

Figure 7: Coronal PD fat saturated scan of professional golfer's right shoulder demonstrating trapping of the superior cuff under the lateral aspect of the acromion with marked abnormality of the peripheral rotator cuff. This involves both the tendon and capsular layers of the rotator cuff with thickening, oedema and cleft formation in keeping with cleft formation without full thickness tearing.

Figure 8a and b: Images of the DP World Tour mobile medical unit containing exercise, massage/treatment and consultation/scanning areas.

in the recreational golfer. Ultrasound can dynamically assess for impingement, as well as looking for rotator cuff tendinopathy, tears, and bursitis. It can also support image guided injections. MRI provides greater anatomical data, and would be the default when the diagnosis is unclear, while high resolution MRI or MR arthrogram may add value when glenoid labrum pathology is suspected.

CONSIDERATIONS FOR PROFESSIONAL GOLF

Due to years of repetitive practice, the anatomy of a professional golfer may vary from the general population. The asymmetrical nature of golf also lead to asymmetries in anatomy, that may represent injury, but in the absence of symptoms may well be adaptions to training.

Musculoskeletal radiologists play an important role in the multi-disciplinary team that support musculoskeletal care of a professional or high-level golfer—both at events and away from competition. Musculoskeletal radiologists are present on site at some, but not all professional events.

As an example, of a day in the life of a musculoskeletal radiologist at an event, for example The Open Championship, arrival would be two days in advance of the competition, and the day may start with a review of the previous week's cases (Genesis Scottish Open) with the sports physician, physio, physical preparation coaches, and orthopaedic specialists. Players will bring MRIs/X-rays/imaging data either for initial review, or for 2nd opinion reviewed at a desktop station. Some players are seen, having been referred for point of care ultrasound (Figure 8).

The mobile European Tour Health and Performance Unit has on board a GE Venue

Go, with a 19-inch screen and multiple 420 matrix probes that provide image quality near equivalent to that possible on bigger hospital based units— and offers immediate assessment to support shared decision making. This is used for first assessments, as well as to follow up and reassess players and caddies scanned the week before. This same system can be used to perform image guided injections, often with local anaesthetic to help diagnostically, or with for example glucocorticoid for synovitis of the dorsal wrist (a common condition at the time of The Open with most players having played a firm 'links' course the week before). MRIs or other relevant imaging is arranged in collaboration with the sports physicians at local facilities. Following consultation, electronic medical records are uploaded.

The radiologist is based at the player facility, which is an excellent place to watch the golf/practice range and look with the rest of the team at potential biomechanical contributors to injury. It also offers an informal setting where players will often ask for an opinion over a coffee— lunches are often interrupted! Having the multidisciplinary team together also allows discussion regarding service enhancements, but also research and development opportunities within golf, and with other sports.

Key Points

- *Medical imaging can help accurately diagnose and provide treatment interventions for the> 66 million people that play golf globally.*
- *Golfers can also sustain injuries away from the golf course, and utilising imaging to accurately diagnose an issue can help these people to play, and to minimise disruption to their golfing performance.*
- *Diagnostic ultrasound is highly portable, non-invasive, and is often provided on site at professional events. This portability helps provide precise imaging of muscles, tendons, ligaments, joints and other tissues.*
- *The asymmetrical nature of golf also lead to asymmetries in anatomy, that may represent injury, but in the absence of symptoms may well represent adaptations to training.*

Further reading

1. *Conaghan, P. G., O'Connor, P., & Isenberg, D. A. (Eds.). (2010). Musculoskeletal imaging. Oxford University Press.*
2. *O'Connor, P. J., Campbell, R., Bharath, A. K., Campbell, D., Hawkes, R., & Robinson, P. (2016). Pictorial review of wrist injuries in the elite golfer. British Journal of Sports Medicine, 50(17), 1053-1063.*
3. *O'Connor, P. J., & Hawkes, R. (2013). Imaging the elite golfer. Skeletal radiology, 42(5), 607-609*

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