ORIGINAL ARTICLE

Stress reaction of the humerus in tennis players

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Background: Overuse injuries are a frequent occurrence among competitive athletes. When analysing the incidence of overuse injuries in tennis players, it has been determined that a significant number of these injures occur in the upper limb area. In this study, we describe five cases of a stress-induced injury to the middle and distal humerus occurring mainly due to repetitive serving.

Methods: Athletes studied were competitive tennis players and elite junior players, two of whom played at international level. Four of the five were male. In all cases, diagnosis was confirmed by magnetic resonance imaging examination. The treatment of middle and distal humeral stress reactions consisted of physical therapy, which focused on analgesia and muscle strengthening. In addition, we analysed each tennis player's strokes in order to identify modifications that would decrease the amount of stress that the upper limbs were subjected to during the service motion.

Results: The players in our study missed on average 3 weeks of play and at follow-up after 1 year were able to play symptom free.

Conclusions: Our study highlights the need for coaches, physicians and players to be aware of distal humeral pain and understand treatment options in order to prevent further injury, including stress fractures.

The motions associated with certain tennis strokes have been shown to place the upper limbs of competitive and professional tennis players at risk of injury. Recently published studies have reported chronic injuries in this region.[1–4] As a consequence of these injuries, the athlete is required to spend weeks or even months recovering and is unable to participate in on-court activities. Muscle and tendon overuse injuries have been well documented in tennis players.[2] However, only a limited number of studies have focused on bone stress injuries associated with overuse.[3–5] Furthermore, most of the studies examining tennis-related bone stress injuries concentrate on injuries to the trunk and lower limbs.[5 6] In fact, only three articles were retrieved that reported stress reactions involving the humerus in tennis players.[3 4 7]

It has been well documented that the elbow, as well as the middle and distal humerus, are prone to overuse injuries.[4 7] Injuries to this portion of the arm occur primarily during the acceleration phase of the service motion, when the arm moves into internal rotation.[8] Valgus stress of the elbow also is a common occurrence during this motion.[8] The repetition of strokes during practice and matches can lead to symptoms of pain and weakness in that region that if left untreated can progress from a bone stress reaction to a complete stress fracture.

This study examined five cases in which overuse resulted in an injury to the middle and distal humerus of competitive tennis players. Our objective was to illustrate the importance of this differential diagnosis to prevent stress fractures in competitive tennis players.

CASE REPORTS

The five competitive tennis players analysed in our study ranged in age from 15–34 years old and presented with pain in the middle and distal portion of the arm. All of the subjects in our study were competitive tennis players; three amateurs and two elite juniors. The duration of their symptoms ranged from 5–52 weeks. Two of the players (patients number 2 and 3; table 1) were previously treated at another medical centre for lateral and medial epicondylitis. During our clinical examination, each patient had pain on palpation of the distal humerus, commonly in the medial and anterior region, as well as some degree of elbow hyperextension, which ranged from 5–15°. *x* Rays of the humerus were normal in all subjects and MRI showed periosteal and medullary oedema to varying degrees. T1, fat sat proton density sequence, T2 fat sat and also coronal, sagittal, and axial STIR sequences were used during the MRI examination (table 1).

The treatment consisted of a physical therapy program that focused on analgesic therapeutic treatments, followed by strengthening of the upper limbs and trunk muscles. The therapy incorporated the entire kinetic chain. In addition, we performed an analysis of each athlete's tennis strokes, focusing primarily on their service technique. Once the tennis player was pain free, the physician and the coach went to a tennis court and filmed the tennis player's service and stroke techniques using a camcorder. Both the coach and physician analysed the video in slow motion, specifically focusing their analysis on the amount of knee flexion and rotation of the trunk and upper limbs during the preparation phase of the serve; shoulder movements from the serve preparation through impact of the ball; and the follow-through motion.

Resulting recommendations to modify certain aspects of each player's tennis strokes were then carried out by the tennis coaches. Most of the tennis players had a bad leg drive motion during the preparation phase of the serve. The time off the court varied for each athlete and ranged from 3–4 weeks. More importantly, the symptoms did not return after 1 year of treatment. Each athlete involved in this study signed an informed consent and granted permission to publish their data.

DISCUSSION

Tennis is a physically demanding sport that can predispose athletes to a number of overuse injuries of bone and muscle-tendon structures.[1] The majority of these injuries have been reported to occur in the lower limb.[2–4] Despite these findings, however, the upper limbs are often reported to be an area at high risk for injury.[1] This is due to the high incidence of chronic injuries, which occur primarily in the shoulder, arm and elbow regions.[2] Overuse of these areas is common among many competitive tennis players.

Table 1 Clinical and radiological data from the tennis players

Patient	Age	Sex	Level	Practice time	Painful stroke	MRI type[9]	MRI findings	RTP
1	34	M	Amateur	6	Serve and forehand	3	Thick and irregular periosteum medullary oedema in the middle and distal humerus in T1 and T2 sequences, with biceps muscle oedema around the periosteal injury in the distal third	4
2	25	M	Amateur	8	Serve	2	Irregular periosteum with liquid, focal medullary oedema in the middle and distal third of the humeral shaft on T2 and STIR sequences	3
3	15	M	Elite Junior	12	Serve and forehand	1	Periosteum with liquid in the under surface part, mild bone oedema in the anterior and lateral distal humerus	2
4	28	M	Amateur	8	Serve	2	Irregular periosteal aspect, with mild bone oedema in the posterior and medial distal humerus	4
5	16	F	Elite junior	12	Serve and forehand	1	Periosteal with liquid in the posterior and medial part of the distal humerus, small amount of medullary oedema on STIR sequences	2

Practice time: h/week of on court practice time. MRI type according to Frederickson *et al*, described by Young and McAllister.[11] STIR, (short T1 inversion recovery); T1 and T2, sequences of the MRI exam performed; RTP: return to play (weeks).

The upper limb, more specifically the arm, is required to support a high amount of internal rotation during the acceleration phase of the service motion.[8] During the serve, the athlete also has to support a high amount of valgus stress at the elbow, which can generate medial and posterior stress.[8] Both factors put the middle and distal humerus at risk for injury because of the high amounts of rotational stress. In fact, these biomechanical risks associated with injury have been well described in the literature for athletes in other sports requiring a similar arm motion including baseball pitching and javelin throwing.[12]

Rettig and Beltz in 1985 described a single case of a 15-year-old junior elite male tennis player with a stress fracture of the humerus.[7] The primary complaint of the athlete was pain in the distal humerus for 2 months and the diagnosis was confirmed by computerised tomography examination. The patient underwent physical therapy for a period of 2 months following diagnosis, however, the pain returned after only 2 weeks of competition after treatment. The patient finally underwent treatment by external electrical stimulation for 2 months, resulting in a complete cure. Although this study examined a seemingly rare tennis injury, the proper diagnosis and treatment of this injury could prevent a more serious injury for occurring that would require substantial rehabilitation and result in prolonged periods of inactivity.

In the current study, MRI examination was utilised to confirm our clinical diagnosis of the patient's injuries. The injuries were characterised by damage to the periosteum, with or without oedema, as well as by a variety of bone medullary oedema patterns (fig 1). The MRI is mainly positive in T2 and STIR sequences (fig 2), which is consistent with the findings of previous studies that focused on the stress reactions of bone.[3 4 11] At the initial phase, the MRI is usually negative in T1 sequences, however, one of the subjects analysed in this study was found to be positive at this phase, which led us to characterise his injury as a Type 3 injury.[11]

Our study, along with those of Hoy *et al*, have demonstrated that the use of an MRI exam is critical for the proper, early diagnosis of bone stress reactions, specifically in the identification of stress reactions found in the humerus.[3] In addition, MRI examination enables analysis of marrow and periosteum oedema, which aids in the interpretation of those results. Other radiological methods, as ultrasound and *x* rays for example, do not have an adequate sensitivity for detecting these abnormalities.

All of the tennis players enrolled in our study return to competition approximately 1 month after beginning their physical therapy program. Considering that the normal recovery time required to rehabilitate from a Type 4 stress fracture is usually around 3 months, assuming no complications arise, the rehabilitation time of the athletes enrolled in our study was brief.[7 11]

Although physical therapy is extremely important for rehabilitating injuries suffered by tennis players, we believe that the stroke modifications were even more important for the successful treatment. It has been previously discussed in the literature[12] that the service technique must be addressed not only to improve power and velocity, but also to avoid injuries. During our evaluation of the service motion, we paid special attention to the lower limbs, specifically focusing on how leg drive generates power and velocity for the upper body. In our athletes, this was the main point of technical error. As pointed out by Elliott, the eccentric stretch and pretensing of the anterior shoulder muscles (particularly the internal rotators) is maximised by a vigorous leg drive that positions the racquet down behind and away from the lower back in preparation for the drive to the ball.[8] This is a very important mechanism of power generation in tennis, and if the leg drive is ineffective stress of the upper limbs can increase.

The humeral stress fracture can be difficult to clearly diagnose during the early phases of the injury. During their early stages, these injuries are characterised by various levels of pain in the arm or elbow.[4] Unfortunately, the athlete and/or coach will often overlook the pain. However, if the injury is treated during the initial phase, the athlete's recovery time can be shorter thereby limiting their time off the court, often to less than a month. The findings reported in this study agree with those of Hoy *et al*,[3] as it is often difficult to differentiate between physiological and pathological overuse that can lead to injury. If these injuries can be detected early, when the symptoms lasts no more than 2 or 3 weeks, the athlete probably will be able to resume play more quickly.

It is our belief that this study, along with previous reports by Lee *et al*[4] and Hoy *et al*[3] will contribute to help in the recognition of the bone stress reaction of the distal humerus that might precede a stress fracture of the humerus.

Figure 1 MRI T2 sagittal image showing the medullar oedema in the middle and distal humerus. Patient consent has been obtained for publication of this figure.

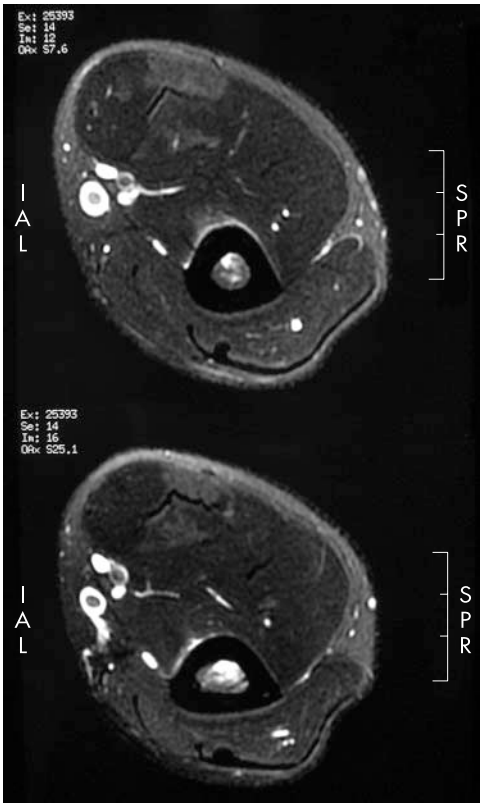

Figure 2 MRI STIR axial images showing the liquid in the periosteum and a mild medullar oedema in the distal humerus. Patient consent has been obtained for publication of this figure.

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Patient consent has been obtained for publication of both figures.

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What is already known on this topic

- Humeral stress reaction has been recently recognised as cause of distal humerus pain in tennis players.
- Early and accurate diagnosis, usually by MRI, is crucial to properly treating this condition.

What this study adds

- Bone stress reactions of the middle and distal humerus can occur in competitive tennis players.
- The serve is identified as the main stroke that results in such humeral overuse injuries.
- Restoration of normal tennis mechanics might help in the treatment of humeral bony stress reaction.