ELBOW INJURIES IN THE TENNIS PLAYER

A CONCISE REVIEW

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INTRODUCTION

The worldwide popularity of tennis has grown in recent years and it is estimated that tens of millions of individuals participate in some form of tennis in the USA alone[1]. This growth in popularity has been mirrored by a surge in the number of adolescent players, along with a growing number of senior participants who continue to play as they become older. Tennis players of all skill levels are constantly exposed to repetitive and abrupt high-energy stressors during competition[2] and the specific demands on the musculoskeletal system during play results in a myriad risk factors for the injury patterns that are often seen in these athletes[3]. During a tennis stroke, a tremendous amount of force is transmitted through the elbow joint and the inherent overhead nature of the sport creates a dynamic valgus and extension overload at the elbow[4]. Not surprisingly, it has been reported that 40 to 50% of tennis players develop symptoms about the elbow at some time during their career[5].

Elbow tendinopathy, valgus extension overload and neuritis broadly encompass the various categories that represent the more common elbow injuries sustained in tennis players. However, less common injuries, such as a stress fracture of the ulna, have also been previously reported and must be entertained when evaluating elbow pain in the tennis player[6,7]. The spectrum of injury pattern can be either acute or chronic and be affected by both player-specific risk factors and sport-specific risk factors. These factors include age, gender, volume of play, skill level, racquet grip position, racquet properties and court surface[3]. The purpose of this article is to review the conventional elbow injuries encountered in tennis players, in regards to aetiology, diagnosis and treatment. The authors will also present a brief overview of the biomechanics of the elbow joint involved with tennis play, so as to provide an adequate rationale and background for the various injury patterns that are often observed.

BIOMECHANICS OF THE ELBOW IN TENNIS

Articular congruity, capsuloligamentous competency and a well-balanced dynamic musculature control are the three major contributors to maintenance of normal elbow joint stability[4]. Osseous articular constraints provide primary stability at a flexion angle of less than 20° or more than 120°. The relatively complex anatomy of the ulnar collateral ligament (UCL) acts as the primary static stabiliser to valgus stress, providing maximal stability at 60° of flexion[8]. Meanwhile, the forearm flexor tendons provide important dynamic stability to the elbow – specifically the flexor carpi ulnaris and flexor digitorum

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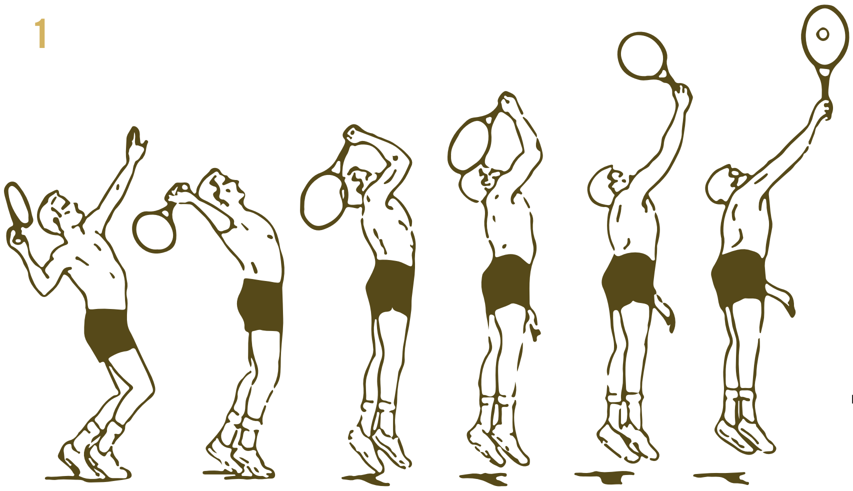

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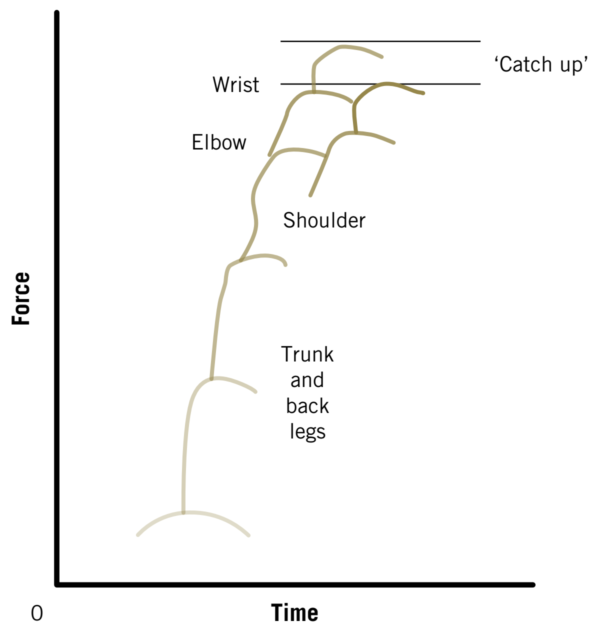

Figure 1: The different phases of the tennis service motion (reprinted with permission from van der Hoeven H, Kibler WB. Shoulder injuries in tennis players. Br J Sports Med 2006; 40:435-440.

Figure 2: A schematic illustration of the kinetic chain theory (reprinted with permission from van der Hoeven H, Kibler WB. Shoulder injuries in tennis players. Br J Sports Med 2006; 40:435-440.

superficialis – both of which possess an intimate anatomic relationship to the fibres of the UCL[9].

Tennis play consists of three basic strokes:

1. the overhead serve,
2. the forehand and
3. the backhand[10].

Each stroke can be further subdivided based upon essential phases encountered during attempted ball strike. The overhead serve is comprised of the wind-up, cocking and deceleration/follow-through (Figure 1)[5]. The ground strokes, forehand and backhand, can be sequentially separated into racquet preparation, acceleration and follow-through[11]. Consequently, each particular stage has key pathological implications, as it relates to elbow function in the tennis player. Possibly even more germane to mechanical evaluation of the athlete's elbow is the concept of the kinetic chain. The kinetic chain describes the composite interplay and transfer of energy from the lower extremities through the trunk/spine, onto the upper extremities and eventual co-ordinated ball strike by the racquet. The elbow serves as a primary link allowing for appropriate transfer of energy from the body to the racquet[5].

Kibler and colleagues have extensively studied the elbow and its relationship to the kinetic chain during tennis participation[12]. Their work, through high-speed video analysis, demonstrates an overall arc of motion of 116 to 20° of the elbow during overheard service. This flexion arc occurs over a 0.21 second time period, with ball impaction occurring at approximately 35° of flexion[12]. In contrast, ground strokes generate a much smaller range of flexion – with the forehand averaging 11° (46 to 35°) and the backhand averaging 18° (48 to 30°). The angular velocity of the elbow in extension during overhead service was calculated at 982°/second[12]. This body of data underscores the extreme forces the elbow is subjected to throughout tennis activities, demonstrating that the elbow must be able to repetitively absorb energy during flexion and extension of all tennis strokes (Figure 2).

COMMON ELBOW DISORDERS

Lateral elbow tendinopathy

Widely considered the most common elbow disorder associated with tennis, the term tennis elbow dates back to Major's first description in 1883[13,14]. The condition itself is not exclusively related to tennis, however it has be noted that up to 50% of persons who play tennis regularly will develop lateral elbow tendinopathy symptoms at some point during their careers[15]. The term 'tendinopathy' is preferred to the more common 'tendinitis'. Acute inflammation is only present for a very short period of time early in the disease the process and angiofibroblastic hyperplasia is most commonly seen on histologic examination in recalcitrant cases that lead to surgical intervention[16]. The term tendinopathy is more suitable as the disease process is often marked by vascular hyperplasia and immature fibroblast proliferation and likely precipitated by repetitive microtrauma (eccentric contraction of the extensor carpi) to the extensor origin at the elbow and chronic disruption of the normal healing cascade.

Specific technical issues related to risk factors associated with tennis play include a combination of excessive forearm pronation leading with the backhand side with a failure to appropriately shift one's body weight and swing from the shoulder[17]. Classically, the disease mainly affects the recreational tennis player, as novice players are more likely to strike the ball with their wrist in a relatively flexed position (eccentric loading position of the wrist extensor tendons)[18]. Professional players, however, are not immune and are often affected based on increased vibrational loads at ball impact coupled with an inappropriate racquet weight[13]. Recent fine wire electromyographic data performed by Elliot and colleagues has questioned the role of grip size and shown that this player-specific factor does not play a role in forearm muscle activation[19].

The onset of pain is typically insidious, although acute direct trauma can be an aetiologic factor and will often begin at the lateral aspect of the elbow and radiate down the forearm. The athlete will often complain of grip strength weakness. Physical examination will often reveal tenderness overlying the lateral epicondyle with distal extension down into the extensor mass. Passive maximal wrist flexion should reliably reproduce pain; alternatively the examiner can perform the Thomsen manoeuvre, whereby resisted wrist extension will exacerbate painful symptoms when the affected elbow is in full extension and pronation[20]. Respectively, these two simple examination techniques replicate eccentric contraction of extensor carpi radialis brevis and passive tensioning of the muscle while it is maximally stretched. Radial nerve entrapment must be ruled out with the absence of pain on resisted supination or resisted long finger extension. Furthermore, elbow stability, range of motion and distal neurovascular status must also be evaluated. Kinetic chain factors to be evaluated include weak core strength and shoulder rotation strength. Advanced imaging is typically unnecessary, however, MRI will often show increase signal on T1- and T2-weighted images about the extensor origin (degree of signal will reliable correlate with degree of pathology)[21].

Treatment

Treatment of the tendinopathy should begin with prevention. The athlete should focus on racquet striking techniques with the wrist in extension during ball impact. Focus should also be placed on balanced concentric and eccentric training of the forearm musculature, as muscle imbalances can often lead to injury[4]. Conservative care for the injured player can range from a number of options including:

- patient education,
- physical therapy,
- anti-inflammatory medications,
- acupuncture,
- braces,
- extracorporeal wave shock therapy,
- iontophoresis and
- injections (corticosteroids or biologics).

Platelet rich plasma

Recent reviews have been inconclusive, in terms of recommendations surrounding the most efficacious non-operative intervention[22]. A complete review of the litany of conservative measures is beyond the scope of this article, however the authors would like to briefly mention some of the recent outcomes regarding platelet-rich plasma (PRP) injections for the treatment of refractory lateral elbow tendinopathy, as this therapy has recently received much attention in literature. A recent systematic review performed by Ahmad and colleagues, that included nine studies, confirmed that the evidence surrounding PRP use in lateral elbow tendinopathy is evolving and currently there is only one study establishing its efficacy compared to more traditional treatment approaches[23].

Surgical treatment of lateral elbow tendinopathy should be reserved only for those patients who have symptoms that are refractory to non-operative intervention. Previous reports confirm that this should be the minority of patients and that only 4 to 11% of patients will require surgical intervention[24]. Surgical treatment options are as numerous as the abovementioned non-operative inventions and include:

- percutaneous,
- endoscopic or open release,
- extensor tendon repair and advancement,
- side-to-side repair or formal repair of the tendon origin to the epicondyle,
- resection and anconeus transfer and
- distal lengthening of the extensor muscle at the wrist[20].

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A recent study by Szabo confirmed no difference between percutaneous, open or endoscopic techniques with regard to recurrence, complications, failures or postoperative functional scores[25]. A few important surgical principles exist that likely outweigh the benefits of any one technique and these include proper patient selection, identification of the diseased tissue and complete resection of all pathologic tendon. The authors' preferred method is an open approach with formal resection of all damaged tissue and suture anchor repair of the extensor tendon at the footprint of the epicondyle. Early physical therapy focuses on regaining range of motion while limiting resisted wrist extension and forearm supination. Athletes typically return to tennis activities at about 3 months after surgery. We recommend they start with lower compression balls and focus on perfecting their technique. The amount of time spent on court should gradually increase with the goal of return to prior level of play by about 6 months after surgery[26].

Medial elbow tendinopathy

Medial elbow tendinopathy is less common in tennis players, but[27] ironically, higher-level tennis players will often develop medial symptoms while lower-level players are usually affected on the lateral side. Overloading the flexor-pronator mass is most often associated with the overhead tennis serve, which can be compounded by the valgus loads seen at the elbow during the cocking phase of the serve. This pathology is more often seen in elite level players and is associated with an excessive wrist snap, 'open stance hitting', short arm serving and opening too soon on the serve[4]. The flexor carpi radialis and pronator teres are most consistently affected by the tendinopathic process and the insidious onset of pain with micro-tearing and failure of healing is analogous to the above description of lateral elbow tendinopathy.

The athlete will most often have tenderness overlying the medial epicondyle that extends distally into the flexor-pronator mass and pain on resisted wrist pronation and flexion has been reported as the most sensitive physical exam finding[27]. Importantly, the clinician must rule-out injury to the UCL and/or irritation to the ulnar nerve, as these processes can often occur concomitantly with flexor mass overuse injuries. The diagnosis should be routinely performed on a clinical basis, plain radiographs should not show any abnormalities. MRI will demonstrate flexor tendon thickening at its origin along with increase signal intensity on T1- and T2-weighted imaging.

Non-surgical intervention is the mainstay of treatment and should include relative rest, ice and non-steroidal medications for pain relief. Bracing should only be utilised judiciously and carries the risk of exacerbating any underlying ulnar nerve compressive neuropathy that might be present. Prospective studies have demonstrated the utility of corticosteroid injections in the treatment of medial elbow tendinopathy, however a paucity of data exists in regards to studies comparing the efficacy of one non-operative intervention over another[28]. Review of stroke mechanics to decrease overload is also helpful. The option of surgical treatment should be retained only for those athletes that have failed a prolonged course of conservative care. Multiple surgical techniques have been described including percutaneous tendon release, open debridement and open medial epicondylecotmy[29]. No comparison studies exist comparing the various techniques and more germane to the surgical outcome includes implementation of proper patient selection, a safe exposure, appropriate protection of the ulnar nerve and collateral ligament and debridement

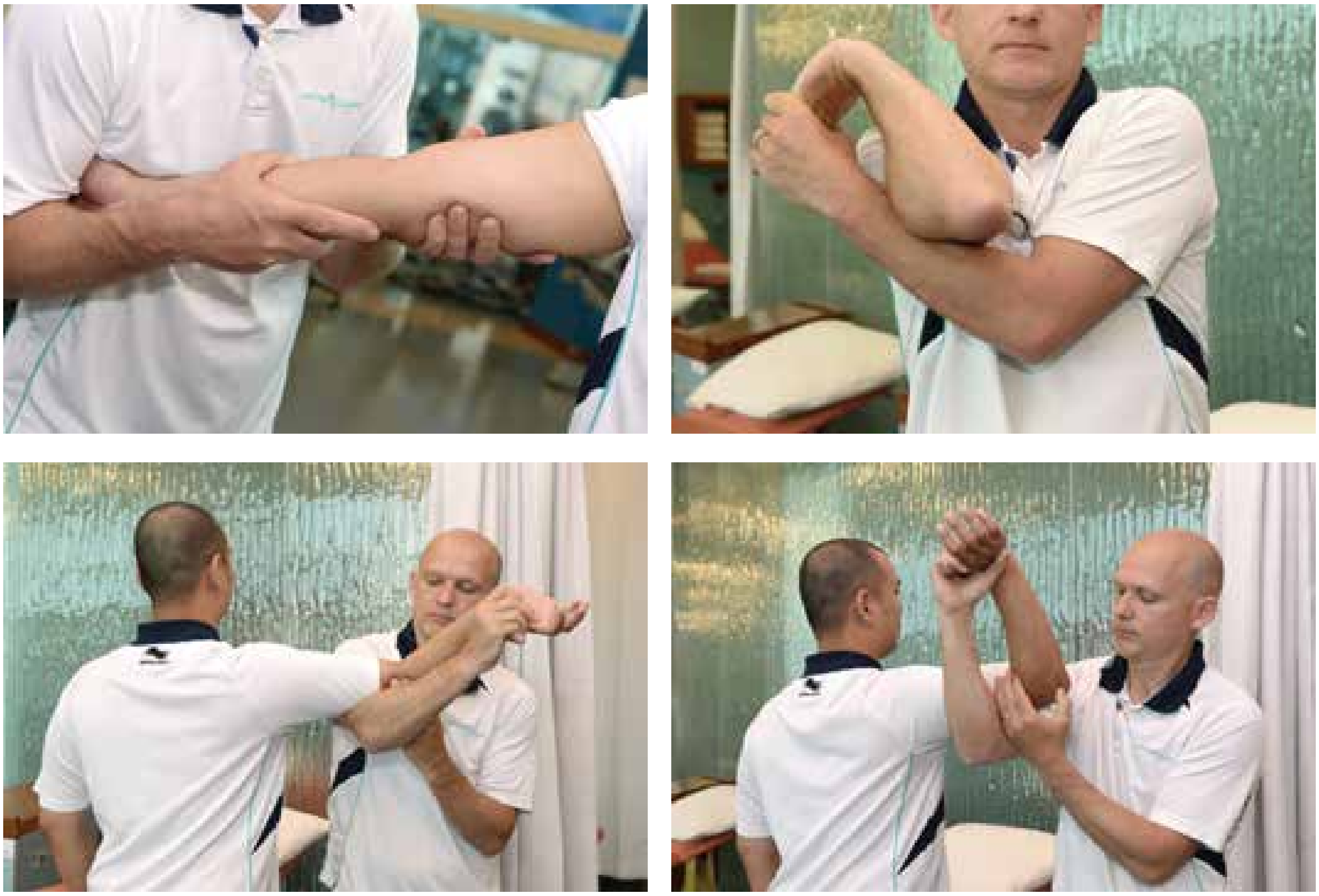

Figure 3: The various manoeuvres utilised to asses competency of the ulnar collateral ligament of the elbow.

of all diseased tissue. That said, we caution against medial epicondylectomy in this patient group. Surgical results have been reported to obtain good to excellent results in 87 to 96% of patients, last for up to 7 years and be negatively affected in those patients with concomitant persistent ulnar nerve symptoms[30]. Postoperative rehabilitation follows the same timeline as that prescribed for extensor tendon surgery, but in our experience, patients recovering from medial-sided tendon surgery progress slightly slower.

VALGUS EXTENSION OVERLOAD

Ulnar collateral ligament injury

Insufficiency of the UCL is a well-recognised phenomenon that commonly affects overhead athletes and has been extensively reported in baseball pitchers and javelin throwers[31]. The UCL is a functional complex that is comprised of the anterior oblique ligament, the posterior oblique ligament and the transverse band. The anterior oblique ligament originates from the anterior inferior portion of the medial epicondyle and inserts onto the sublime tubercle of the ulna and is the most important soft-tissue constraint to valgus instability of the elbow from 20 to 120° of flexion.

Initial evaluation must begin with a comprehensive history and physical examination as these injuries can represent a spectrum from acute disruption to chronic attenuation. In the acute setting the player will recount a sudden onset of pain that will likely be accompanied by a popping sensation related to one particular stroke/incident. In the chronic overuse setting the athlete will complain of a gradual onset of medial elbow soreness with a resultant decrease in performance standards with certain strokes (i.e. overhead serving). Elite athletes will also notice a significant decrease in ability to generate power during ball strike. Physical examination must include a careful evaluation of active and passive range of motion of the affected elbow and whether there is any pain elicited during motion. The maximal point of tenderness will be located 2 cm distal to the medial epicondyle (in contrast to the more proximal tenderness with medial elbow tendinopathy). Assessment of functional stability can be ascertained with a variety a techniques including the valgus stress test at 20° of flexion, the milking manoeuvre and the moving valgus stress test (Figure 3). Kinetic chain factors to be evaluated include weak core strength and shoulder range of motion. Plain radiographs, with or without stress views, should be ordered, however MRI is the gold standard imaging choice for diagnosis of UCL injuries. Specifically, the MRI can evaluate the entire course of the ligament and has both excellent sensitivity and specificity[32].

Treatment can be either conservative or surgical. If the non-operative route is chosen, physical therapy must focus on the dynamic valgus stabilisers of the elbow

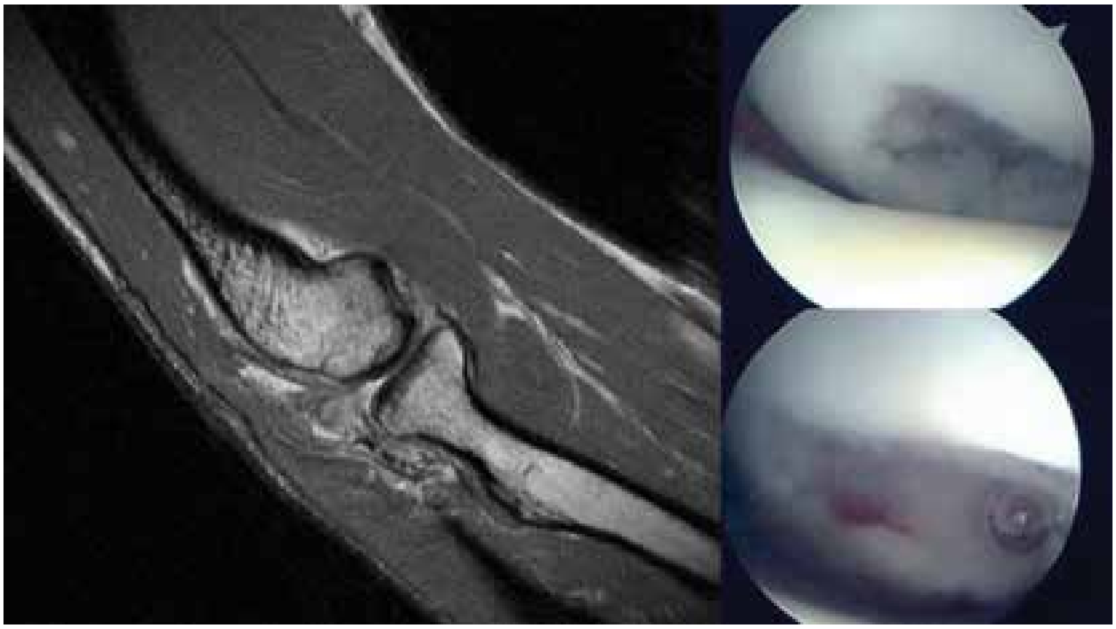

Figure 4: The MRI and intraoperative findings associated with osteochondritis dissecans of the capitellum (before and after surgical debridement).

(flexor carpi ulnaris, pronator teres and flexor digitorum), along with any range of motion deficits in the affected shoulder or elbow. Although little data exists on the non-operative intervention of UCL injuries in tennis players, conservative management is certainly reasonable in the recreational player. Surgical intervention should be reserved for those players who fail conservative care or the elite level athlete and involves reconstruction of the torn ligament. Surgical reconstruction of the UCL has evolved over the years and newer modifications to the originally proposed procedure by Frank Jobe[33] have shown improved outcomes and decreased complication rates. A recent systematic review has shown that the docking technique, performed with a flexor-pronator muscle-splitting approach and decreased handling of the ulnar nerve, has improved outcomes and decreased complication rates compared with other techniques. Furthermore, this technique has shown a reliable clinical track record, with return to pre-injury levels of play approaching 95%[34,35].

Posterior impingement

Pathologic impingement of the posteromedial tip of the olecranon process on the medial wall of the olecranon fossa is an uncommon phenomenon in the general population, however it can be quite common in the overhead athlete. The lesion is a result of repetitive hyperextension of the elbow combined with both a valgus and supination moment. The pathologic process can then be accelerated in the setting of UCL insufficiency. The athlete will typically complain of pain along the posterior joint line that is often accompanied by a joint effusion, locking, crepitus and/or an extension deficit. The time course is typically insidious in nature. Physical examination must focus on the arc range of motion, as well as stability testing of the UCL, as the competency of this structure will have important implications for the treatment algorithm. The valgus extension overload manoeuvre is pathognomonic for impingement if it reproduces pain over the posterior medial tip of the olecranon. This exam technique is performed by forcing the elbow into terminal extension while maintaining a steady valgus load on the elbow[36]. Plain radiographs are pertinent to the work-up and can document the presence of osteophytes located in the posteromedial joint space. MRI can be used to evaluate the associated soft tissue about the elbow.

Management should first begin with conservative care that focuses on improvement of flexor pronator strength and maintenance of range of motion. Surgical intervention should be considered for those athletes that have failed non-operative care, where terminal extension is ultimately causing significant pain and limitations of tennis play. The goal of surgical intervention is posteromedial joint decompression with excision of the offending osteophytes and synovium. Open or arthroscopic techniques have been described, however no direct comparison between their outcomes have been reported. The authors' preferred method includes arthroscopic debridement of the fossa, as this technique has proven to be safe and reliable with results consistent with significant improvements in both extension deficits and pain scores (at rest and with sport) in tennis players[37].

Osteochondritis dissecans of the elbow

Osteochondritis dissecans of the elbow is a phenomenon that typically occurs in the skeletally maturing elbow as a result of pathologic valgus and extension overload. Most commonly it occurs in the region of the capitellum and its relative increase in incidence mirrors the increase in competitive year-round tennis involvement in adolescent athletes. Overhead tennis play creates a compression load across the elbow that ultimately leads to a cascade of events that overloads the subchondral bone resulting in an eventual osteochondritis dissecans lesion (as continual play will interfere with healing). Symptoms are most often diffuse and non-specific. Elbow range of motion in all planes must be fully assessed and diagnostic work-up must begin with a complete set of radiographs. Aiming the X-ray beam 30° cephalad will show the capitellar surface end-on. MRI is the imaging modality of choice as it will allow for complete evaluation of all cartilaginous surfaces in the elbow, along with the underlying subchondral bone (Figure 4).

Treatment must begin with rest and cessation of tennis play, conservative care has the best prognosis in those patients with open physes. Complete healing can often take up to 6 months and a gradual return to activities should not be entertained until complete healing of the subchondral bone is achieved (minimum 6 weeks). Once the player consistently complains of clicking and catching, non-operative intervention has a low likelihood of being successful and surgical care aimed at preserving function and minimising symptoms must be undertaken. Surgery should be guided by the stage of the lesion, its arthroscopic appearance and future demands of the athlete. Fragment excision and debridement vs re-fixation is currently up for debate, as there are no current comparison studies to guide surgeons appropriately. Typically the decision to fix the fragment depends on the geometry of the bony bed and amount of bone available for fixation of the free fragment. Osteochondral restoration procedures are often reserved for those patients whose lesions extend beyond the shoulder of the capitellum, as the lateral support for the radial head is lost and some degree of instability ensues[38].

NERVE COMPRESSION SYNDROMES

Ulnar nerve

Cubital tunnel syndrome is the most common compressive neuropathy about the elbow that is encountered in tennis players. Irritation of the nerve is the direct result of repetitive traction or compression and valgus stress that is associated with racquet play. There are many sources of external compression, with the two heads of the flexor carpi ulnaris being the most common. During overhead athletic activity the nerve has an overall excursion of 12.4 mm and during the acceleration phase of overhead activity the maximum strain reaches the upper limits of its circulatory safe zone[39]. Furthermore, the nerve is exposed to considerable longitudinal strain during the extreme flexion that is generated with overhead serving[4].

A detailed neurovascular exam must be performed on these athletes and special tests including Tinel's sign, elbow flexion test and Froment's sign can all be used in the work-up of ulnar neuritis. Electrodiagnositic studies should only be utilised if the diagnosis is unclear or the location of the lesion in not discernable from the physical examination. An initial 3 to 6 month non-operative trial is the first line of treatment and should consist of a night splint in relative elbow extension, non-steroidal pain medications and routine stretching of forearm musculature. Surgical intervention should be offered for recalcitrant cases and includes decompression (open or endoscopic) with or without a nerve transposition technique. Recently, there have been a number of meta-analyses showing that simple decompression of the cubital tunnel performs just as well as transposition of the nerve, in terms of clinical outcomes and postoperative motor nerve conduction velocities[41,42].

Other nerve compression syndromes

The radial nerve, median nerve (pronator syndrome) and forearm sensory nerves (medial and lateral antebrachial) can also become entrapped as a result of tennis activity and warrant symptomatic treatment for the affected athlete. These other compressive neuropathies occur less frequently than cubital tunnel syndrome, but can be equally debilitating[40]. Repetitive rotatory movements of the forearm during stroke play put the tennis player at specific risk and a prolonged course of conservative care, including modification of tennis mechanics, must be exhausted prior to undergoing surgical decompression.

SPECIAL CONSIDERATIONS

The paediatric player

Paediatric and adolescent tennis participation is on the rise, as well as the number of yearly hours of tennis participation in these special populations[2]. A comprehensive review of maladies affecting the elbow in youth tennis players is beyond the scope of this article. However, the treating physician must be aware that these athletes represent a different subset of tennis players, with unique anatomic characteristics that place them at risk for injury[43]. Common problems that can occur include:

- Panner disease,
- medial epicondyle apophysitis,
- coronal ligament avulsion fractures and
- olecranon apophyseal injury[44].

Paramount to treatment of these injuries is early recognition and employment of proper techniques that allow for prevention. Surgical intervention should only be utilised after a thorough diagnostic work-up has been achieved and failure of satisfactory non-operative intervention when appropriate.

CONCLUSION

Tennis activities place a high demand on the osseous, soft-tissue and neural structures of the elbow. Proper training techniques that focus on prevention, while respecting the kinetic chain, should be stressed to tennis players of all competition levels. Lateral- and medial-sided elbow injuries can occur and the recreational level player is often at an increased risk of soft-tissue overuse injury associated with poor swing mechanics. All elbow injuries that occur with tennis must undergo a thorough work-up that excludes any associated pathology. In general, most conditions of the elbow can be treated successfully with conservative measures, surgical intervention should only be considered after failure of non-operative treatment.

References

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