REVIEW

Lateral epicondylitis in tennis: update on aetiology, biomechanics and treatment

Thomas De Smedt, Andy de Jong, Wim Van Leemput, Dossche Lieven, Francis Van Glabbeek

Br J Sports Med 2007;**41**:816–819. doi: 10.1136/bjsm.2007.036723

Lateral epicondylitis (tennis elbow) is the most frequent type of myotendinosis and can be responsible for substantial pain and loss of function of the affected limb. Tennis biomechanics, player characteristics and equipment are important in preventing the condition. This article presents an overview of the current knowledge on lateral epicondylitis, and focuses on treatment strategies. Conservative and surgical treatment options are discussed, and recent techniques are outlined.

See end of article for authors' affiliations

Correspondence to: Thomas De Smedt, Wilrijkstraat 10, 2650 Edegem, Belgium; thomasdesmedt1@yahoo.com

Accepted 18 June 2007
Published Online First 6 July 2007

Tennis elbow is a painful condition affecting the tendinous tissue of the origins of the wrist extensor muscles at the lateral epicondyle of the humerus, leading to loss of function of the affected limb. Therefore it can have a major impact on the patient's social and professional life.[1]

This article provides an overview of the different aspects of tennis biomechanics and the importance of player characteristics and equipment in preventing tennis elbow.

PATHOPHYSIOLOGY

Pain around the lateral epicondyle is known by a variety of names, and was described as periostitis, extensor carpi radialis brevis (ECRB)-tendinosis and epicondylalgia. The most commonly used names are ''tennis elbow'' and ''lateral epicondylitis''. The use of the terms ''periostitis'' and ''epicondylitis'' was questioned over time, as histological studies failed to show inflammatory cells (macrophages, lymphocytes and neutrophils) in the affected tissue.

Microscopical studies by Nirschl *et al* showed mainly fibroblastic tissue and vascular invasion that led him to describe the condition in 1999 as ''angiofibroblastic tendinosis''.[2] These findings left the researchers to conclude that a more appropriate term for the condition is ''lateral elbow tendinosis'', which defines a degenerative process characterised by an abundance of fibroblasts, vascular hyperplasia and unstructured collagen. The term tendinosis or tendinopathy implies the absence of chemical inflammation.[3] It has been postulated that tendinosis or tendinopathy is acquired by overuse of a hypovascular zone, which leads to subsequent neovascularisation.[4]

Despite the absence of inflammatory cells the condition is painful. Recent studies showed sensory fibres containing substance-P and CGRP (calcitonine gene-related peptide)-like immunoreactivity in the origin of the ECRB.[5 6] The presence of these neuropeptides, which is limited to a subgroup of small vessels, implies the possibility of neurogenic inflammation as a cause of the perceived pain.[7]

EPIDEMIOLOGY

Tennis elbow is a common disorder of the elbow. A recent demographic study described the epidemiology of this condition and investigated its risk factors in a sample of 4783 people aged 30–64 years. The prevalence in this group was 1.3% and did not differ between men and women. The condition was most prevalent in the age group of 45–54 years. People with a history of current or prior tobacco use were found to have an increased risk of developing tennis elbow. Repetitive movements and forceful activities were also positively correlated with lateral epicondylitis.[8]

Although pain around the lateral epicondyle is commonly referred to as ''tennis elbow'', tennis players make up only 10% of the patient population.[9 10] Half of tennis players develop pain around the elbow, of which 75% represent true tennis elbow.[11]

The natural course of the condition seems to be favourable, with spontaneous recovery within 1–2 years in 80–90% of the patients, however there is very little scientific data available on the natural history of the disease.[12]

AETIOLOGY AND TENNIS BIOMECHANICS

Tennis elbow is thought to result from overuse of the extensor carpi radialis brevis (ECRB) muscle by repetitive microtrauma resulting in a primary tendinosis of the ECRB, with or without involvement of the extensor digitorum communis (EDC). In tennis, the predominant activity of the wrist extensors in all strokes (serve, forehand and one- and two-handed backhand) might be one explanation for predisposition to the condition.[13] Comparison of tennis players suffering from tennis elbow with unaffected players showed that the former had a significantly greater activity of the wrist extensor muscles during ball impact and early follow-through. This increase in activity might have been caused by a less favourable technique, including a ''leading elbow'', wrist extension, an open racquet face near the time of ball impact, or ball contact in the lower half of the strings. These mechanics do not only result in a lower level of play, but also

Abbreviations: ASTM, augmented soft tissue mobilisation; CGRP, calcitonine gene-related peptide; ECRB, extensor carpi radialis brevis; EMG, electromyographic studies; ESWT, extracorporeal shock wave therapy, NSAID, Non-steroidal anti-inflammatory drugs leave the wrist extensors and pronator teres muscles vulnerable to injury.[14]

It is generally believed that tennis players using a two-handed backhand rarely develop tennis elbow as the non-dominant arm appears to absorb more energy, which changes the mechanics of the swing. Electromyographic studies (EMG) showed reduced amplitudes in the extensor muscles during a two-handed backhand stroke. In addition, the decreased incidence of tennis elbow in players using a two-handed backhand might not only be caused by decreased extensor activity, but also by factors associated with faulty stroke mechanics, which are more often seen with the one-handed technique.[15]

The higher occurrence of tennis elbow amongst recreational tennis players compared to experienced players has been shown to be due to the ability of experienced players to reduce impact transmission from the racquet to the wrist and elbow. EMG studies showed a significant difference between both groups. Follow-through control was proposed as a critical factor for reduction of shock transmission. Clinicians and trainers should instruct novice tennis players to quickly release their grip tightness after ball-to-racquet impact in order to reduce impact transmission to the wrist and elbow.[16]

Amongst recreational tennis players and popular media it is commonly believed that string vibration dampers reduce shock transmission to the forearm, thereby decreasing the risk of developing tennis elbow. However, a recent study has shown no significant differences in amplitude of vibration at the resonant frequency for the wrist or the elbow when damped and non-damped impact were compared.[17] They also noted no significant differences in discomfort ratings between damped and undamped impacts.[18] This evidence does not support the use of such devices.

Shock transmission is influenced by body weight, level of experience and tennis racquet properties. Increased racquet head size, as well as a higher resonance frequency of the racquet, were found to reduce arm vibration. Reduction of arm vibration is also noted in players with a higher body weight and in players with a higher level of experience.[19]

Tennis racquet grip size is also cited as a risk factor for overuse injuries about the forearm and elbow. Hatch *et al* recently studied its effect on forearm muscle firing patterns, and concluded that over- or undersizing the recommended racquet grip size by 6.35 mm does not alter forearm muscle activity significantly and therefore might not represent a clear risk factor for tennis elbow.[20]

Improper racquet weight and racquet stringing generate high loads on the lateral muscle tendon unit. In addition, harder court services impart a greater momentum to the ball and subsequently increase the force transmitted through the racquet to the extensor mass.[21]

Faulty wrist kinematics during the backhand stroke is purposed as another possible explanation for the higher incidence of tennis elbow amongst novice tennis players. Experienced players perform backhand stroke with the wrist extended to about 23° from neutral alignment, with the wrist moving further into extension at impact. Novice players however strike the ball with the wrist flexed about 13° from neutral alignment, with the wrist moving further into flexion at impact. Wrist extensor EMGs in experienced players show greater levels of activity after ball impact, consistent with the wrist extension. In contrast, the wrist extensor EMGs in novice players show similar levels of activity, despite the continued flexion. The wrist kinematics and EMG data show that novice players eccentrically contract their wrist extensor muscles throughout the stroke, which could contribute to tennis elbow.[22]

SIGNS AND SYMPTOMS: DIAGNOSIS

A patient affected by tennis elbow will complain of pain around the lateral elbow, radiating toward the extensor region. Diminished extension forces of the forearm as well as grasp function are often noted, and clinical testing reveals painful resistance against dorsiflexion of the wrist. These complaints could be present during normal daily activities or primarily during sporting activities.

Several conditions can mimic the presentation of lateral epicondylitis and should be considered when tennis elbow is suspected. The differential diagnosis includes radiculopathy (C_6–C_7), entrapment of the posterior interosseus nerve, arthrosis of the radiohumeral joint, osteochondritis dissecans, osteonecrosis (Panner) and plica synovialis.

The initial diagnosis of tennis elbow is clinical in nature and special tests are rarely indicated. However, in chronic cases ultrasound, radiographic examination, MRI and electromyophysiological testing could be helpful in identifying other causes of lateral elbow pain.[23 24]

TREATMENT

The treatment of tennis elbow aims at reducing pain, increasing strength and improving the quality of life of the patient, while minimising the possible side effects of treatment.

Ergonomic measures are often initially recommended, as occupational conditions are responsible for the initiation and maintenance of tennis elbow in many labourers.

For tennis players, proper stroke biomechanics are essential.[19] Aberrant techniques should be identified and corrected. The forehand stroke should allow the player to hit the ball in front of the body with the wrist and elbow extended. This allows the torso and upper arm to provide the majority of the power and reduces the stress on the wrist extensors. The two-handed backhand stroke allows a distribution of force between the upper extremities and also greatly diminishes force on the lateral epicondyle.

Proper equipment is also essential in preventing tennis elbow. According to Nirschl, the proper racquet grip size is assessed by measuring from the proximal palmer crease to the tip of the ring finger, along its radial border. Currently, most tennis players use a racquet grip size 2 or 3 (size 1 for children), whereas a grip size 4 or 5 was used more frequently in the past. Lighter racquets are easier to manoeuvre, but provide less momentum for impact. Frames of low-vibration materials, such as graphite and epoxies, dampen impact forces imparted to the extensor origin. Using racquets with less string tension or with a higher string count per unit area and playing on ''slower'' surfaces, such as clay courts, will diminish the loads transmitted to the elbow.[21]

Cessation of the offending activity is required initially, but complete inactivity or immobilisation should be avoided, as this might lead to disuse atrophy, which compromises later rehabilitation. Ice is recommended for its local vasoconstrictive and analgesic effects.[21]

The use of local anti-inflammatory agents has been shown to significantly reduce pain in short term as compared to placebo.[25] Hay *et al* compared efficacy of three treatment groups: consisting of an oral NSAID (naproxen 2×500 mg/d), a placebo and a steroid infiltration (methylprednisolon 20 mg + lidocaine). In the short term, they found no significant difference between the first two groups in terms of pain and grasping force, but the last group showed a 92% reduction of symptoms. Long-term results (6 months and 1 year) demonstrated no significant differences between the three groups.[26]

Physiotherapy (ultrasound, phonophoresis, electrical stimulation, manipulation, soft tissue mobilisation, neural tension, friction massage, augmented soft tissue mobilisation (ASTM) and stretching and strengthening exercises) has long played an important role in the conservative treatment of tennis elbow. A randomised trial evaluating the effect of steroid injections, physiotherapy and a wait-and-see policy concluded that steroid injections were significantly better than all other therapeutic options at 6 weeks. Success rates at 52 weeks were 69% for injections, 91% for physiotherapy and 83% for a wait-and see policy.[27] These data suggest that a wait-and-see policy is advised, as long-term results do not differ significantly between the treatment strategies.

Studies that evaluate the effect of bracing show various results. Wuori *et al* detected no difference in decrease of pain or increase of grasping force between a tailored brace, a placebo brace or no-brace-situation.[28] By contrast, Jensen *et al* concluded that tailored braces show similar results for pain and function after 6 weeks as compared to steroid infiltrations.[29] Faes *et al* showed a positive effect of a dynamic extensor brace, with decreased pain and improved function and grasping force after 6, 12, 18 and 24 weeks.[30] The available bracing systems show different biomechanical effects on the vibration and acceleration of the forearm and elbow. Bracing systems with padding on the forearm demonstrate the highest reduction of acceleration amplitudes and acceleration integrals compared to padding on the lateral epicondyle and clasp-based brace systems.[31] Further research is required before any firm conclusion can be drawn regarding this matter.

The use of extracorporeal shock wave therapy (ESWT) has shown controversial results. The multiple variables associated with this therapy, such as the amount of energy delivered, the method of focusing the shock waves, frequency and timing of delivery, and whether or not anaesthetics are used, makes comparing clinical trials difficult. A Cochrane review in 2005 compared nine trials that randomised 1006 participants to ESWT or placebo and showed shock wave therapy to provide little or no benefit in terms of pain and function.[32] The lack of positive evidence regarding its effectiveness does not support the use of ESWT for tennis elbow.[33]

Microtenotomy using a radiofrequency probe, however, seems to be beneficial in chronic lateral epicondylitis. Two recent trials demonstrate reduced pain and increased functional outcomes in the short and long term after radiofrequent microdebridement of the symptomatic tendon.[34 35]

Several studies evaluated the effect of acupuncture. A review paper of three studies that compared acupuncture with placebo showed some evidence to support the efficacy of acupuncture over placebo as a treatment for tennis elbow in the short term (2–8 weeks).[36]

The efficacy of laser therapy was studied in two recent review papers. No evidence of a beneficial effect of laser treatment was found, in either the short or long term.[36 37]

A recent prospective, placebo-controlled, double-blind study in 130 patients showed significantly improved clinical findings compared to placebo after a single injection of botulinum toxin A into the painful origin of the forearm extensor muscles. A beneficiary effect was noted as early as 2 weeks after the injection. Subjective general assessment also showed improvement. A consistent increase in fist closure strength was noted in both groups, without any significant difference. As an expected side effect of the therapy, extension strength of the third finger was observed to be significantly weakened at 2 weeks, but this complication had completely resolved at 18 weeks.[38]

Infiltration with autologous blood, buffered platelet-rich plasma or autologous growth factors also seems promising, but requires further investigation.[39] A recent study investigated the effect of a single percutaneous injection of platelet-rich plasma versus placebo in 20 patients unresponsive to initial conservative measures and considered for surgery. Eight weeks after the treatment the platelet-rich plasma patients noted 60% improvement in their visual analogue pain scores versus 16% improvement in control patients. Pain scores in treated patients improved to 81% at 6 months and 93% at final follow-up (mean 25.6 months, range 12–38 months).[40]

Other recent techniques target the pathophysiological mechanisms that lead to tennis elbow. Examples of these techniques include ultrasound-guided intratendinous injection of a sclerosing agent such as polidocanol, or application of glyceric-trinitrate patches.[41 42] The former technique reduces neovascularisation, the latter restores the collagen structure of the tendon. Both techniques seem to be promising, but require further research before being used as a routine treatment.

Surgery is indicated in case of proven tennis elbow, resistant to conservative measures. Prior to surgery it is mandatory to exclude other possible causes for the patients' symptoms. Surgery is indicated in approximately 8% of patients.[43 44]

An open approach with release of the tendons of the extensor muscles at their origin on the lateral epicondyle is most widely used. The original technique, described by Hohmann in 1933, involved a simple release of the extensor muscles.[45] Several modifications have been suggested over time.

Currently an extra-articular technique is advised, with excision of the pathologic portion of the extensor tendon origin, repair of the defect, and reattachment of the origin to the lateral epicondyle. Satisfactory results are described in 85% to 90% of the patients.[21]

An arthroscopic treatment of tennis elbow is considered a valuable alternative to an open surgical technique and produces similar results.[46 47]

Sonographically guided percutanous needle tenotomy of the extensor origin is another surgical treatment option. Using a local anaesthetic and under sonographic guidance a needle is advanced into the common extensor tendon. The tip of the needle is used to repeatedly fenestrate the tendinotic tissue. Calcifications, if present, are mechanically fragmented, and the adjacent bony surface of the apex and face of the epicondyle are abraded. Finally the fenestrated tendon is infiltrated with a mixture of a steroid and a local anaesthetic.[48] According to Dunkow *et al* this method produces significantly better short-term results compared to an open procedure.[49]

Anconeus muscle transposition is widely described as a treatment for chronic or recurrent tennis elbow. Rotation of the anconeus muscle close to the epicondyle makes it possible to cover the epicondyle bone and the exposed radiohumeral joint. When this technique is performed in refractory tennis elbow the results are especially good.[50]

What is already know on this topic

- Lateral epicondylitis is a common disorder of the elbow
- Studies concerning epidemiology, pathophysiology, diagnosis and treatment have been conducted, providing valuable information for the physician.

What this study adds

- The present study focuses on the importance of tennis biomechanics, player characteristics and equipment in prevention and treatment of lateral epicondylitis.
- An overview of the most recent treatment options and their short-term results is presented.

CONCLUSION

Tennis elbow is a common disorder amongst tennis players, but all individuals exposed to repetitive stress on the wrist extensors are at risk for developing the condition. Recreational players are more likely to develop the condition as compared to experienced and well instructed players.

The diagnosis of tennis elbow is initially clinical in nature. However, in chronic cases, ultrasound, radiographic examination and MRI might be useful to exclude other causes of lateral elbow pain.

Patients should be advised on the benign nature of the condition. Initial treatment should consist of rest and ergonomic measures to diminish the repetitive stress on the extensor muscles. Tennis players in particular should be advised on the correct biomechanics of the strokes as well as appropriate equipment.

At this time, there is no scientific evidence regarding the efficacy in the long term of the currently used conservative treatment options. New treatments, such as radiofrequency microdebridement, infiltrations with polidocanol, botulinum toxin A, autologous blood, buffered platelet-rich plasma or autologous growth factors, or application of glyceric-trinitrate patches are promising, but require further research in order to define their definitive role in the treatment of tennis elbow.

A wait-and-see approach is initially advised, but if complaints persist, a surgical approach can be considered. Many different surgical techniques have been described, with comparable results.

Authors' affiliations

Thomas De Smedt, Andy de Jong, Wim Van Leemput, Dossche Lieven, Francis Van Glabbeek, University Hospital Antwerp, Antwerp, Belgium

Competing interests: None declared.

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