Elbow Tendinopathies: Clinical Presentation and Therapist’s Management of Tennis Elbow

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TENDON STRUCTURE AND FUNCTION
HISTOPATHOLOGY OF TENDINOPATHIES
DIFFERENTIAL DIAGNOSIS
CLINICAL PRESENTATION

CRITICAL POINTS

- A comprehensive examination should be performed to allow an adequate differential diagnosis of lateral elbow pain.
- The patient’s age, duration of symptoms, exposure to risk factors, and number of recurrences are associated with degenerative changes to the common extensor tendon.
- There are no optimal guidelines for selecting therapy interventions such as physical agents and exercise.
- Patient education to avoid aggravating activity is essential to resolution of symptoms.

There is a great likelihood that an elbow tendinopathy will develop in individuals between the ages of 35 and 55, particularly if they have a high activity level that includes repetitive upper extremity motion. This includes workers in a variety of occupations and athletes, particularly those that play tennis or golf. However, a single event, such as lifting a heavy object or performing an awkward grasping movement, can develop into a tendinopathy. The dominant arm is most commonly affected.

The incidence of medial elbow tendinopathy is much lower than lateral elbow tendinopathy. Tendinopathies of the biceps and triceps are rare, including ruptures. Chapters 83 and 84 offer additional information on the less common elbow tendinopathies. This chapter focuses on examination and therapeutic management of lateral elbow tendinopathy, but these principles generally apply to the management of medial elbow tendinopathy as well.

Various names including tendinitis, tendinosis, paratenonitis, and peritendinitis have been used to represent the clinical condition of tendinopathy, depending on the status of the tendon tissue at different stages of healing. The common extensor tendon inserts onto the lateral epicondyle, which explains the use of the clinical terms lateral epicondylitis, lateral epicondylalgia, and lateral epicondylalgia to describe what the layperson calls “tennis elbow.” The use of the suffix “itis” may be misleading because it assumes that there is an acute inflammatory state within the injured tendon. The suffix “osis” and “algia” indicate a degenerative condition or pain, respectively. Although the term tennis elbow does not reveal the state of the tendon tissue, it is also not an appropriate term because most patients referred to hand therapy do not get the condition from playing tennis. The term lateral elbow tendinopathy encompasses all states of healing or lack of tendon healing, but the reality of this academic discussion is that our patients, most clinicians, and the general public refer to the condition as tennis elbow. As a search phrase for electronic literature databases, tennis elbow and lateral epicondylitis reveal significantly more citations (about 1300 each) than any of the other terms. Lateral epicondylitis only revealed 15 citations followed by 62 for lateral epicondylalgia, and 67 for lateral elbow tendinopathy. For consistency, tennis elbow is used in this chapter.

Tendon Structure and Function

Tendons serve as the interface between bone and muscle to transmit muscle force to the bone to create joint movement.
The composition of tendon is primarily collagen, ground substance, and tenocytes. An aggregate of collagen fibrils form a collagen fiber that is the basic unit of a tendon. A network of thin reticular connective tissue known as the endotenon binds collagen fibers together to form the primary (subfascicle), secondary (fascicle), and tertiary bundles that compose the tendon (Fig. 1). In addition to binding collagen fibrils together, the endotenon surrounds each of the collagen bundles. Tendons that are not enclosed in a tendon sheath are surrounded by two connective tissue layers called the epitenon and the paratenon. Together these two layers are known as the peritendon. The paratenon, a layer of loose areolar connective tissue, is the outermost layer and serves as an elastic sleeve to allow gliding of the tendon within the surrounding tissues. It is composed of type I and III collagen fibrils, elastic fibrils, and synovial cells that line the inner surface of the paratenon that interfaces with the endotenon. The epitenon is sandwiched between the paratenon and the tendon and consists of a dense network of collagen fibrils. The orientation of these fibrils is varied including longitudinal, oblique, and transverse to withstand loads applied from various directions.

Tendons receive innervation, primarily sensory, from surrounding nerve fibers in the muscle or skin. The peritendinous tissues (paratenon and epitenon) are richly innervated with free nerve endings that function as pain receptors. Other nerve fibers penetrate through the connective tissue sheaths to the surface of the tendon and terminate on sensory nerve endings. The sensory end-organs are thought to play a role in coordination, motor control, and pain mediation. Neurokinin-1 receptor, a primary receptor for substance P, has been observed in the proximal extensor carpi radialis brevis (ECRB) tendon. Substance P, a neuropeptide, is a recognized pain modulator.

The vascular supply of tendons arises from three distinct locations including the myoteninous junction, osseoteninous junction, and the paratenon. Tendons enclosed in a sheath have a more distinct vascular supply that arises from the vincula and mesotenon. In general, the vascularity of a mature tendon is poor and even absent in some regions of the tendon. This may contribute to the poor healing potential of some tendon injuries. Neovascularization is present with tendon grafts, acute tendon injuries, and chronic tendinopathies. Although the increased capillary infiltration at the level of the chronic tendon lesion is not associated with tissue repair, it is not clear what role vascularity may play in the degenerative process of tendinosis. Abnormal vascularity may contribute to pain mediation.

**Histopathology of Tendinopathies**

**Tendinosis**

The etiology associated with degenerative tendon changes is not well understood, but is described extensively in the literature for the Achilles tendon, patellar tendon, and the ECRB tendon. The term *tendinosis* has been used to describe the histopathologic findings identified in an overuse injury to a tendon. The findings include absence of inflammatory infiltrates; tenocyte or fibroblast hyperplasia and morphology; endothelial cell hyperplasia; microvascular thrombosis; hyaline, fatty, mucoid, calcified, fibrous infiltrates within the tendon substance; and cell necrosis.

Nirschl and Kraushaar described four stages of tendinosis that may assist the therapist in determining what type of intervention to provide the patient. Stage 1 is described as a peritendinous inflammation. This stage is actually what most clinicians refer to as tendinitis. Crepitus is usually palpable over the common extensor tendon. Stages 2, 3, and 4 refer to the presence of angiofibroblastic degeneration, with stage 4 being the most severe. Because of fibrosis, stage 3 may lead to tendon rupture and stage 4 to calcification.

Despite the absence of cell-mediated inflammation, patients with tennis elbow still present with pain, particularly with aggravating activity. The reason for this distinct pain in patients with tendinosis is not well understood. Also, tendinosis has been observed via tissue analysis after excision of the involved tendon. Staging a patient's tendinosis via clinical examination remains a challenge.

**Neurogenic Inflammation**

Despite the absence of inflammation, patients with tennis elbow still present with pain, particularly with abusive or aggravating activity. Tissue studies have identified the
The presence of neurochemicals within the tendon of the ECRB is compromised on its volar surface in the zone between the enthesis and the musculotendinous junction. This may add to its vulnerability to degenerative changes. Muscle biopsy specimens from the proximal and distal portions of the ECRB muscle were obtained from 20 patients with chronic tennis elbow and compared with those from controls. Abnormalities such as moth-eaten fibers, fiber necrosis, and muscle fiber regeneration had a higher incidence in the patient group than in the control group. The researchers theorized that the morphologic changes in the muscle might be attributed to a cumulative effect of mechanical or metabolic overload.

It is difficult to determine morphologic changes in the ECRB during a clinical examination. Palpable nodules, common in Achilles and patellar tendinopathies, are not common or readily palpable in the ECRB. The worst case scenario for a degenerative tendinopathy is a full-thickness tear of the tendon. Ruptures of the Achilles, patellar, and biceps tendons are easily identified. This may be attributed to the location of the rupture within the midsubstance of the tendon away from the point of insertion. Tears in the ECRB may not be identified with a clinical examination because the tear occurs at the enthesis or osseous-tendinous junction and it may not be a full-thickness tear due to the shared common tendon. The patient may only present with wrist extension weakness because the other common extensors, the extensor carpi radialis longus, would remain intact. The mild weakness may be attributed to pain if it is present.

### Differential Diagnosis

Therapists should perform a thorough examination of a patient referred with lateral elbow pain. Because tennis elbow is such a common condition, many physicians are quick to label nontraumatic elbow pain “tennis elbow” despite the multiple sources of lateral elbow pain. Table 82-1 illustrates the numerous local and remote sources that may generate lateral elbow pain. A differential diagnosis should be developed with a thorough clinical examination. It is important to rule out proximal sources of elbow pain, such as cervical radiculopathy, proximal neurovascular entrapment, and radial tunnel syndrome. Referred pain from proximal upper quarter structures should be ruled out through patient interview, upper quarter screen, cervical examination, shoulder examination, and neurodynamic assessment as described by Greenbaum and colleagues.

<table>
<thead>
<tr>
<th>Local Sources</th>
<th>Remote Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common extensor tendon</td>
<td>Cervical discs (C5–C7)</td>
</tr>
<tr>
<td>Radial nerve</td>
<td>Facet joints (C5–C7)</td>
</tr>
<tr>
<td>Posterior interosseous nerve</td>
<td>Nerve roots (C5–C7)</td>
</tr>
<tr>
<td>Musculocutaneous nerve</td>
<td>Brachial plexus (upper trunk)</td>
</tr>
<tr>
<td>Radial head</td>
<td>Spinal cord connective tissues (dura)</td>
</tr>
<tr>
<td>Distal humerus</td>
<td>Neuropathic changes in CNS</td>
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<tr>
<td>Radiohumeral joint</td>
<td>Glenohumeral joint pathology</td>
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<tr>
<td>Superior radiohumeral joint</td>
<td>Wrist complex pathology</td>
</tr>
<tr>
<td>Fascia</td>
<td>Remote nerve entrapment</td>
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<tr>
<td>Vascular</td>
<td>Trigger points</td>
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*Posterior lateral plicae syndrome.
CNS, central nervous system.
Clinical Presentation

Pain

Pain is the primary sign of tennis elbow; it is usually centered near the lateral epicondyle but may radiate proximally or distally depending on the severity of the condition.\textsuperscript{1,2,30}

The presence of posterolateral plicae in the radiocapitellar joint is another source of lateral elbow pain that is often mistaken for tennis elbow. These patients typically fail therapy for tennis elbow. Clinical examination reveals exquisite point tenderness posterior to the lateral epicondylo and centered at the posterior radiocapitellar joint. Patients frequently report a painful click or snap with terminal extension and forearm supination without instability. Analgesic injections to the lateral epicondyle may confirm this diagnosis because the pain does not subside. Elbow arthroscopy is used to diagnose and manage (remove) posterolateral plicae.\textsuperscript{38}

Another common painful condition that causes lateral elbow pain is radial tunnel syndrome.\textsuperscript{2} It is often difficult to differentiate between tennis elbow and radial tunnel syndrome in an acutely painful elbow. Clinical examination techniques used to provoke symptoms of each condition usually stress the same tissues. An important clinical feature for differential assessment is the location of point tenderness. If a patient has pain from inflammation or degeneration of the common extensor tendon, the point tenderness would most likely be located on or near the lateral epicondyle.\textsuperscript{1,2,30} If radial nerve entrapment or irritation is more likely, the point tenderness will be approximately 2 to 3 cm dorsal and distal to the lateral epicondyle within the extensor muscle mass.\textsuperscript{39,40} Pain (dull ache) will be referred to the dorsal wrist capsule because it is innervated by the posterior interosseous nerve.\textsuperscript{35} Figure 2 illustrates these areas of point tenderness.

Palpation may reveal point tenderness directly on the lateral epicondyle or slightly anterior or up to 5 mm distal to it. Point tenderness along the lateral supracondylar ridge may suggest involvement of the extensor carpi radialis longus.\textsuperscript{2} Patients often report increased aching in the evening and elbow stiffness in the morning.\textsuperscript{30} In addition to pain at rest, functional use of the involved upper extremity, especially gripping activities, usually exacerbates pain symptoms. Pain is elicited with resisted wrist extension, radial deviation, finger extension, or forearm supination.\textsuperscript{2,30,33,42} All or some of these movements may be painful, depending on the irritation of the tissues. Resisted range-of-motion (ROM) movements may be more painful with the elbow extended.\textsuperscript{2,42} Active wrist extension may be limited secondarily to pain.\textsuperscript{30}

Age

Initially, the age of the patient should help the therapist correlate the clinical findings to determine the appropriate clinical diagnosis. The incidence of tennis elbow is greatest from 35 to 55 years of age.\textsuperscript{1,2,4} Lateral elbow pain in patients younger than 35 years should be screened for other causes.\textsuperscript{4} The age of the patient also helps the therapist determine the prognosis or outcome after conservative management.\textsuperscript{33} Buckwalter and colleagues\textsuperscript{44} described age-related morphologic changes in tendons that appear to make tendons more susceptible to injury and more difficult to heal because of decreased vascular perfusion. Mechanical properties of the tendon diminish with age because of changes in cell function (especially fibroblasts) and the collagen fiber matrix, particularly with decreased tissue hydration.

Onset

Although commonly an overuse problem, many patients can relate the initial onset to a particular event.\textsuperscript{1,2} Hotchkiss\textsuperscript{1,2} suggested that patients who can provide definitive information about onset will respond more successfully to treatment than patients who describe a slow, gradual onset. The number of previous episodes may help therapists determine tissue status (symptomatic degenerative state), prognosis for therapy, and predict outcome. At a minimum, this information would direct clinicians to emphasize patient education and neuro-muscular conditioning in an attempt to reduce recurrence rates.
Occupation and Avocational Activities

Tennis elbow is considered the most prevalent work-related musculoskeletal disorder at the elbow, and sufficient evidence exists for a strong association between the prevalence of epicondylitis and a combination of physical risk factors including force, repetition, and posture. Information gathered about work duties and avocational activities can help therapists determine potential causes of tennis elbow. Physical workplace demands such as force, repetition, and awkward upper extremity postures are not only risk factors for the development of tennis elbow, but also indicators of poor prognosis for medical intervention. Job modification to reduce physical demands during recovery may be more important than passive medical interventions. Interventions such as ergonomic counseling, sports modifications, and other lifestyle changes to reduce aggravating activity during the current episode and prevent recurrent episodes are key components of patient education.

Components of the Clinical Examination

The examination components presented in this section are based on evidence in the literature germane to the examination and intervention for tennis elbow. The results of these examination procedures should assist the therapist in collecting information about the patient's impairments, help to confirm a therapy diagnosis, and aid in making an assessment about the prognosis or outcome of therapeutic management.

The clinical examination cannot confirm the tissue status of the tendon, inflammatory versus degenerative. This author believes that the index of suspicion is directed toward a degenerative condition if the patient (1) is between 35 and 55 years old, (2) has a duration of symptoms longer than 3 months, (3) has had more than one episode of tennis elbow in the same arm, and (4) has exposure to risk factors (repetitive, forceful, awkward movements). Research is needed to examine the use of clinical tests and measures as diagnostic tools and prognostic indicators for resolution of the condition.

Radiologic Findings

Most patients will not require radiologic studies, but if therapy fails or there is evidence that the signs and symptoms are not characteristic of tennis elbow, radiologic studies may be indicated to be sure that other diagnoses have not been overlooked.

Therapists should ask their patients whether any radiologic studies were performed. Diagnostic ultrasound is becoming the imaging technique of choice for tennis elbow. Plain radiographs may be used to rule out injuries to the radial head, radiohumeral joint, and proximal radioulnar joint such as radiocapitellar arthritis. Plain radiographs may also reveal calcification in the soft tissue or osteophyte formation on the lateral epicondyle. Bone scans should rule out the presence of bone tumors in patients with uncharacteristic elbow pain. Magnetic resonance imaging studies may determine the severity of a common extensor tendon tear and associated conditions such as posterolateral instability of the elbow. However, if a tear is not evident on magnetic resonance imaging, the increased signal intensity indicates increased metabolic activity, but the tissue status cannot be determined.

Patient-Rated Tennis Elbow Evaluation (PRTEE)

Overend and colleagues demonstrated high test-retest reliability of the patient-rated forearm evaluation questionnaire and its two subscales, pain and function, in patients with tennis elbow. It was modified slightly, renamed the PRTEE, and validated as an outcome measure for tennis elbow patients. Either form is a one-page self-report questionnaire that allows clinicians to quickly assess pain and function in patients with tennis elbow. Because tennis elbow is primarily a pain problem, other pain assessment tools may be used, but the PRTEE is easy to use and score.

Clinical Examination

Pressure Pain Threshold

Numerous authors have reported the reliable use of a pressure algometer to quantify the amount of pressure necessary to produce point tenderness as reported by the patient's report of pain with pressure. Lower algometer scores would indicate increased point tenderness or pain. Higher pressure-tolerance scores would indicate less pain. Klaiman and colleagues used standard algometry technique over the area of maximal point tenderness in patients diagnosed with tendinopathy (see Fig. 6). Visual analog scale scores may be recorded when the therapist directly palpates the lateral epicondyle. Reliability may not be established, but the pressure algometer does not conform well to the lateral epicondyle.

ROM

In general, ROM of the upper extremity, especially the elbow, forearm, and wrist, is not significantly impaired. Second ary to pain, active or passive ROM may be limited in wrist extension or II flexion and elbow extension. Solveborn and Olerud demonstrated that patients with tennis elbow had impaired ROM in the involved limb as compared with the symptom-free limb. In this study, most subjects had right elbow symptoms. The results indicated that with right arm symptoms, all measured active or passive motions of the elbow and wrist were limited except for passive supination. Patients with left arm symptoms had restrictions in active and passive wrist flexion, active and passive supination, and active elbow extension. These investigators argue that ROM measurements can be precisely measured in symptomatic patients and that these ROM impairments support the use of stretching in the rehabilitation of patients with tennis elbow. The measurement differences were so small that despite statistical significance, the changes may be difficult to measure with a standard clinic goniometer; however, the use of stretching may be indicated with the perception of tightness.
Grip Strength

Several studies demonstrated that grip strength will vary with shoulder, elbow, and wrist positions using a standard grip dynamometer. Therefore, therapists should use a consistent position for measurement. De Smet and Fabry demonstrated decreased grip strength with the elbow extended compared with the elbow flexed in patients with tennis elbow. They found that an increase in grip strength with the elbow extended significantly correlated with a satisfactory clinical outcome.

Pain-free grip strength can be measured on a standard grip dynamometer in the standard seated testing position with an average of three trials. The patient is instructed to squeeze the handle to the point where the pain starts and then stop. This method of grip strength testing is a commonly used outcome measure and more sensitive to change than maximal grip strength in tennis elbow patients.

Because patients with tennis elbow commonly report pain with gripping activities and pain reports are often influenced by many factors, grip strength may be used to assess treatment response. Grip strength can be measured maximally with elicited pain noted or no pain with a submaximal performance. The expectation is that as symptoms resolve with treatment, submaximal grip strength will improve and maximum grip strength will be less painful.

Special Tests

It is important to keep in mind that special tests are not pathognomonic of a particular condition. To date, common special tests that have been described in the literature for tennis elbow have not been tested for their sensitivity or specificity. Each of the described special tests stresses other soft tissue located in the lateral elbow region, especially the radial nerve. Therefore, it is important to correlate the results of the special tests performed with the rest of the clinical examination. Because each special test is targeted to examine the same soft tissue, with appropriate rest, the ability to differentiate between structures should improve.

Tennis Elbow Test. The tennis elbow test, the traditional test used to assess tennis elbow, is sometimes referred to as Cozen’s test. Figure 3 shows that the patient’s elbow is stabilized by the examiner’s thumb, which rests on the patient’s lateral epicondyle. The patient actively makes a fist with the forearm in a pronated position. The patient actively extends the wrist and radially deviates while the examiner resists the motion. A positive finding is sudden, severe pain in the area of the lateral epicondyle of the humerus.

Mills’ Tennis Elbow Test. In 1937, Mills originally described this test as a manipulation technique for patients with lateral elbow pain and limited elbow extension with the forearm pronated. He indicated that the limited elbow extension might be slight and have only a springy resistance to movement not evident on the noninvolved extremity. Mills deduced that some “tense bands,” which were painful upon stretch, were ruptured with the manipulation. It is not clear what structures in the lateral elbow region may be associated with the tense bands. Mills clearly stated that this technique should not be used on patients with muscular pain in the region. He recommended that the manipulation be performed only if there was a limitation in elbow extension.

In current practice, many clinicians do not perform the manipulation maneuver, but they use the extremity positions to provoke symptoms associated with tennis elbow. While palpating the lateral epicondyle or the most tender point near the lateral epicondyle, the examiner pronates the patient’s forearm and fully flexes the wrist as the elbow is gradually brought into full extension from the flexed position, as shown in Figure 4. Although the original description by Mills does not indicate shoulder position, the test is usually performed with the arm at the side to avoid tension on radial nerve. A positive sign is exacerbation of pain over the lateral epicondyle, which may be accompanied by a slight limitation in elbow extension with a springy end-feel.

The Mills’ test position is often used during the rehabilitation phase as a stretching technique.
not recommend surgery over a trial of therapy based on this tendinosis. It should be noted that Kraushaar and Nirschl do.

If the pain elicited is similar with the elbow flexed position, therapy is more likely to be successful — considered a reversible tendinosis. If the pain elicited is less intense in the elbow flexed 90 degrees (Fig. 5B). The patient’s report of pain is expected in the area of the lateral epicondyle. The examiner should note the severity of the pain with both elbow positions. If the elicited pain is more intense in the flexed position, therapy is more likely to be successful — considered a reversible tendinosis. If the pain elicited is similar with the elbow flexed and extended, surgical intervention will probably be needed — considered an irreversible tendinosis. It should be noted that Kraushaar and Nirschl do not recommend surgery over a trial of therapy based on this test.

Simple Handshake Test. Kraushaar and Nirschl described this test primarily to determine which patients are likely to have a good outcome with therapy. The patient shakes the examiner’s hand firmly with the elbow extended and then supinates the forearm against resistance from the examiner (Fig. 5A). The handshake is then repeated in the same manner with the elbow flexed 90 degrees (Fig. 5B). The patient’s report of pain is expected in the area of the lateral epicondyle. The examiner should note the severity of the pain with both elbow positions. If the elicited pain is less intense in the flexed position, therapy is more likely to be successful — considered a reversible tendinosis. If the pain elicited is similar with the elbow flexed and extended, surgical intervention will probably be needed — considered an irreversible tendinosis. It should be noted that Kraushaar and Nirschl do not recommend surgery over a trial of therapy based on this test.

Resisted Middle Finger Extension. Roles and Maudsley described this as the pathognomonic special test for radial tunnel syndrome, although they did not provide any testing procedures. A positive test is pain with resisted middle finger extension. The pain response may differ with wrist position. Resisted middle finger extension may be more pain provacative with the wrist in flexion than with the wrist in neutral or extension. This may be due to tension placed on the posterior interosseous nerve with the flexed wrist. This test may be equally painful in patients with tennis elbow because the extensor digitorum shares a common tendon with the ECRB.

Chair Test. The patient is asked to raise the back of a chair with the elbow in complete extension with the wrist pronated and extended. Plancher and colleagues indicated that asking a patient to perform this test may generate an apprehensive facial expression. The test itself should demonstrate voluntary weakness caused by pain in the wrist extensors. This correlates with a normal neurologic examination.

Dumbbell Test. Solveborn and colleagues described this as a functional test to assess pain with resisted wrist extension and supination. The patient is asked to pick up a 2-kg dumbbell from a tabletop, using wrist extension while gripping the dumbbell followed by supinating the forearm. Pain is assessed during this procedure using a scale of 0 to 4, where 0 represents no pain and 4 indicates pain so strong that the patient feels in danger of fainting. Therapists in the United States who want to use this test should select either a 4- or 5-pound dumbbell.

Other Examination Considerations

Parascapular Muscle Strength. The role of the scapula in optimal shoulder function is well described. Normal scapular mechanics and neuromuscular control of the parascapular muscles allow for (1) proper glenohumeral joint alignment, which enhances the function of the rotator cuff muscles; (2) adequate retraction and protraction along the thoracic wall; and (3) elevation of the acromion for overhead activities such as throwing. In addition, two particular roles of the scapula may affect optimal function of joints distal to the shoulder in the upper extremity. First, the scapula serves as the proximal link in the upper extremity kinetic chain. This sequencing allows the transfer of kinetic energy and force from the base of support (trunk) to the terminal link (hand). The efficiency of this kinetic chain depends on a stable scapula. Second, the scapula serves as a point of attachment for many muscles known as scapular stabilizers. These muscles include the trapezius, rhomboids, levator scapulae, and serratus anterior. Although the contribution of activity varies by task, the serratus anterior muscle has been identified as a primary scapular stabilizer.

The balanced muscle strength and synergistic function of these muscles maintain scapular position or stability during upper extremity tasks. Scapular dysfunction may cause injury and dysfunction to distal joints in the upper extremity, particularly the elbow.

Intrinsic Hand Muscle Strength. Simulated low median and ulnar nerve injuries by nerve blocks have demonstrated the intrinsic hand muscle force contribution for grip strength. Preinjection grip strength decreased by 32% with median nerve block, 38% with ulnar nerve block, and 49% with injections to both nerves. The strength of the intrinsic muscles should be assessed to determine whether weakness might contribute to decreased grip strength commonly attributed to pain. Comparisons of intrinsic muscle strength in normal controls and in patients with tennis elbow should be performed.
Therapist’s Management: The Need for a Comprehensive Rehabilitation Program

Lack of Evidence

Current practice patterns encourage therapists to rely on evidence in the scientific literature to support therapeutic intervention. Recent systematic reviews of the literature related to rehabilitation of tennis elbow indicate that there is a lack of scientific evidence to draw conclusions about optimal therapeutic interventions. Many problems were identified in the available literature, including the lack of randomized, controlled clinical trials; poor study design; and vague selection criteria. In addition, most of the studies that included therapeutic management looked at only one or two treatment interventions, such as a particular physical agent and orthotic intervention, and compared the results with those of conservative management with steroid injections. These studies did not incorporate exercise and patient education, which are essential to a quality rehabilitation program.

On the other hand, many authors have indicated that only about 10% of patients with tennis elbow require surgery, and good outcomes have been reported postoperatively. This suggests that therapy for tennis elbow works more often than the systematic reviews of the literature have indicated, but therapists have failed to report their outcomes in peer-reviewed literature. Finally, as discussed previously, many studies to date have addressed only one or two therapy techniques in the management of tennis elbow. Good outcomes should be expected if a quality rehabilitation program is used. Such a program incorporates interventions to promote tissue healing, pain modulation, neuromuscular conditioning, and patient education. In addition, with emphasis on neuromuscular retraining, the recurrence rates may be reduced.

Phases of Rehabilitation: Acute and Restorative

Therapeutic management of tennis elbow may be classified into two phases. The acute phase is often characterized by resting pain and easy provocation of pain with ROM or functional activity. The interventions used during the acute phase primarily address a reduction in pain and facilitating tissue healing. The restorative phase of rehabilitation typically begins when resting pain has subsided and there is little evidence of pain with active ROM or light activity.

During the restorative phase, emphasis is placed on restoring flexibility, strength, and endurance to the extensor muscle mass and common extensor tendon to increase tolerance to tensile forces placed on the musculotendinous unit. In addition to neuromuscular conditioning to the forearm, training is also considered for the shoulder, scapula, and hand to allow for efficient use of the involved upper extremity. Ergonomic considerations and sports modifications should be incorporated based on the patient’s occupation and avocational activities.

Common Therapy Interventions

In a recent survey, hand therapists identified patient education, activity modification, and exercise (stretching) as essential components of therapy for tennis elbow, both acute and chronic conditions. Patient education regarding activity modification (rest) to reduce exposure to aggravating activity appears to play a crucial role in resolving the pain associated with tennis elbow. Further clinical investigations regarding the nature and delivery of patient education are needed to determine the optimal methods of delivery and content.

Physical Agents

In a recent survey, hand therapists indicated that numerous physical agents were included in therapy for tennis elbow. There is at least level 2b evidence to support the use of ultrasound, phonophoresis, and iontophoresis to manage pain symptoms associated with tennis elbow. Iontophoresis is typically performed with dexamethasone sodium phosphate to deliver a current dosage of 40 mA/min. Pulsed or continuous wave ultrasound may be used. Although there is support for the use of phonophoresis, it does not appear to be superior to ultrasound. The relative transmission quality of coupling agents used for phonophoresis remains questionable, so it is not a favorable option to the other physical agents.

Laser or low-level light therapy only recently received Food and Drug Administration approval in the United States. However, it has been widely used to treat minor musculoskeletal pain in Europe, Canada, and Australia. Trudel and colleagues indicated that there was no evidence to support the use of laser to resolve pain in tennis elbow, but a more recent systematic review demonstrates that it may be beneficial. Similar to studies of other agents, comparisons are difficult due to lack of information about parameters.

Because tennis elbow was perceived to be primarily an inflammatory condition, most interventions have been directed toward resolving inflammation. What is currently known about the histopathology of tennis elbow indicates that although tennis elbow may start out as an inflammatory condition, it will progress to a degenerative state. In addition to pain modulation, physical agents such as ultrasound or electrotherapy may be used to facilitate tissue healing. Tendinosis, at least at the initial onset, is similar to a stagnant state of fibroplasia. Theoretically, ultrasound and electrotherapy may be able to stimulate cellular responses to promote tissue healing. Detailed information on the physiological effects of ultrasound and electrotherapy may be found elsewhere.

It is important to state that although there is evidence for the use of physical agents to resolve pain associated with tennis elbow, most studies involving physical agents incorporated patient education and exercise into the plan of care. Physical agents may only be effective in the short term. In fact, the study by Nirschl and colleagues demonstrated that the iontophoresis control group had outcomes similar to those of the iontophoresis treatment group at 1-month follow-up compared with group differences observed after 6 visits (2 weeks) for iontophoresis. This suggests that the other therapy interventions were helpful to both groups.
weeks after iontophoresis treatment was completed and that physical agents should not be used in isolation.

**Transverse Friction Massage and Soft Tissue Mobilization**

Cyriax advocated the use of transverse friction massage for soft tissue conditions such as tendinopathies to reduce pain and to promote tissue healing. He theorized that friction massage would promote collagen alignment and fiber lengthening, which would reduce scar formation within the common extensor tendon. He also believed that blood flow would increase in the area of massage as a result of a reactive hyperemia from the firm pressure applied. A recent systematic review determined that no conclusions could be drawn from the current literature due to lack of controlled clinical trials, adequate sample size, and comparable methods.

In general, massage techniques enhance local blood flow and muscle relaxation through passive movement of the tissue. Many patients do not tolerate the required firm pressure because of exquisite point tenderness. Additional research is necessary to determine the clinical efficacy of massage and soft tissue mobilization, especially with therapist-assisted instruments, in the outcome of therapeutic management of tennis elbow.

**Orthotic Intervention**

During the acute phase of rehabilitation, a wrist extension orthosis may be used to rest wrist extensors. It may be custom fabricated or prefabricated, as shown in Figure 82-6. Jansen and colleagues demonstrated that a wrist orthosis does reduce muscle activity, especially during lifting, but not as much as anticipated. The orthoses in this study held the wrist in 15 degrees of extension, which would explain the observed loss of grip strength during use of the orthosis. O’Driscoll and colleagues demonstrated that optimal grip strength is achieved when wrist extension is approximately 35 degrees. Therefore, it is recommended that the wrist be positioned in approximately 35 to 40 degrees of extension to allow optimal use of the hand while offering some rest to the wrist extensors.

Counterforce bracing may be used to resolve pain symptoms during either the acute or restorative phase of rehabilitation. In theory, the counterforce brace is thought to limit full expansion of the wrist extensor muscle mass during contraction, which may diminish pain with gripping activities. The brace may also increase the area of applied tensile stress, dispersing forces and creating an artificially wider muscle origin. This may promote rest to the injured common extensor tendon. The counterforce brace should be placed with moderate pressure over the bulky region of the extensor muscle mass on the dorsum of the forearm, distal to the lateral epicondyle, as shown in Figure 6A. Full elbow flexion should be permitted. If the brace is applied too tightly, pain may be exacerbated and compression of the radial nerve may occur.

Although the actual benefits of the counterforce brace remain unclear, Snyder-Mackler and Epler demonstrated decreased muscle activity as measured by surface electromyography. The brace may serve as a reminder for the patient not to overexert the extensor muscles. Wuori and colleagues did not observe any advantages to the use of a counterforce brace in reducing pain scores or improving pain-free grip strength compared with no bracing. These authors do state that there may have been limitations in the brace designs chosen for the study.

Recent systematic reviews offer different conclusions. Borkholder and associates identified 1 level 1b and 10 level 2b studies that offer evidence of orthotic intervention efficacy for tennis elbow. The authors do indicate that most of these studies have low quality scores due to inadequate sample size. Struijs and co-workers were unable to draw any conclusions from their systematic review due to inadequate sample size and the lack of randomized, controlled trials. Instead of more systematic reviews being performed, researchers need to focus on randomized, controlled clinical trials with adequate sample size for both orthotic intervention and other interventions used for tennis elbow.

**Therapeutic Exercise and Neuromuscular Conditioning**

**Acute Phase.** The primary focus during the acute phase is pain modulation and reduction of overload or aggravating forces. Therefore, pain-free, submaximal exercise is emphasized, especially if the patient is still working. Patients will perform pain-free elbow and wrist ROM. Multiaxial isometric strengthening exercises for the elbow, forearm, and wrist should be added as pain subsides. Therapists should monitor for exacerbation of pain symptoms after exercise. Strengthening of the parascapular and hand muscles may begin during this phase, provided that elbow pain is not increased. Proprioceptive neuromuscular facilitation techniques for the shoulder girdle (see Fig. 2A and B) are helpful for initiating strengthening of the parascapular
Intrinsic hand exercises, including finger adduction and abduction, may be performed with resistive therapeu-
tic putty.

Restorative Phase. During the restorative phase, it is assumed that there is little or no pain at rest and minimal pain with activity in the wrist extensors. Multifocal isometric strengthening exercises for the elbow, forearm, and wrist are continued with a more vigorous contraction. Patients should continue with progressive resistive exercises using concentric isotonic contractions, initially starting with low weight and repetitions. The patient is gradually progressed to eccentric contractions as tolerated, initially reducing the weight and repetitions.

A total arm strengthening program that includes strengthening exercises for the biceps, triceps, rotator cuff, and para-
scapular muscles should be incorporated into the plan of care. Isometric grip-strengthening exercises should be used to augment grip strength before starting repetitive gripping activities. If repetitive gripping is suspected as a cause of the tennis elbow, it should be avoided. Isokinetic exercise, medici-
ne ball plyometrics (Figs. 3 and 1), and "closed-chain" activities with a therapeutic ball have been advocated. Repet-
titive oscillatory movements using a B.O.I.N.G. (OPTP, Min-
neapolis, MN) or Bodyblade (Madd Dog Athletics, Venice, CA) are recommended for co-contraction and stabilization exercises of the upper extremity.

Curwin and Stanish have described a protocol of stretch-
ing and eccentric strengthening of muscles involved in tendinitis disorders. Because eccentric contractions are the most force-
ful, patients should first demonstrate their tolerance for increased force with the other types of resistive exercise. Eccen-
tric training is necessary to build up tissue tolerance for eccentric loading during functional or sports activities.

In addition to strengthening exercises, stretching exer-
cises should be incorporated as a warm-up to maintain muscle flexibility and ROM. Hand therapists believe that stretching for tennis elbow is an essential component of the therapy program. The Mills’ test position is commonly used to provide optimal stretching of the involved muscles in patients with tennis elbow.

Eccentric Exercise

In recent years, painful eccentric exercise has been advocated to resolve pain associated with chronic tendinopathies. Alfredson theorizes that painful eccentric exercise reduces neovascularization within the tendon, common in chronic lower extremity tendinopathies. Neovascularization is the implicated source of pain mediation (e.g., neurogenic inflam-
mation in tendinopathies). Decreased pain and neovascular-
ization have been observed in patients with chronic Achilles tendinopathy.

Eccentric strengthening exercises may result in remodeling at the musculotendinous junction, including hypertro-
phy and increased fibroblast activity, which leads to increases in collagen production. Therefore, this form of exercise may facilitate healing in chronic tendinopathies, which would result in a resolution of pain symptoms. Tensile strength should improve, and the patient should be able to tolerate eccentric loading of the common extensor tendon, which occurs with an extended elbow during gripping activities.

The use of eccentric exercises for tennis elbow has not shown superior results for symptom resolution compared with other types of stretching and strengthening exer-
cises. Several factors need to be considered. Tennis elbow is an insertional tendinopathy, whereas the degenera-
tive changes in the Achilles tendon occur in the midsub-
stance, about 1 cm proximal to the insertion of the tendon. This suggests that although the etiology of the tendinopathies are similar, there are discrete biomechanical factors that may be different and need to be identified.

In a recent systematic review, the benefits of eccentric strengthening exercises for tendon remodeling were confirmed, but the impact of this type of exercise on pain, function, and patient satisfaction are inconclusive. This is especially true for tennis elbow. The results for Achilles tendinopathy were more favorable. The protocol for the Achilles tendinopathy is more established at a dose of 3 sets of 15 repetitions, 7 days per week, for 12 weeks using body weight as resistance. Although the authors state that the exercise is painful, there is no reported level of pain that the patient should exceed or not exceed while performing the exercises. The eccentric strengthening exercise dosage parameters for tennis elbow are all over the place in terms of the number of repetitions and the manner in which the exercise is performed (e.g., dumbbells and resistive bands). Some prescriptions include stretching, some do not, and all exercise is performed relatively pain free. Thus, it is difficult to make comparisons between the lower extremity tendinopathies and tennis elbow due to the type of tendinopathy (midsubstance vs. insertional) and dosage parameters.

Two recent clinical research studies demonstrated symptom resolution when eccentric strengthening exercises were incorporated into the plan of care for tennis elbow. Crosnier and associates demonstrated improvement in pain after eccentric exercise performed on an isokinetic dynamo-
meter. This may not translate well into clinical practice because not all hand clinics have this equipment. Tyler and colleagues conducted a randomized, controlled trial that incorporated eccentric wrist extensor strengthening exercises with traditional therapy for tennis elbow that included stretching of the wrist extensors (Mills’ test), ultrasound, friction massage, heat, and ice therapy. The participants were assigned to either a standard treatment group that performed isotonic wrist extensor strengthening using a dumbbell or an eccentric exercise group that performed a series of eccentric exercises using an inexpensive rubber bar (FlexBar, Thera-
Band; Hygenic Corporation, Akron, OH) performing 3 sets of 15 repetitions daily. This work has not yet been published, so questions remain. The method of exercise used by the isotonic wrist extensor strengthening group using a dumb-
bell is unknown. It is assumed that this group performed concentric exercise, but the isotonic strengthening could have been performed eccentrically. The FlexBar group performed their exercises daily, but the dosage parameters for the isotonic/dumbbell group were not provided. The study by Tyler and colleagues shows promise and translates well into current clinical practice.
Work and Sports Modifications

Work Considerations. Therapists need to determine whether work activities are related to the cause of the tennis elbow. These activities may include repetitive movement such as gripping and awkward or static postures of the involved upper extremity. All patients should perform gripping activities with the wrist in a self-selected extension position; tool handles should be of adequate size to match the worker.

Sports Considerations. After neuromuscular rehabilitation, patients involved in sports should participate in interval training programs that include playing on alternate days and limiting skill components. For example, in tennis, one should start with the backhand stroke and progress gradually to a tennis serve.

Because there is a high incidence of tennis elbow in patients who play tennis, golf, and other racquet sports,1,2,30,116 therapists should be aware of some of the general considerations for equipment and stroke modifications. Good technique is essential. If the therapist is unable to give adequate advice about stroke modification, patients should be encouraged to seek help from a tennis or golf professional. Table 2 presents suggestions for tennis equipment modifications. The reader can also refer to Web sites listed at the end of the chapter. It is important to note that these recommendations and modifications may not result in biological changes but may improve participation in sports.

Summary

Therapist’s management of tennis elbow requires a thorough examination of the upper quarter to determine an adequate differential diagnosis and to determine all potential impairments that may affect the rehabilitation outcome. Patients who are able to rest from the aggravating activity early after onset and are free of confounding variables respond well to therapy. A comprehensive quality rehabilitation program that addresses pain and muscle strength impairments of the entire upper extremity should minimize recurrence of a tennis elbow condition.42,83 Patient education is required to identify work- and sports-related modifications. A small percentage of patients who do not respond well to therapy require surgery. Typically, most of these patients have a favorable outcome after the surgical procedure and postoperative rehabilitation.1,4,18,60,76 Despite current evidence in the literature, there is a need for randomized, controlled clinical studies to confirm these rehabilitation outcomes.

Table 2

<table>
<thead>
<tr>
<th>Equipment or Aspect of Equipment</th>
<th>Suggested Modification</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racquet</td>
<td>Midsize frame with medium flexibility 90–95 square inches</td>
<td>The greater the stiffness, the greater the shock on the arm on impact with ball, particularly with off-center impact; midsize frames have less stiffness</td>
</tr>
<tr>
<td>String tension</td>
<td>Lower the string tension by a few pounds</td>
<td>Creates a greater postimpact ball velocity, which produces greater power with less stroke effort</td>
</tr>
<tr>
<td>Proper grip size</td>
<td>Larger handle preferred</td>
<td>Larger grip will require less effort to hold on to racquet</td>
</tr>
<tr>
<td>Tightness of grip</td>
<td>Use submaximal grip strength</td>
<td>Elite players use submaximal grip tightness to minimize wrist stiffness and fatigue; avoid “deathgrip” common in novice players</td>
</tr>
<tr>
<td>Grip bands</td>
<td>Apply to handle</td>
<td>May reduce impact vibration and prevent slippage, allowing a looser grip</td>
</tr>
<tr>
<td>Tennis court</td>
<td>Play on slower court surfaces such as clay or asphalt</td>
<td>Slows ball velocity, which will decrease impact forces</td>
</tr>
<tr>
<td>Tennis balls</td>
<td>Use new tennis balls</td>
<td>Less impact force and less power required to hit them</td>
</tr>
<tr>
<td>Stroke modification</td>
<td>Use correct stroke mechanics; seek professional instruction</td>
<td>Hitting the ball incorrectly has been associated with increased incidence of elbow pain</td>
</tr>
</tbody>
</table>

Internet References: Patient Resources for Tennis Equipment and Modifications

Racquet Research: www.racquetresearch.com
Tennis.com: www.tennis.com
United States Tennis Association: www.usta.com