Symposium on Sports Injuries

Tennis Elbow

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Use of the term “tennis elbow” dates back at least to 1900,1 and undoubtedly, if one were industrious enough, it could be traced to the initiation of tennis itself. Traditionally prior pertinent articles written on the subject malign use of the term “tennis elbow,” and in most series tennis players are a conspicuous minority.2,3 In fact, however, tennis players with the malady are legion. Although the present discussion encompasses the etiological factors involved in the initiation and perpetration of symptoms about the lateral epicondyle primarily in tennis players, the same conceptual principles are applicable to most other sports and occupations as well.

PATHOLOGY

There seems to be general confusion in reference to the true pathological entity of tennis elbow. We suspect that Garden4 is correct in his analysis when he stated, “This problem would doubtless have been long clarified had the surgeon been less reluctant to explore the elbow in a condition which scarcely warrants such interference with this unusually sensitive joint.”

The most extensive study on the subject was undertaken by Goldie5 of Sweden in 1964. Basically he described the pathological entity as an inflammation of the extensor carpi radialis brevis and extensor communis aponeurosis at the lateral epicondyle as well as its subtendinous triangular space at the lateral condyle. His description is, indeed, consistent with my own clinical observations. Goldie noted the inflammatory process to be characterized by the following:
1. Hypervascularization of the extensor aponeurosis.
2. Presence of granulation tissue (fibrosis, long term).
3. Edema and cellular invasion of the aponeurosis.
4. No tendinous degenerative changes with advancing age (20 to 50 year age group).

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5. Loose areolar tissue in the normal subtenidous space with a few scattered vascular channels but with no nerve fibers.

6. An increased quantity of free nerve endings in the subtenidous space of symptomatic patients.

Recent literature has suggested the possibility of radial nerve entrapment. In my own clinical experience I have never seen a patient with alteration of the sensory distribution of the superficial radial nerve, however, and although it occurs occasionally, it is not commonplace for there to be palpable tenderness in the track of either the motor or the sensory branch of the radial nerve. More commonly tenderness of the muscle belly of the extensor carpi radialis brevis is noted; we ascribe this to myositis. The patient with this malady is never, however, without tenderness at the epicondyle. These authors offer convincing evidence—the relief of symptoms following decompression of the course of the radial nerve about the elbow—but they are careful to state that release of the extensor carpi radialis brevis is important for operative success, and certainly this observation is consistent also with Goldie's observations.

In summation, therefore, the pathological entity is extra-articular and is most likely an acute inflammatory process with an increase in the number of free nerve endings. Associated rupture of the tendinous aponeurosis is not common.

ETIOLOGY

The prime etiologic factor appears to be a force overload at the aponeurosis. The variables here are multiple, but can be classed as intrinsic overload (muscle contracture) or extrinsic overload (outside force-stretch injury). It would appear that these factors can be cumulative in nature, not unlike those causing a fatigue fracture.

The concept of force overload relates specifically to tennis elbow in the following ways:

1. A mechanical predisposition of the elbow to stress overload on the basis of a disadvantaged leverage force system—a medial sloping lateral condyle creating a fulcrum effect of the prominent radial head, the tension of soft tissue structures in this area increasing with hyperpronated position of the forearm (Fig. 1).

2. Inadequate forearm extensor power and endurance to withstand moments of force placed against the forearm (intrinsic overload).

3. Inadequate forearm extensor flexibility (extrinsic overload).

4. Overwhelming moments of force or repetition in the face of reasonable muscle power, endurance, and flexibility (intrinsic and extrinsic overload).

5. Interestingly, Goldie's study of cadaver specimens from ages 20 to 50 failed to reveal the anticipated obvious histologic changes that had been assumed. Clinically the malady is most common between ages 35 and 50, and certainly some factor related to age must play a role, but in view of Goldie's study it may be associated more with a physiological rather than with a histological change. In this context we have noted
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Figure 1. X-ray view of elbow with forearm in pronated position, demonstrating prominence of radial head associated with exaggerated medial slope of lateral condyle.

what appears to be a more than casual relationship in women in this age category with gynecological dysfunction (including hysterectomy without oophorectomy), and we at present openly speculate about a hormonal deficiency state, presumably estrogen.6

TREATMENT

The treatment of tennis elbow includes the following: relief of acute and chronic inflammation; increase in forearm extensor power, flexibility, and endurance; decrease in the moments of force placed against the elbow by stroke alteration, equipment change, and elbow support; and alteration of the disadvantaged leverage force system by surgery.

Relief of Acute Inflammation

1. Application of ice immediately after play.
2. Rest with absence from the sport for approximately seven days.
3. If symptoms persist, injection of the localized tender area. (My preference is 20 mg. of triamcinolone with 3 ml. of 0.5 per cent Xylocaine.)

In this regard, in approximately 700 injections we have encountered one case of subcutaneous atrophy with increasing symptoms (Fig. 2). Due caution should be taken to ensure instillation of the medication under the aponeurosis to guard against spillage into a potential steroid sensitive subcutaneous area.
4. Systemic administration of Alka Butazolidin (one capsule given three times daily, after meals, for five to seven days).
5. We do not recommend cast immobilization. There is no question that the patient is relieved of the discomfort at the time of casting, but the muscle groups atrophy and with resumption of the same activities symptoms recur—in most instances with the additional problem of further loss of muscular power.

Relief of Chronic Inflammation

1. Application of heat one-half hour before play.
2. Utilization of aspirin, 10 grains, ten minutes before play.
3. Massage with a liniment containing methylsalicylate.
4. Ultrasound in low frequency for a maximum of two minutes. (Utilize daily for a maximum of five days. If no relief, discontinue.)
5. Utilization of whirlpool for 20 minutes daily is comforting to some patients.

Increase in Forearm Power, Flexibility, and Endurance

In this regard, a determination of the class of the player is important in one’s treatment concept. Tournament class players generally are younger and have adequate muscle power and endurance but often lack flexibility. Emphasis on flexibility exercises therefore is more meaningful for this player. Conversely, intermediate club players characteristically lack strength and endurance and therefore emphasis on this aspect of the program is more meaningful.

1. Isometric exercise program to forearm extensors.
   a. Fully extend the elbow with the forearm pronated and effect maximum dorsiflexion of the wrist and fingers for a count of 10 seconds 30 times daily (Fig. 3).
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Figure 3. Isometric exercise to strengthen finger and wrist extensors.

Figure 4. Extensor forearm curl weight lifting exercise to strengthen wrist extensors and shoulder abductors.
Figure 5. Military press weight lifting exercise to improve forearm and shoulder girdle strength and endurance.

Figure 6. Stretching exercise to improve flexibility of wrist, elbow, and anterior shoulder muscle groups utilizing a 5 lb. weight. A and B demonstrate the extremes of this swinging pendulum exercise.
5. Military press weight exercise to improve forearm girdle strength and en-

![Figure 7. Stretching exercise to improve flexibility of forearm extensor muscle mass.](image)

b. Squeeze a tennis ball and hold for a count of 15 seconds as many times daily as feasible.

2. Weight-lifting forearm curls in flexion and extension with a 3 to 5 lb. weight; hold for a count of 10 seconds 20 times a day (Fig. 4).

3. Weight-lifting military press, 5 to 20 lb. weight. Progress to 40 repetitions with maximum weight (20 lb.) and 40 repetitions with half maximum weight (Fig. 5).

4. Flexibility exercise for the shoulder and forearm, utilizing a 5 lb. weight (Fig. 6).

5. Stretching of the wrist to attain a maximum 90 degrees of palmar flexion, utilizing the opposite hand for pressure and holding the elbow in full extension with the forearm in pronation, for a count of 10 seconds 15 times daily (Fig. 7).

The foregoing exercise program is simple, not time consuming, and should suffice for the average player. Due caution is indicated with any exercise program, particularly in an unsupervised and overzealous patient. I have seen patients undertaking excessively ambitious weight lifting programs with resultant muscle, ligament, and tendon rupture, as well as muscle rupture associated with ulnar nerve entrapment.

**Decrease in Moments of Force Placed Against the Elbow**

The considerations discussed up to this point have been general and are, as noted in our introductory remarks, applicable to almost any sport or occupation. The following discussion deals directly with specific problems relative to tennis.
1. Improvement of skill level by alteration of stroke production.

**Backhand, Ground Stroke, and Volley.** It has been our experience that in approximately 90 per cent of tennis players with tennis elbow the difficulty is initiated on the backhand side (Fig. 8). A quality backhand stroke includes weight transfer to the forward foot prior to ball impact, with impact occurring basically parallel to the forward foot (Fig. 9). The forward shoulder is leaning toward the net and the elbow and wrist are firm at the time of impact. There is a smooth flow to the stroke, and there is no attempt to decelerate the follow-through by antagonistic muscle groups. The power source for this quality stroke is the
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posterior shoulder muscular groups in association with body weight transfer.

The usual nontournament tennis player uses an entirely different method of stroking the ball. The weight is still characteristically on his back foot with his trunk leaning away from the net. The impact point is generally 12 to 18 inches in front of the forward foot, and the wrist and elbow are still moving at the time of impact. The power source is therefore clearly the forearm muscle mass. The concepts of intrinsic and extrinsic muscle overload therefore play a direct role in the stroke. Inexperienced players often mis-hit the ball as well, increasing the forces of torque on the racquet head and thereby increasing the overload problem. A solution to this difficulty is improvement of the backhand ground stroke and volley. This, in my experience, takes professional instruction, concentrating on body weight transfer.

Forehand. As noted in prior discussion, the pronated position of the forearm exaggerates the fulcrum effect of the radial head. A forehand that is sharp, rolling, and jerky places the forearm in a hyperpronated position initiates or exacerbates the malady in many instances (Fig. 10). Interestingly, the player who hits this way feels he is placing top spin on the ball. In actuality, world class players brush the ball upward to obtain top spin rather than using the hyperpronated position. The stroke therefore is bad medicine and bad tennis.

Serve. This is generally the only area in which tournament class players have difficulty (especially true of players who have considerable forearm muscle mass with a lack of wrist-palmar flexibility). The player with a good serve motion reaches up and out from the serve loop, the ball being hit at full arm extension. Quality players generally serve with a backhand grip, forcing the forearm into a hyperpronated position (Fig. 11). An additional attempt at wrist snap for extra power at the time of impact adds pressure in the form of a stretch injury to the extensor
muscle mass. The American twist serve particularly aggravates this hyperpronated position and is not recommended for all players, but particularly for those who have recurring difficulties with tennis elbow.

Elbow Brace. A nonelastic brace approximately 2 inches wide placed about the proximal forearm just distal to the crease of the elbow has been found to be clinically quite beneficial in the relief of symptoms of tennis elbow (Fig. 12). It is my opinion that the brace acts by supplying the extensor muscle mass with a second origin distal to the radial head and thereby decreases the fulcrum leverage effect that occurs at the aponeurosis attachment to the lateral condyle and epicondyle.

Figure 11. Hyperpronated forearm in follow-through of quality serve. (Demonstrated by world class tournament player, Tom Okker.)

Figure 12. Nonelastic elbow support with advanced curvilinear design and ease of one person application.
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2. Alteration of equipment.

**Racquet Frame.** A heavy, large throated, relatively firm, wooden racquet tends to aggravate the acute inflammatory symptoms of tennis elbow. The newer metal frames, either stainless steel or aluminum alloys and lightweight, have from a practical point of view improved this situation. The newer wood frames with fiberglass reinforcement and thin-throat design also seem to be effective now in this regard. In considering frames we have found metal racquets with an unconventional stringing not nearly as successful as others. It would appear that increased torque is transmitted to the forearm by balls hit off center. We therefore recommend a racquet frame that has conventional rather than trampoline stringing.

**String Tension.** A tension of racquet frame stringing higher than 55 pounds is ill advised. Utilization of 16 gauge gut has some minor advantage over nylon, but the cost may outweigh this advantage.

**Racquet Handle.** Most players tend to play with too large a handle. We have found that the distance from the proximal palmar crease of the hand along the radial border of the ring finger to its tip approximates in general the size handle that should be utilized (Fig. 13). Manufacturers characteristically supply handles from 4 1/2 to 4 3/4 inches, and this fits most male hands. Adult women's hands, however, characteristically measure from 4 1/8 to 4 1/4 inches.

**Tennis Ball.** Heavy duty or rubber center balls impart more concentrated moments of force at the time of impact and have been noted to aggravate the symptoms of tennis elbow. Regular duty balls therefore are recommended.

**Playing Surface.** The actual play of tennis is greatly altered by the playing surface. "Faster" surfaces, such as grass, cement, or laykold,
increase the velocity of the ball and therefore increase the moments of force. This increased velocity also increases the hazards of mis-hitting the ball. We therefore recommend playing with slower hitting players and on “slower” surfaces, such as clay.

ALTERATION OF LEVERAGE FORCE BY SURGERY

Following institution of the foregoing treatment plan, the malady will persist in approximately 5 per cent of players. The timing of surgery, of course, is variable, but in general if the player has had four injections of cortisone and has had an ample trial of the other treatment methods, surgical intervention is recommended.

As noted, the uncomplicated tennis elbow is an extra-articular problem. Unless there is some other over-riding reason, we do not recommend exploration of the joint. The surgical procedure is simple and is limited in scope and includes a release of the extensor digitorum communis and extensor carpi radialis brevis aponeurosis from the lateral epicondyle (Fig. 14). Inspection of the triangular subaponeurotic space occasionally reveals small amounts of granulation tissue, and these are excised sharply as well. Care is taken not to violate the synovium or to enter the joint itself. Note at this point in the operation that the aponeurosis has been lifted and is now basically parallel with the ra-

![Figure 14](image.png)

Figure 14. Muscle list eliminating fulcrum effect of radial head on extensor aponeurosis. The hemostat is lying free under the subaponeurotic space created by releasing the extensor digitorum communis aponeurosis from the lateral epicondyle. The bulge in the aponeurosis adjacent to the first suture is due to the underlying radial head. The two specimens of tissue at the top of the elbow wound are fibrous calcifications removed from the extensor carpi radialis brevis at and just anterior to the suture line.
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...dial head. From a mechanical point of view, therefore, we have now eliminated the fulcrum effect of the radial head. The operation essentially involves muscle lift and excision of granulation tissue and free nerve endings from the subaponeurotic space. We do not find it necessary to resuture the aponeurosis to surrounding tissues, but a few stitches do no harm and may prevent muscle herniation.

The postoperative treatment includes plaster splinting with the forearm in a neutral position and the elbow at 90 degrees of flexion for ten days. The sutures are removed at this time and gentle active-assistive range of motion exercises are instituted. When full motion has returned and the patient is relieved of pain, a gentle exercise program to increase the strength of the forearm muscular mass is re instituted. The patient is generally asymptomatic at the end of the two month postoperative period and is allowed to return to tennis on a gradual basis, utilizing the elbow support initially.

SUMMARY

A discussion of the pathology, etiology, and treatment of tennis elbow has been presented. It is our conclusion that the pathological abnormality is an inflammatory alteration of the extensor aponeurosis at the lateral epicondyle of the elbow as well as the triangular subaponeurotic space. Pertinent etiological factors involve intrinsic and extrinsic muscle overload, aggravated in large part by the design of the human elbow.

Treatment includes the relief of acute and chronic inflammation; the improvement of forearm muscular strength, endurance, and flexibility; alteration of the moments of force placed against the elbow by improvement of skill level; a change of equipment and elbow support; and improvement in a disadvantaged mechanical leverage force system at the elbow by surgery.

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REFERENCES


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