Ultrasonographic Evaluation of Median Nerve in Tennis Training Athletes

Tenis Eğitimi Alan Sporcularda Mediyan Sinirin Ultrasonografik Değerlendirilmesi

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Abtract
Objectives: Racquet using is a risk factor for carpal tunnel syndrome (CTS). Ultrasonography (US) has been used for diagnosis of CTS, recently. We aimed to determine the possible CTS related effects of tennis training on median nerve by US.
Patients and Methods: Thirty two voluntary students who had not played any racquet sports before and had no symptoms of CTS were included in the study. Participants were examined for CTS and their dominant and non-dominant hands underwent US before and after 14 weeks of tennis training. The cross-sectional area of the median nerve of each participant was measured at the carpal tunnel proximal, inlet, and outlet by US.
Results: There was no significant increase related to CTS in measurement of the cross-sectional area of the median nerve of dominant and non dominant hands at all three levels and also symptoms and physical examinations of participants for CTS were negative after tennis training.
Conclusion: We did not observe any significant damage in median nerve related to CTS at the end of the 14 weeks of tennis training. Further prospective studies with larger number of patients in a longer time period are needed to demonstrate early changes of the median nerve pointing CTS in tennis sports by US.

Key Words: **Carpal Tunnel Syndrome; Tennis; Ultrasonography.**

Özet
Amaç: Raket kullanımı karpal tünel sendromu (KTS) için bir risk faktörüdür. Son zamanlarda ultrasonografi (US) KTS' nin tanısı için kullanılmaktadır. Bu çalışmada US kullanarak tennis eğitiminin, mediyan sinirde muhtemel KTS ile ilişkili etkilerini belirlemeyi amaçladık.
Hastalar ve Metod: Daha önce raket sporları ile uğraşmayan ve KTS şikayetleri olmayan 32 gönüllü öğrenci çalışmaya dahil edildi. Katılımcılar 14 haftalık tenis eğitimi öncesinde ve sonrasında KTS açısından muayene edildi ve dominant ve dominant olmayan elleri US ile değerlendirildi. Her bir katılımcının mediyan sinirinin kesitsel alanı karpal tünelin girişinde, içinde ve dış kısmında ölçüldü.
Bulgular: Tenis eğitimi sonrasında tüm seviyelerde dominant ve dominant olmayan ellerin mediyan sinir kesitsel alanında anlamlı artış yoktu ve katılımcıların fizik muayene bulguları ve şikayetleri KTS açısından negatifti.
Sonuçlar: On dört haftalık tenis eğitimi sonunda mediyan sinirde KTS ile ilişkili belirgin hasar tesbit etmedik. US ile tenis sporunda mediyan sinirde CTS' yi işaret eden erken değişiklikleri göstermek için daha uzun süreli ve daha fazla sayıda hasta katılımlı çalışmalara ihtiyaç vardır.

Anahtar kelimeler: **Karpal tünel sendromu; Tenis; Ultrasonografi.**

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Introduction

Peripheral nerve lesions are uncommon but are serious injuries in sports. These lesions may delay or preclude an athlete's safe return to sports. Nerve lesions in sports may be due to an acute injury (e.g. from a direct blow) or chronic injury related to repetitive microtrauma (entrapment) (1). Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy in sports. It is frequently seen in racquet sports, weightlifting, cycling, throwing and swimming (2).

CTS is defined as a localized compression of the median nerve at the wrist (3) that may occur as a result of narrowing of the canal or crowding of the median nerve by the other elements within the carpal tunnel (4). The symptoms are typically worse at night and among active workers may present with repetitive hand activities (3). Diagnosis is usually based on clinical symptoms, physical examinations and electrodiagnostic studies (3, 5).

Although electrodiagnostic studies are highly specific for diagnosis of CTS (6), it is reported that false negativity can be seen by 10% (7). Examination of the median nerve by ultrasonography (US) has recently been proposed as a useful alternative to electrodiagnostic studies in the diagnosis of CTS (8-11).

In this study, we aimed to determine possible median nerve swelling as an early indicative of CTS by using US in athletes who begin tennis training. To our knowledge, this study is the first study, investigating early affects of tennis training on median nerve by using US.

Patients and Methods

Participants. Thirty two voluntary students (13 girls, 19 boys) from the School of Physical Education and Sports who had not played racquet sports previously were included in this study. Informed consent was obtained from all students. The protocol was approved by the local ethics committee and the study was performed in accordance with the principles of the Decleration of Helsinki. Students who had symptoms and signs of CTS or had disorders which may have cause CTS such as diabetes mellitus, hypothyroidism, distal forearm fracture history or had participated in sport activities that require usage of the wrist such as body building and gymnastics were not included in the study.

Procedure. Body mass indexes (BMI) of all students were measured. We noted the dominant hands of students used while playing tennis. They were asked for symptoms consistent with CTS and their dominant and non dominant hands were examined especially for tinel, phalen and reverse phalen signs, sensory loss in median nerve innervations area and atrophy of the thenar eminence at the beginning and end of the tennis training session by the same physician. The duration of the session was 14 weeks. In the first four weeks, the techniques of all strokes (forehand, backhand, service, volley and lop techniques etc.), which are main focus of the tennis training, were practiced for at least 3 hours a week. In the following six weeks, the participants practiced the rules and habit of one- to -one match for at least 3 hours a week. They were also advised for extra practicing. For the last four weeks, tournament matches were held in league format. In the tournament every student played at least four matches, which lasted minimum two hours. Students were asked to note the total hours of lessons that they participated in at the end of the 14-weeks session.

Sonographic Technique. US of the median nerves were performed in dominant and non dominant hands at the beginning and at the end of the tennis lessons by the same radiologist who was blinded about the clinical status of the participants. We used high-resolution ultrasound system (Siemens Sonoline Antares, Erlangen, Germany) with 5-13 MHz transducer. Subjects were seated facing the examiner, with their wrists resting on a hard surface in a prone neutral position and their fingers semiextended (12). Transverse images of the median nerve were obtained at 3 levels; level 1) immediately proximal to the carpal tunnel inlet (at radioulnar articulation), level 2) at the carpal tunnel inlet (at the level of pisiform bone), and level 3) at the carpal tunnel outlet (at the distal edge of flexor retinaculum) (13). At each level, the cross-sectional area of the median nerve (in mm^2) was measured by tracing with electronic calipers around the margin of the nerve at the time of US (direct tracing) (8) (Figure 1). The margin of the nerve was defined as the margin outside the hypoechoic nerve fascicles and inside the hyperechoic nerve sheath (10). For dominant and non dominant wrist, the measurements were repeated two times and average of the two values was taken (13). None of the examined patients experienced any pain or discomfort during US. Examination of each wrist took approximately 5 minutes.

Statistics. The measurements of the cross sectional areas of the median nerve at three levels of the dominant and non dominant hands of participants before and after tennis training were compared by paired samples t test. Independent samples t test was used for comparison of the dominant hand and the non dominant hands both before and after tennis training. $P<0.05$ was considered as statistically significant.

Results

Sixty four wrists were examined. All of the students were right-handed. The mean age of students was 21.4±1.2 years. There was no significant difference in the BMI of the students before (20.8 kg/m^2±2.8) and after (20.8 kg/m^2±2.6) tennis training (p>0.05). Physical examination findings and symptoms related to CTS were negative in all of the participants at the beginning and at the end of the lesson. Twenty five of the 32 students played extra tennis other than the classroom activity. The mean hour of tennis lessons was 71.3±31.6 (42-182) at the end of 14 weeks. The students were trained for tennis approximately 5.1 hours per week. One of the participants had a persistent median artery. The initial ultrasonographic measurements of the median nerve of the dominant and non dominant hand were compared with the measurements after the 14 weeks session. There was no statistically significant increase in measurement of the cross-sectional areas of the median nerve of dominant and non dominant hands at all levels after tennis training (For dominant hand Level 1: p=0.125, Level 2: p=0.057, Level 3: p=0.086 for nondominant hand Level 1: p=1.000, Level 2: p=0.572, Level 3: p=0.683). The cross sectional areas of the median nerve at three levels of the dominant hand were not statistically different from that of the non dominant hand before and after tennis training (Before tennis training Level 1: p=0.099, Level 2: p=0.141, Level 3: p=0.229, after tennis training Level 1: p=1.000, Level 2: p=0.938, Level 3: p=0.890). Values of ultrasonographic measurements of the median nerve of the dominant and the non dominant hands before and after tennis training in participants are given in Table I.

Table I. Ultrasonographic measurements of the median nerve of dominant and non dominant hands before and after tennis training in participants.

	Before tennis training	After tennis training	P value
Cross-sectional area at level 1, mm^2			
Dominant	8.4±1.3	8.8±1.6	0.125
Non dominant	9±1.6	9±1.7	1.000
P value	0.099	1.000	
Cross-sectional area at level 2, mm^2			
Dominant	8.4±1.4	8.8±1.6	0.057
Non dominant	8.9±1.5	8.8±1.6	0.572
P value	0.141	0.938	
Cross-sectional area at level 3, mm^2			
Dominant	8.5±1.8	8.8±1.8	0.086
Non dominant	9±1.7	8.9±1.8	0.683
P value	0.229	0.890	

mm^2: square millimeter

Discussion

In the present study, we did not find any significant difference in the three cross-sectional areas of the median nerve between dominant and non-dominant hands before and after tennis training. At the end of the 14 weeks of tennis training, there was no increase in the cross-sectional areas of three levels of the median nerve in the non-dominant hands but we observed an increase in the cross-sectional areas of the median nerve at all levels especially in the pisiform level (p=0.057) of the dominant hands. In the present study, the duration of the training session or the number of participants may affect statistics to give non significant result. Perhaps these results could be statistically significant by increasing the number of participants and increasing the training period as the p value is very near to the significance level. For this reason, the increase in the level of pisiform can indicate an early finding of CTS in individuals taking tennis training. Also the physical examination findings and symptoms were negative for CTS.

CTS is an important health problem in swimming, moto-cross-riding, cycling, throwing, body-building, archery, and racquet sports (2,14). It is characterized by compressive neuropathy of the median nerve as it passes through the carpal tunnel, which is formed by the flexor retinaculum and the bony corpus (15). Clinically, athletes present with complaints of pain in the hand or wrist, with paresthesia in the distribution of the median nerve. Athletes may also

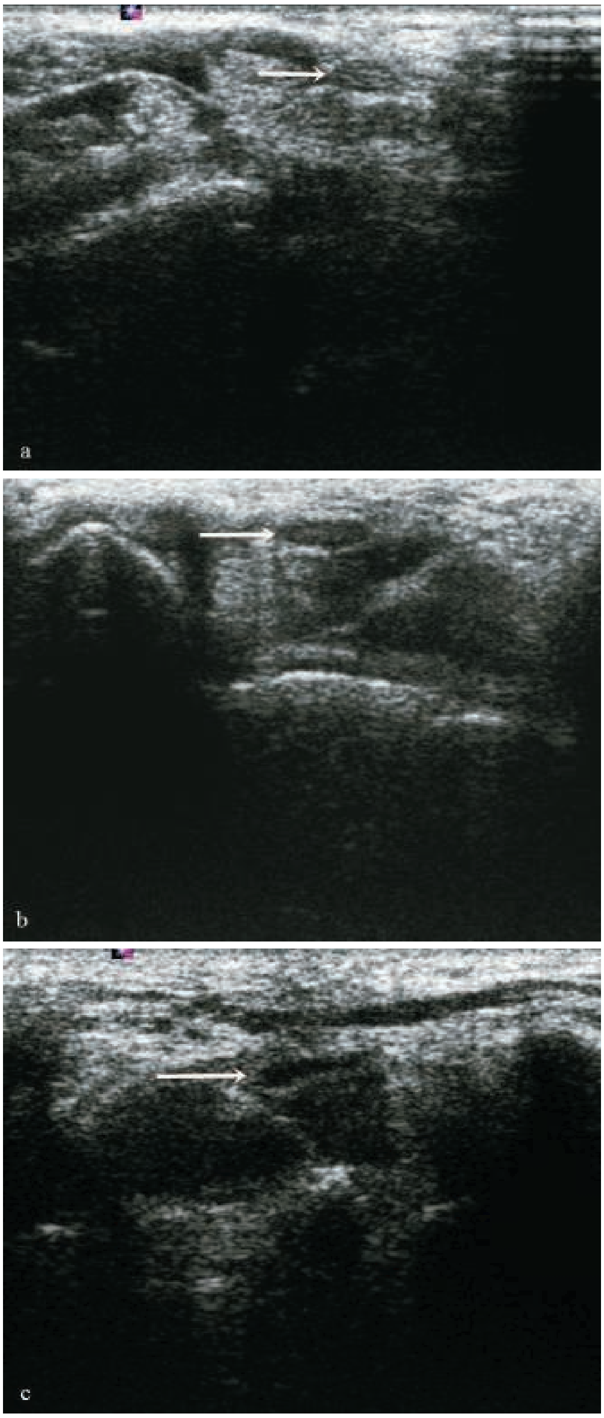

Figure 1. Axial US image of median nerve at the distal radioulnar articulation (a), at the carpal tunnel inlet (at the level of pisiform bone) (b), and at the carpal tunnel outlet (at the distal edge of flexor retinaculum) (c).

demonstrate diminished thumb opposition and muscle wasting in the thenar eminence. It may cause loss of training time and missed competitions (2). In racquet sports, vessels and nerves of the wrist and hand are prone to injuries because of direct impact with the handle as well as repetitive stretching that occurs as the wrist is forcefully used in extreme positions (16). The handle touches the wrist above the flexor retinaculum and the median nerve route while holding the racquet in tennis. This contact increases while hitting the ball and during forced grasping. Repetitive blunt trauma of the racquet handle to the median nerve and repetitive and forceful use of finger flexors are risk factors for CTS (16, 17). It is known that the mechanical stress and cumulative trauma on the median nerve result in elevated carpal tunnel pressure end localized ischemia. These pathological changes in median nerve responsible for CTS (4, 18-21). High force- high repetition is associated with a high incidence when compared to low force-low repetition (20, 22). It has been shown that there is a positive correlation between training time and the development of CTS in athletes who practice swimming, moto-cross-ridding and body-building (14). According to our results, we can say that there is no damage in median nerve related to CTS by using racquet for period of 14 weeks. Perhaps we could have found results pointing CTS if we had increased the training period.

The earliest alteration found in experimental nerve compression is reduced epineural blood flow accompanied by formation of perineural edema. Continued compression results in blockage of axonal blood flow, intraneural ischemia, and subsequent edema. In persistent median nerve compression, long-standing edema induces an invasion of fibroblasts, with subsequent endoneural fibrosis, that ultimately results in demyelination and axonal degeneration. Retrograde swelling of the median nerve to the distal radius seen in advanced CTS presumably also causes the retrograde axonal degeneration (23).

The ultrasonography appears to be the most useful discriminatory criteria for CTS in the detection of the median nerve swelling due to edema. It is calculated by using cross sectional area of median nerve (8, 9, 11, 13, 24-26). We used US as a diagnostic tool for showing the early changes in the median nerve before axonal damage. Several studies indicated that electrodiagnostic studies may be negative, at the early stages of CTS while US may show swelling of the median nerve by demonstrating increased cross sectional area (25, 27). US can demonstrate anatomic variations of the median nerve such as bifid median nerve, and persistent median artery which can be thrombosed and cause CTS. In addition, US can determine the disorders of the surrounding structures that may damage the median nerve leading to CTS including tendonitis, edema, inflammation and tumors (10). In the early stage of entrapment, swelling due to edema is detectable at US while it is not severe enough to cause impairment in nerve conduction (25). This shows that the electrodiagnostic studies but not US can be negative in early stage of entrapment. There is a linear relationship between increasing nerve dimension and decreasing nerve conduction (10, 11). The level of pisiform bone, which was regarded as the level of maximum swelling, was used for ultrasonographic measurement of the cross-sectional area of the median nerve in diagnosis CTS in many studies (8, 10, 11, 24, 26, 28, 29). In these studies, the critical values were diverse and ranged from 9.0 to 15.0 mm^2 (8, 10, 11, 26, 28). These values were obtained from patients who had both positive symptoms and electrophysiologic signs for CTS. Koyuncuoglu and co-worker (27) notified the critical value of 8.83 mm^2 for pisiform level in patients who had CTS symptoms with negative electrodiagnostic tests.

Unfortunately, in later stages of CTS, the grasping force of hand decreases due to diminished thumb opposition as well as muscle wasting. This may cause delay or preclude an athlete's safe return to sports which requires force grasping such as tennis. Thus, early detection of the nerve injury before axonal damage is important in athletes. It may help in early prevention measures. From this point of view, we aimed to evaluate early changes of the nerve that may be detected with US, which has not been previously investigated in racket sport injuries. Measurements of median nerve and also physical examination findings and symptoms were negative for CTS in all our participants at the end of the training session.

In the present study, we could not find any significant damage in median nerve related to CTS induced by using racquet at the end of the 14 weeks tennis training. US seems to be an useful method for diagnosis of CTS as it is reliable, quick, noninvasive, easily available. Further prospective studies with larger number of patients in a longer time period are needed for demonstrate whether US has the capability of detection early changes of the median nerve related to CTS in tennis sport.

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