REVIEW DERLEME

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Current Issues in Physical Therapy Modalities in Carpal Tunnel Syndrome: A Literature Review

Karpal Tünel Sendromunda Fizik Tedavi Modalitelerinde Güncel Konular: Bir Literatür Taraması

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ABSTRACT Carpal tunnel syndrome (CTS) is the most common and widely studied nerve entrapment syndrome, accounting for approximately 90% of all compressive neuropathies. It is caused by compression of the median nerve while it passes through the carpal tunnel, a limited space. Nowadays, many treatments are proposed for CTS, which can be categorised into two groups of invasive and non-invasive. The invasive treatments include surgery and corticosteroid injection of carpal tunnel. Current non-invasive treatments include acupuncture, exercise therapy and mobilization techniques, splinting, ultrasound, extracorporeal shock wave therapy (ESWT), low-level laser therapy, high-power laser therapy, kinesiotaping and cupping therapy. Acupuncture successfully alleviates pain, inflammation, numbness, and restores motor ability. Gliding exercises improve symptoms by preventing, or stretching, the adhesions among the tendons and median nerve. Shockwaves (ESWT) are rapid but short duration acoustic waves that carry energy and can propagate through tissues. Laser therapy is a photobiomodulation intervention which may cause either biological stimulation or inhibition. Kinesiotaping is an elastic bandage that lifts up the skin, relieving compression to increase blood and lymphatic flow and reduce pain. Cupping therapy is an ancient method of applying quick, vigorous, rhythmic force for improving blood supply. As a result; Various conservative treatments can relieve symptoms and improve functional abilities of patients with mild-to-moderate CTS. The above new treatment modalities and combinations have proven effective in CTS. However, in studies, both the optimal treatment doses and the long-term results of physical therapy modalities are still not fully known.

Keywords: Carpal tunnel syndrome; physical therapy; new modalities

ÖZET Karpal tünel sendromu (KTS), en sık görülen ve üzerinde en çok çalışılan sinir sıkışma sendromudur ve tüm kompresif nöropatilerin yaklaşık %90'ını oluşturur. Medyan sinirin dar bir alan olan karpal tünelden geçerken sıkışması sonucu oluşur. Günümüzde KTS için invaziv ve invaziv olmayan birçok tedavi önerilmektedir. İnvaziv tedaviler arasında cerrahi ve kortikosteroid enjeksiyonu yer alır. Bu güncel noninvaziv tedaviler arasında ise akupunktur, egzersiz ve mobilizasyon teknikleri, splintleme, ultrason tedavisi, ekstrakorporeal şok dalga terapisi [extracorporeal shock wave therapy (ESWT)], düşük seviyeli lazer tedavisi, yüksek seviyeli lazer tedavisi, kinesiotaping ve kupa tedavisi yer almaktadır. Akupunktur ağrıyı, inflamasyonu, uyuşukluk hissini başarılı bir şekilde hafifletir ve motor becerileri geri kazandırır. Sinir kaydırma egzersizleri, tendonlar ve medyan sinir arasındaki yapışıklıkları önleyerek semptomları iyileştirir. Şok dalgaları (ESWT), enerji taşıyan ve dokular boyunca yayılabilen hızlı ancak kısa süreli akustik dalgalardır. Lazer tedavisi, biyolojik uyarıma veya inhibisyona neden olabilen bir fotobiyomodülasyon tedavisidir. Kinesiotaping, kan ve lenfatik akışı artırmak ve ağrıyı azaltmak için baskıyı hafifleten elastik bir bandajdır. Kupa terapisi, kan akışını iyileştirmek için hızlı, güçlü ve ritmik kuvvet uygulayan eski bir yöntemdir. Sonuç olarak; çeşitli konservatif tedaviler, hafif-orta dereceli KTS'li hastaların semptomlarını hafifletebilir ve fonksiyonel yeteneklerini geliştirebilir. Yukarıdaki yeni tedavi yöntemleri ve kombinasyonlarının KTS'de etkili olduğu kanıtlanmıştır. Ancak yapılan çalışmalarda hem optimal tedavi dozları hem de fizik tedavi yöntemlerinin uzun dönem sonuçları hala tam olarak bilinmemektedir.

Anahtar Kelimeler: Karpal tünel sendromu; fizik tedavi; yeni modaliteler

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Carpal tunnel syndrome (CTS) is the most common and widely studied nerve entrapment syndrome, accounting for approximately 90% of all compressive neuropathies.[1,2] It is caused by compression of the median nerve while it passes through the carpal tunnel, a limited space. Inflammation, edema, tendon spasm, hormone level changes, and physical activity are all associated with increased nerve compression, causing pain and numbness. In severe cases, muscle weakness in muscles innervated by the median nerve may occur.[3]

CTS is often diagnosed through patient history and physical examination. Provocation tests that can be used to diagnose CTS are Phalen's test, Tinel's test, Flick's sign, and Thenar wasting. Thenar wasting can be done by examining the patient's palms and palpations and finding the presence of atrophy of the thenar muscles. Electrodiagnostic examination can be used to support the diagnose of CTS. On electromyoneurography study it can be found that nerve velocity will decrease when the distal latency is prolonged, this shows that there is a disruption in nerve consumption in the wrist.[4]

Nowadays, many treatments are proposed for CTS, which can be categorised into two groups of invasive and non-invasive. The invasive treatments include surgery and corticostreoid injection, non-invasive treatments include taking medications and physical therapy.[5]

In this study, we aimed to review the literature on current issues in physical therapy modalities in CTS. These studies are summarized in Table 1.

ACUPUNCTURE AND LOW-LEVEL LASER THERAPY

Acupuncture originated in China 4,000 years ago. The practice is based on traditional Chinese medicine, according to which, the body's vital energy, known as Qi, flows through 12 primary and eight secondary meridians in the body. The proper flow of Qi is believed to be restored when acupuncture needles are inserted into the skin, with or without manipulation, at specific points along the meridians.[6] The manipulation of the needles can elicit in patients a "needle grasp" sensation called "De Qi", a subjective feeling of soreness, fullness, numbness, or tingling. Dry needling, also known as myofascial trigger point needling, is similar to the use of acupuncture at Ah Shi points, which often correspond to trigger points or tender points (or both) in the myofascial tissue. Dry needling is now known as myofascial acupuncture. Both acupuncture and dry needling can be given further stimulatory effects using small electrical currents (electroacupuncture), moxibustion (burning the herb moxa at the handle of the needle), or heat lamps.[7]

Acupuncture is an effective treatment modality for patients with CTS. Independent investigations confirm that acupuncture is more effective than usual care, including anti-inflammatory medications. Acupuncture successfully alleviates pain, inflammation, numbness, and restores motor dexterity. Electroneurography confirms the results, including improvements across multiple parameters (e.g., median nerve sensory latency, sensory nerve conduction velocity, sensory amplitude, motor latency, motor nerve conduction velocity, motor amplitude) (Figure 1).[8]

Mamipour et al. studied a randomized clinical trial which comparing the effect of physiotherapy plus acupuncture with physiotherapy alone on pain, disability and grip strength in CTS patients. This study shows preliminary evidence that physiotherapy plus acupuncture was more effective than physiotherapy alone in pain relief and improving disability of patients suffering from CTS.[9]

Laser acupuncture (LA), a new, non-invasive therapy which uses low-level laser therapy (LLLT) in acupuncture could help to manage CTS. LLLT is a non-invasive method and can promote wound healing, peripheral nerve regeneration, pain relief, and further reduction of inflammation.[10] LLLT general applies wave lengths ranging from 600 to 1,070 nm and power outputs ranging from 1 mW to 1,000 mW.[11] Some studies showed that LLLT leads to pain relief and improvement in hand function of CTS.[12]

Juan et al. compared the efficacy of LA treatment with that of placebo LA treatment in patients with idiopathic, mild-to-moderate CTS. They found that LA may be more effective than placebo LA in the treatment of mild-to-moderate idiopathic CTS.[13]

TABLE 1: Studies investigating the effectiveness of physical therapy modalities in carpal tunnel syndrome.

Author and study design	Patient group in the study	Therapy	Measurements used in the study	Results
Mamipour et al.[9] RCT 2023	n=40 Mild-moderate CTS Group 1=Exercise and manual techniques (10 sessions) n=20 Group 2=Physiotherapy plus acupuncture (30 min of acupuncture in every session) n=20	Group 1=Physiotherapy Group 2=Physiotherapy+ Acupuncture	VAS BCTQ Quick-DASH Grip strength	VAS, BCTQ and Quick-DASH in the physiotherapy plus acupuncture group statistically significant difference No significant difference between groups in grip strength improvement
Juan et al.[13] SBCS 2019	n=84 Group 1=LA Group 2=Placebo LA	Group 1=n=43 LA (Chinese acu-points, once a day, 5 times a week, for 4 weeks) Group 2=n=41 Placebo LA	GSS (at baseline and two and four weeks later) EMG (at baseline and repeated at the end of the study)	Significantly greater reduction in GSS in the LA group at week 2 ($p<0.01$) and at week 4 ($p<0.01$) No significant difference between the two groups in EMG
Ballestero-Pérez et al.[16] A computer-based search 2017 (year)	118 articles	Neurodynamic treatment of CTS	Key words: nerve tissue, gliding, exercises, CTS, neural mobilization, neurodynamic mobilization	Positive effects median nerve mobilization
Talebi et al.[17] RCT 2020	n=30 Divided into 2 groups Mild-moderate CTS	Mechanical interface mobilization Nerve mobilization	VAS, SSS and FSS Motor and sensory distal latencies of median nerve At the 4th week	VAS, SSS and FSS significantly improved in both groups ($p<0.05$) Motor and sensory distal latencies of median nerve only improved in the nerve mobilization group ($p<0.05$)
Nadar et al.[21] 2023 An assessor- blinded randomised controlled trial	n=59 Divided into 2 groups Mild-moderate CTS	Group 1=Wrist splint (control group) Group 2=MCP splint (intervention group) for 6 weeks	Grip and pinch strength The static two-point discrimination test Phalen's manoeuvre test-Tinel's sign BCTSQ	MCP splint groups had significant improvements in lateral pinch strength ($p=0.032$ and $p=0.002$, respectively) The MCP splint group had additional improvements over the wrist splint group in tip pinch ($p=0.012$) and Palmar pinch ($p=0.011$) strength
Gatheridge et al.[22] Prospective RCT 2020	n=30 subjects (37 hands) Mild to moderate CTS	Neutral wrist splint Group A=For 6 weeks Group B=For 12 weeks	SSS and FSS was repeated at 6 and 12 weeks Median motor and sensory distal latency was repeated at 12 weeks	Mean FSS improved only in group A Mean symptom severity and median sensory peak latency significantly improved in both groups at 12 weeks
Ortanca et al.[26] A randomized-controlled clinical trial 2022	n=27 subjects (46 hands) Idiopathic mild-moderate CTS	Group 1=Ultrasound (US group) Group 2=Steroid phonophoresis (PH group) Group 3=Placebo US group	VAS BCTSQ SSS FSS Grip strength EMG (before the treatment, after the treatment, and three months later)	Splinting therapy combined with steroid PH, placebo or continuous US is effective for both clinical and electroneurophysiological improvement However, EMG improvement is limited
Bagcaci et al.[27] A randomized sham-controlled study 2023	n=75 subjects (114 hands) Mild-moderate CTS	Group 1=Underwater pulsed US Group 2=Sham US Group 3=Control group	Hand grip strength, VAS, PQAS and EMG [at baseline, at the end of treatment (two weeks), and 12 weeks after the treatment]	VAS score and PQAS was found to be superior in the pulsed US group at both two weeks after the treatment and at the 12th week after the treatment
Menekseoglu et al.[31] PCDBCT 2023	n=37 (total 55 wrists) Mild-to-moderate CTS	Group 1 (n=27): ESWT Group 2 (n=28): Sham ESWT	VAS BCTSQ score LNSSA score EMG 1st month after therapy	Group 1=There was a significant decrease in VAS scores ($p<0.001$) significant increase in BCTQ scores ($p<0.001$) and LNSSA scores ($p<0.001$) There were significant results in EMG

TABLE 1: Studies investigating the effectiveness of physical therapy modalities in carpal tunnel syndrome *(contunied)*.

Author and study design	Patient group in the study	Therapy	Measurements used in the study	Results
Hojjati et al.[34] PRSBCT 2020	n=45 Control (splint) LPL HPL Mild-moderate CTS	Group 1 (n=15): Control (splint) Group 2 (n=15): LPL Group 3 (n=15): HPL	VAS BCTS EMG Pinch strength(Before treatment, immediately and 12 weeks after the treatment)	All groups showed improvement regarding pain, function, and pinch strength No significant difference between HPL and LPL groups Any significant difference in EMG in three groups
Ezzati et al.[35] DBRCT 2020	n=98 Moderate CTS	Group 1 (n=20): Exercise therapy +LPL with low fluence: (50 mW- 8 J/cm^2), Group 2 (n=19): Exercise therapy+LPL with high fluence 50 mW-20 J/cm^2) Group 3 (n=20): Exercise therapy+HPL with low fluence (1/6 W-8 J/cm^2), Group 4 (n=19): Exercise therapy+HPL with high fluence (1/6 W- 20 J/cm^2), Group 5 (n=20): Control group: exercise therapy alone	VAS EMG (Before and 3 weeks after the interventions)	HPL with a power of 1.6 W and a fluence of 8 J/cm2 produced the best effects compared to other groups in reduction of pain and improvement of the median nerve electrophysiological studies
de Sire et al.[38] DBRCT 2021	n=42 Mild CTS	Group 1 (n=21): KT group Kinesiotaping+specific exercise Group 2 (n=21): Control group sham taping+specific exercise All patients performed 2 sessions/week for 5 weeks of exercises of mobilization of fingers and carpal joint	BCTQ At the baseline, after 5 weeks and after 6 months	KT compared to a sham taping might be more effective (clinically significant difference)
Külcü et al.[39] PCS 2016	n=40 Mild-moderate CTS	Group 1 (n=13): KT group Group 2 (n=13): Placebo KT Group 3 (n=14):Orthotic device group KT was applied to both groups at the beginning of the week, to stay on for 5 days, with a 2-day rest, for a total of four times.	VAS DN4 scores BCTSQ Dynamometric grip strength measures Before treatment and after treatment	All groups significantly improved in terms of VAS scores ($p<0.05$), DN4 scores ($p<0.05$), and BQ scores ($p<0.05$) Grip strength improved in Group 3 ($p=0.001$)
Mohammadi et al.[41] RCT 2019	n=56	Group 1=(n=28) Control group treated with routine physiotherapy (transcutaneous electrical nerve stimulation and ultrasound) Group 2=(n=28) Test group treated with routine physiotherapy with cupping therapy	SSS FSS Distal sensory latency and distal motor latency	Significant improvement in symptom severity ($p=0.006$) and also a significant decrease in distal sensory latency ($p=0.007$) of the test group

CTS: Carpal tunnel syndrome; RCT: Randomized clical trial; VAS: Visual analogue scale; SSS: Symptom Severity Scale; FSS: Hand Functional Status Scale; ESWT: Extracorporeal shock wave; PCDBCT: Placebo-Controlled Double-Blind Clinical Trial; BCTSQ: Boston Carpal Tunnel Questionnaire; LNSSA: Leeds Neuropathic Symptom And Symptom Assessment; EMG: Electromyography; DASH: Disability of the Arm Shoulder and Hand; SBCS: Single-Blinded Controlled Study; LA: Laser acupuncture; GSS: Global symptom score; PRSBCT: Prospective Randomized Single Blind Clinical Trial; LPL: Low-power laser; HPL: High-power laser; DBRCT: Double-Blind Randomized Controlled Trial; KT: Kinesiotaping; PCS: Placebo Controlled Study; DN4: Douleur neuropathique 4.

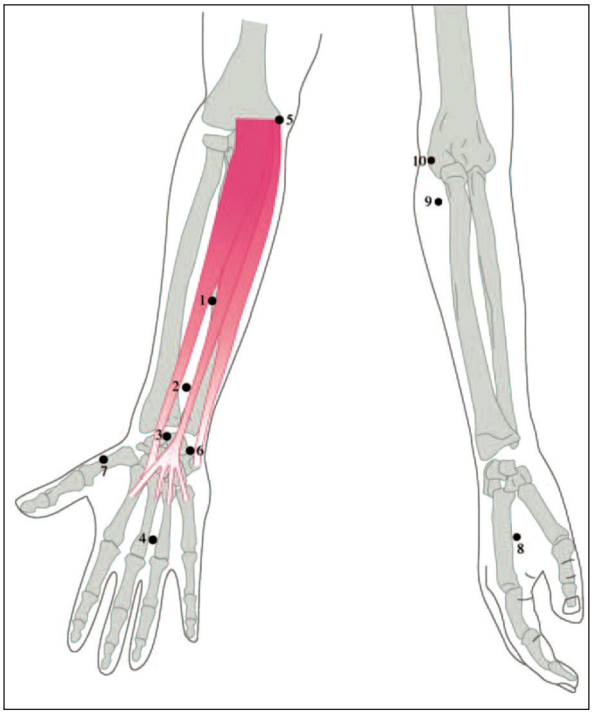

FIGURE 1: Acupoints used for carpal tunnel syndrome.[14]

EXERCİSE THERAPY AND MOBİLİZATİON TECHNİQUES

The rationale for using dynamic exercises as a treatment of CTS is derived from cadaver and in vivo ultrasound (US) studies showing median nerve and tendon excursions through the carpal tunnel during the wrist and/or finger movement. According to several authors, gliding exercises improve symptoms by preventing, or stretching, the adhesions among the tendons and median nerve, decreasing tenosynovial edema, improving venous return and, thus, reducing pressure inside the carpal tunnel.[15]

Ballestero-Pérez et al. found positive effects of median nerve mobilization in their systematic review. However, some studies reported similar effects of this neural technique compared with other conservative methods for treatment of CTS.[16]

Talebi et al. compared two manual therapy techniques in patients with CTS in a randomized clinical trial. They found that mechanical interface mobilization and nerve mobilization techniques are not superior to each other in reducing pain and improving hand symptoms and functional status.[17]

SPLİNTİNG FOR CTS

Splinting generally immobilises the wrist joint by using an external orthosis. The splint usually leaves the fingers and thumb free to move, but some designs may include the fingers. The wrist is generally positioned in a neutral position in the splint; although, the precise angle has yet to be determined, between less than 20 degrees extension and closer to zero degrees has been found to be optimal. This splint may be worn either at night-time only or during both the night and day.[18] Splinting could decrease the exposure to the elevated pressure and alleviate symptoms arising from ischemia. Moreover, it has been hypothesized that extension of the metacarpophalangeal (MCP) joints could lower the pressure by moving the lumbrical muscles away from the carpal tunnel.[19,20]

Nadar et al. compared the efficacy of wrist splinting that incorporates the MCP joints and traditional wrist-only splinting patients with mild-to-moderate CTS. They found that a wrist splint that incorporates the MCP joints is more effective than the traditional wrist-only splint, with long-lasting improvements that remained consistent after 6 months of the splint intervention.[21] Gatheridge et al. studied a prospective clinical trial. In this study, subjects were assigned to wear a neutral wrist splint for 6 (Group A) or 12 weeks (Group B). They found that there was no additional benefit in extending splinting 6 additional weeks.[22]

US THERAPY

Therapeutic US is a physical therapy modality with a thermal (deep heating) and nonthermal effect formed by the conversion of a high-frequency electric current into high-frequency acoustic energy.[23] It is widely used to reduce pain and disability in musculoskeletal disorders. The efficiency of US treatment for CTS has depended on the suppression of inflammation, the removal of edema, and the stimulation of nerves.[24,25]

Ortanca et al. compared the efficacy of US and steroid phonophoresis (PH) treatments in patients with idiopathic CTS. They found in their study that splinting therapy combined with steroid PH, placebo or continuous US is effective for both clinical and electroneurophysiological improvement; however,

electroneurophysiological improvement is limited.[26] Bagcaci et al. evaluated the efficiency of therapeutic pulsed US applied underwater in mild-to-moderate CTS in their study. They found that therapeutic underwater pulsed US is an effective, safe, and easy-to-apply treatment option in the conservative treatment of mild-to-moderate CTS.[27]

EXTRACORPOREAL SHOCK WAVE THERAPY

Extracorporeal shockwave therapy (ESWT) has become a popular non-invasive therapeutic modality for the treatment of many musculoskeletal disorders. The essential principle behind this technique revolves around the action of shockwaves, which are rapid but short duration acoustic waves that carry energy and can propagate through tissues. The application of shockwaves can be beneficial due to their ability to cause interstitial and extracellular responses which lead to tissue regeneration.[28]

ESWT has recently been used in the treatment of mild to moderate CTS. ESWT are clinically effective in symptom relief, functional enhancement, and electrophysiologic parameters improvement for patients with mild-to-moderate CTS.[29] Li et al. found in their extracorporeal shock wave therapy versus local corticosteroid injection meta-analysis study that the effects of ESWT and local steroid injection (LCI) are not significantly different. In terms of electrophysiological parameters, LCI has a stronger effect on shortening motor distal latency; ESWT is superior to LCI in improving action potential amplitude. ESWT is a noninvasive treatment with fewer complications and greater patient safety.[30] Menekseoglu et al. similarly found that ESWT treatment was effective in mild-moderate CTS.[31]

HİGH-POWER LASER THERAPY

Laser therapy is a photobiomodulation intervention which may cause either biological stimulation or inhibition, increasing or decreasing cell activity, respectively. One group preferred to use a fluence (energy density) range of 9 to 225 J/cm^2 while another group reduced fluence to 1.2 to 6 J/cm^2.[32] The high-power laser (HPL) is a technological advancement in the low-power laser (LPL) field and can treat a much larger part of the body surface. Furthermore, it has deeper penetration and consumes less time compared with the LPL. The HPL or hot laser is 24 times more powerful than conventional lasers and its effective penetration depth is more than 4 centimeters, while LPL has an effective penetration depth of half a centimeter and can mainly help treat superficial and small tissues.[33]

Hojjati et al. studied prospective, randomized, single-blind clinical trial. The study population included 45 patients aged 30-50 years who mild or moderate CTS was confirmed for them. Patients were randomly assigned to control, LPL therapy, and HPL therapy groups. HPL therapy showed better results, although not significantly different from LPL therapy.[34] On the contrary, Ezzati et al. found in their study that HPL with a power of 1.6 W and a fluence of 8 J/cm^2 produced the best effects compared to other groups in reduction of pain and improvement of the median nerve electrophysiological studies.[35]

KİNESİOTAPİNG

Kinesiotaping (KT) is an elastic bandage that lifts up the skin, relieving compression to increase blood and lymphatic flow and reduce pain in the muscle and joint injuries. Pain alleviation through KT results from pain modulation via gate control theory of pain.[36] A study indicated that KT enables people with CTS to regain their ordinary skills.[37]

de Sire et al. found in their double-blind randomized controlled trial that KT might be considered as an effective technique combined to rehabilitative treatment in terms of hand function and symptoms in patients affected by mild CTS.[38] Like this study, Külcü et al. found similar results (Figure 2).[39]

CUPPİNG THERAPY

Cupping therapy is an ancient method of applying quick, vigorous, rhythmic force for improving blood supply. It is used for various neuropathy conditions. Hence, there is need of reviewing cupping therapy as an alternative treatment option for CTS as it is cost effective and traditional healing option.[40]

Mohammadi et al. found in their randomized clinical trial that incorporation of cupping therapy in a routine physical therapy programme can reduce the

FIGURE 2: a) Kinesiotape application; **b)** Placebo kinesiotape application.

severity of symptoms and improve the distal sensory disturbance of the median nerve.[41]

CONCLUSION

There are many physical therapy modalities used in the treatment of CTS. The main aim of all treatment modalities is to reduce compression on the median nerve. In this study, we touched upon current conservative treatment modalities. These conservative treatments are able to relieve symptoms and improve functional ability of patients with mild-to-moderate CTS. These include acupuncture, oral drugs, electrotherapy, specific manual techniques and neural gliding exercises as well as different combinations of the above, splinting, US, ESWT, LLLT, HPL therapy, KT and cupping therapy. The above new treatment modalities and combinations have proven effective in CTS. However, in studies, both the optimal treatment doses and the long-term results of physical therapy methods are still not fully known. Likewise, it has not been clearly demonstrated which physical therapy modality is superior to another. There is a need for studies with a large number of patients and long follow-up periods in which the effectiveness of physical therapy modalities, optimal treatment dose and duration can be determined.

Source of Finance

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

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