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# Evaluating the Therapeutic Impact of Transcutaneous Radiofrequency Therapy on Myofascial Pain Syndrome Patients: A Clinical Study

# Transkutanöz Radyofrekans Tedavisinin Miyofasyal Ağrı Sendromlu Hastalar Üzerindeki Terapötik Etkisinin Değerlendirilmesi: Klinik Çalışma

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## ÖZET

**AMAÇ:** Bu çalışmada, miyofasyal ağrı sendromu tanısı konmuş hastalarda, transkutanöz radyofrekans terapisinin kronik ağrı üzerindeki etkisinin araştırılması amaçlanmıştır.

**GEREÇ VE YÖNTEM:** Ocak 2021-Ağustos 2021 tarihleri arasında, Ordu Devlet Hastanesi Ağrı Polikliniği'ne başvuran 30 hasta retrospektif olarak incelendi. Hastaların tamamında, üst trapezius kas bölgesinde miyofasyal ağrıya uyumlu tetik noktalar bulunuyordu. Tüm hastalar, bu teknikte özel eğitim almış bir algolog tarafından yönetilen transkutanöz radyofrekans terapisi (TCRFT) geçirdi. Her hasta, yaklaşık 15 dakika süren tek bir tedavi seansı aldı. Tedavi, servikal bölgenin her iki tarafını, bilateral skapula medial ve bilateral skapula inferior bölgelerini kapsayacak şekilde 6 bölgeye odaklandı. Hastaların işlem öncesi bazal görsel analog skala (VAS) skorları ve işlem sonrası 1., 4. ve 12. haftalarda VAS skorları, toplam analjezik kullanımı (TAU) ve hastaların global değişim izlenimi (PGIC) skorları kaydedildi.

**BULGULAR:** Hasta grubunun 22'si kadın (%73,3) ve 8'i erkek (%26,7) olup, yaş ortalaması 45,27±13,05 yıl idi. Miyofasiyal ağrı sendromu tanısı alan hastalarda, görsel analog skala skorlarında ve toplam analjezik kullanımında 1. haftadan itibaren anlamlı bir azalma gözlendi ve 4. haftaya kadar bu azalma devam etti. Hastanın global değişim izlenimi skorları, hastaların 1. haftada %77'lik bir memnuniyet seviyesi olduğunu belirtirken, 2. haftada memnuniyet seviyesinde istatistiksel olarak anlamlı olmasa da hafif bir artış olduğunu ve ardından dördüncü haftadan itibaren memnuniyette bir düşüş olduğunu ortaya çıkardı.

**SONUÇ:** Transkutanöz radyofrekans tedavisinin, analjezik tüketimini azaltmada ve miyofasyal ağrıyı hafifleterek yaşam kalitesini artırmada etkinliği gösterilmiştir. Bu invaziv olmayan, ağrısız ve kolayca uygulanan tedavi yöntemi, miyofasyal ağrı sendromunun ötesinde çeşitli ağrı durumlarının ele alınması için umut vaat ettiği söylenebilirdi. Araştırmanın bulguları, transkutanöz radyofrekans terapisinin klinik pratikte değerli bir seçenek olarak kabul edilmesini desteklemektedir. Gelecekte yapılacak daha kapsamlı randomize kontrollü çalışmalarla bu bulguların doğruluğunun ve tedavinin uzun vadeli etkilerinin daha net anlaşılması sağlanabilir.

**Anahtar kelimeler:** Miyofasyal ağrı sendromu, transkutanöz radyofrekans terapisi, yaşam kalitesi

## ABSTRACT

**AIM:** This study aimed to investigate the effect of transcutaneous radiofrequency therapy on chronic pain in patients diagnosed with myofascial pain syndrome.

**MATERIAL AND METHOD:** Between January 2021 and August 2021, 30 patients who presented to Ordu State Hospital Pain Polyclinic were retrospectively examined. All patients exhibited trigger points compatible with myofascial pain in the upper trapezius muscle region. All patients underwent transcutaneous radiofrequency therapy (TCRFT) administered by an algologist specially trained in this technique. Each patient received a single treatment session lasting approximately 15 minutes. The treatment targeted 6 regions, including both sides of the cervical region, bilateral scapula medial, and bilateral scapula inferior regions. Baseline visual analogue scale (VAS) scores before the procedure and VAS scores, total analgesic use (TAU), and patients' global impression of change (PGIC) scores at the 1st, 4th, and 12th weeks after the procedure were recorded.

**RESULTS**: Demographic characteristics of the patients were as follows: 22 women (73.3%) and 8 men (26.7%), with an average age of 45.27±13.05 years. In patients diagnosed with myofascial pain syndrome, a significant decrease in visual analog scale scores and total analgesic use was observed starting from the 1st week, continuing until the 4th week. Patient global impression of change scores indicated a satisfaction level of 77% in week 1, with a slight, albeit statistically insignificant, increase in satisfaction in week 2, followed by a decrease in satisfaction from the fourth week.

**CONCLUSION:** Transcutaneous radiofrequency therapy has been shown effective in reducing analgesic consumption and improving quality of life by alleviating myofascial pain. This noninvasive, painless, and easily applied treatment method holds promise for addressing various pain conditions beyond myofascial pain syndrome. The study's findings support the integration of transcutaneous radiofrequency therapy as a valuable option in clinical practice. Future comprehensive randomized controlled studies may provide a clearer understanding of the accuracy of these findings and the treatment's long-term effects.

**Keywords:** Myofascial pain syndrome, transcutaneous radiofrequency therapy, quality of life.

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## INTRODUCTION

Myofascial pain syndrome (MPS) is defined as a disease characterized by regional pain originating from hypersensitive points in the tense bands of skeletal muscle known as myofascial trigger points. Common causes of myofascial pain syndrome may include direct or indirect trauma, spinal pathology, exposure to cumulative or repetitive strain, postural dysfunction, or physical deconditioning.[1,2] Treating the underlying etiology is currently the most widely accepted strategy for the treatment of MPS. If the root cause is not treated, trigger points may reoccur and symptoms may reappear.[2] Interestingly, there are deficiencies in specific diagnostic criteria for MPS. According to these criteria, electrodiagnostic and morphological findings have been identified, but they are not widely used in clinical practice due to cost and time constraints.[3] Especially considering the underlying pathology that is difficult to detect and trigger points that have become permanent, the difficulty of definitive treatment will become even more difficult.[4]

Pulsed Radiofrequency (PRF) therapy, which was first defined by Sluijter in 1997, is currently used as an effective and safe treatment method in chronic painful syndromes.[5,6] PRF therapy works by delivering an electrical current and bursts of heat to these tissues without damaging the targeted tissue. Conventional radiofrequency (RF), on the other hand, exposes the target nerves or tissues to a continuous electrical stimulation and causes tissue damage on the target tissue by increasing the temperature around the RF needle tip.[7] Unlike conventional RF, PRF applies a short electrical stimulation followed by a long rest phase. Accordingly, the PRF does not generate enough heat to cause structural damage. The proposed mechanism of PRF is that the electric field produced by PRF can alter pain signals.[8] In the literature, there are case series and double-blind randomized controlled studies for knee and shoulder pain with transcutaneous radiofrequency therapy (TCRFT) using surface-mounted gel electrodes placed on the area for painful conditions in the neck area, around the shoulder, chin, back, and wrist.[9,10,11,12] The aim of this study is to examine the effects of TCRFT on pain, analgesic use, and patient satisfaction in patients with MPS in the shoulder and neck region.

## MATERIAL AND METHOD

This study was conducted in accordance with the principles outlined by the Declaration of Helsinki and received ethical approval from the Ethics Committee of Ordu University and the Ordu Provincial Health Directorate (Approval No: 2021/257, Date: 03.12.2021- E35766640-799, Date: 07.12.2021).

We retrospectively analyzed data from 30 patients who visited the pain outpatient clinic at Ordu State Hospital between January and August 2021. These patients were identified as having a trigger point in the upper region of the trapezius muscle, indicative of myofascial pain. Routine blood tests and cervical radiographs were conducted for all patients. We excluded patients with fibromyalgia syndrome, disc or skeletal disorders, cervical radiculopathy or myelopathy diagnoses, and those whose symptoms started less than 3 months ago. Patients with neck and/or back pain exhibiting a palpable taut band on the trapezius muscle and at least one active trigger point were considered for TCRFT. During our retrospective analysis, we reassessed patients' MPS diagnosis based on Travell and Simons' diagnostic criteria and included data from patients meeting these criteria.[13]

We recorded demographic information including age, gender, height, and weight of the patients. Baseline visual analogue scale (VAS) values before treatment, as well as VAS and total analgesic use (TAU) at 1st, 4th, and 12th weeks post-treatment, were documented. Additionally, patient global impression of change (PGIC) scores at week 12 were noted. The resting pain intensity of the patients was measured using a 10 cm VAS, where 0 indicated no pain and 10 represented the most severe pain. Furthermore, the PGIC score post-treatment, rated on a scale of 1 to 7 (1 = no change, 2 = almost the same, 3 = slightly better, 4 = better, 5 = moderately better, 6 = better, 7 = much better), was recorded.

### Technique

All patients underwent TCRFT administered by an algologist specially trained in this technique. Each patient received a single treatment session lasting approximately 15 minutes. During the session, a bipolar therapy delivering 80 volts (V), 2 minutes, 10 milliseconds (ms), 5 pulsed/second was applied to 6 standard areas in the painful neck region using electrodes specifically designed for TCRFT. Treatment targeted 6 regions, covering both sides of the cervical region, bilateral scapula medial, and bilateral scapula inferior.

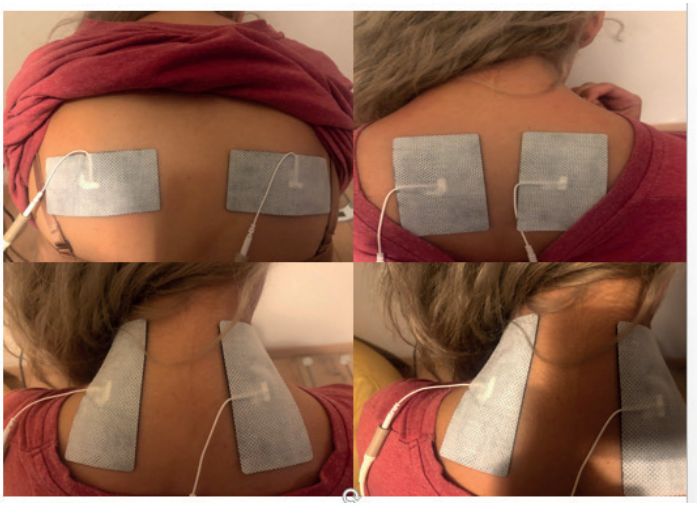

Figure 1. Transcutaneous Pulsed Radiofrequency Therapy; Method of Application and Determined Areas

Surface-mounted, self-adhesive 45x99 millimeter (mm) disposable fully gelled neurostimulation electrodes were used during the procedure. These electrodes were connected to the NeuroTherm NP1000 radiofrequency lesion generator via a cable provided by the supplier. The machine operated in non-thermocouple mode using the manual voltage setting.

### Statistical analysis

Pre-procedural baseline and postoperative outcome measures, including VAS (visual analogue scale), total analgesic use (TAU), and patient global impression of change (PGIC) scores at 1st, 4th, and 12th weeks after the procedure, were compared using the independent groups t-test. The comparison was conducted at a 95% confidence interval with a significance level of $p<0.05$.

## RESULTS

Among the patients, 22 (73.3%) were female, and 8 (26.7%) were male. The mean age of the patients, ranging from 24 to 67 years old, was 45.27 ± 13.05. The mean BMI ranged from 19.8 to 31.1, with a calculated mean of 24.66 ± 3.46. The duration of complaints varied from 4 to 120 months, with a mean of 27.87 ± 33.72. Additionally, 73.3% of patients (n=22) had no additional diseases. 13.3% (n=4) had coronary artery disease, 6.7% (n=2) had diabetes, and 6.7% (n=2) had rheumatoid arthritis.

**Table 1.** Demographic Findings

| | | n | % |
|---|---|---|---|
| Gender | Female | 22 | 73.3 |
| | Male | 8 | 26.7 |
| Additional Disease | No | 22 | 73.3 |
| | Coronary artery disease | 4 | 13.3 |
| | Diabetes Mellitus | 2 | 6.7 |
| | Rheumatoid arthritis | 2 | 6.7 |
| Age *(Min.-Maks.; Mean±sd)* | | 24-67; **45,27±13,05** | |
| BMI *(Min.-Maks.; Mean±sd)* | | 19,8-31,1; **24,66±3,46** | |
| Complaint Period (month) *(Min.-Maks.; Mean±sd)* | | 4-120; **27,87±33,72** | |

The mean PGIC of the patients at week 1 was 5.60 ± 1.61. This mean increased slightly by 0.20 ± 0.76 at the 2nd week to 5.80 ± 1.58. However, this increase was not found to be significant ($t(29) = 1.439$; $p > 0.05$). By the 4th week, the mean PGIC decreased by 0.20 ± 1.35 points compared to the 1st week, reaching 5.40 ± 2.06. Again, this decrease was not statistically significant ($t(29) = -0.812$; $p > 0.05$). However, at the 12th week, the mean PGIC decreased significantly by 0.87 ± 1.53 points compared to the 1st week, down

to 4.73 ± 2.50 (t (29) = -3.112; p < 0.05).

Based on these findings, it can be inferred that patient satisfaction with the treatment was initially high at around 77% in the first week, increased slightly in the second week, and then declined from the fourth week onwards. However, by the 12th week, satisfaction levels had decreased to approximately 62%

**Table 2. PGIC Findings**

| PGIC Measurements (Mean±sd) | ΔMean±sd | 95% CI Δ Lowest | 95% CI Δ Highest | t | Df | p |
|---|---|---|---|---|---|---|
| 1st week - *(5.60±1.61)* | | | | | | |
| 2nd week - *(5.80±1.58)* | 0.20±0.76 | -0.08 | 0.48 | 1.439 | 29 | 0.161 |
| 4th week - *(5.40±2.06)* | -0.20±1.35 | -0.70 | 0.30 | -0.812 | 29 | 0.423 |
| 12th week - *(4.73±2.50)* | -0.87±1.53 | -1.44 | -0.30 | -3.112 | 29 | **0.004** |

*ΔMean±SD represents the change in mean score ± standard deviation (SD), t: t-statistic, Df: degrees of freedom*

Before the treatment, the mean VAS score of the patients was 7.40 ± 0.81. This mean decreased significantly by 5.00 ± 2.41 points to 2.40 ± 2.40 at week 1 (t (29) = -11.378; p < 0.05). By the 4th week, the mean VAS score further decreased by 5.13 ± 2.37 points to 2.27 ± 2.59 compared to pre-treatment, and this decrease remained significant (t (29) = -11.843; p < 0.05). At week 12, the mean VAS score decreased by 3.73 ± 2.79 points to 3.67 ± 3.08 compared to pre-treatment, and this decrease was also significant (t (29) = -7.327; p < 0.05). However, it is noteworthy that there was an increase between the 4th and 12th weeks.

On the other hand, the mean TAU score of the patients before the treatment was 14.47 ± 3.46. This mean decreased significantly by 9.93 ± 5.60 to 4.53 ± 3.93 at week 1 (t (29) = -9.713; p < 0.05). In the 4th week, the mean TAU score decreased by 11.07 ± 5.54 compared to pre-treatment, reaching 3.40 ± 3.60, and this decrease was again significant (t (29) = -0.942; p < 0.05). The mean TAU score at the 12th week decreased by 7.93 ± 6.19 to 6.53 ± 5.17 compared to pre-treatment, and this decrease was also significant (t (29) = -7.024; p < 0.05). However, an increase was noted between the 4th and 12th weeks

**Table 3.** VAS and TAU Findings

| Pre-treatment (Mean±sd) | Post-treatment (Mean±sd) | Δ Mean±sd | 95% CI Δ Lowest | 95% CI Δ Highest | t | Df | p |
|---|---|---|---|---|---|---|---|
| VAS *(7.40±0.81)* | 1st week - *(2.40±2.40)* | -5.00±2.41 | -5.90 | -4.10 | -11.378 | 29 | **0.000** |
| | 4th week - *(2.27±2.59)* | -5.13±2.37 | -6.02 | -4.25 | -11.843 | 29 | **0.000** |
| | 12th week - *(3.67±3.08)* | -3.73±2.79 | -4.78 | -2.69 | -7.327 | 29 | **0.000** |
| TAU *(14.47±3.46)* | 1st week - *(4.53±3.93)* | -9.93±5.60 | -12.02 | -7.84 | -9.713 | 29 | **0.000** |
| | 4th week - *(3.40±3.60)* | -11.07±5.54 | -13.14 | -9.00 | -10.942 | 29 | **0.000** |
| | 12th week - *(6.53±5.17)* | -7.93±6.19 | -10.24 | -5.62 | -7.024 | 29 | **0.000** |

*VAS: Visual Analogue Scale scores, TAU: Total Analgesic Use , ΔMean±SD represents the change in mean score ± standard deviation (SD), t: t-statistic, Df: degrees of freedom*

## DISCUSSION

Upon evaluating the results, it can be concluded that TCRFT had a positive effect on chronic pain, analgesic use, and patient satisfaction in individuals with myofascial pain syndrome. Following the application of TCRFT, there was a significant reduction in both VAS scores and TAU from the 1st week, with this reduction persisting through the 4th week and even surpassing the 1st week values. By the 12th week, although there was a slight increase in both VAS and TAU scores, they remained significantly lower compared to pre-treatment levels, indicating the sustained efficacy of TCRFT in alleviating chronic pain severity and reducing analgesic dependence.

Regarding patient satisfaction, approximately 77% reported satisfaction with the treatment in the 1st week. Satisfaction levels increased in the 2nd week but declined thereafter, with satisfaction dropping to around 62% by the 12th week. Ultimately, while the initial impact of TCRFT on quality of life was notably positive, there was a subsequent decrease of approximately 20% by the 4th week.

In a pivotal prospective, randomized controlled study by Choe Tae et al. conducted in 2017, the comparative efficacy of interfacial field local anesthetic and PRF treatment modalities was meticulously scrutinized in patients afflicted with MPS. [14] Initially, the investigation revealed no discernible disparity between the two treatment groups during the initial 2-week follow-up period. However, as the study progressed, a notable divergence emerged: by the 4th week, a striking decrease in pain intensity was unequivocally discerned within the PRF treatment cohort when juxtaposed against their counterparts receiving local anesthetic. This pivotal finding underscored the superior efficacy of PRF therapy in assuaging the relentless burden of pain experienced by MPS patients. The profound impact of PRF therapy on pain amelioration was further emphasized during the protracted 8-week follow-up, wherein the PRF-treated group exhibited an unprecedented reduction in pain intensity by nearly 70%. Despite the technical variances inherent between the PRF application techniques employed in the referenced study and those of our own investigation, the congruence of outcomes underscores a compelling narrative: the non-invasive therapeutic approach harnessed in our study yielded outcomes strikingly akin to those gleaned from the rigorous examination by Choe Tae et al.[14] This congruence substantiates the compelling efficacy of PRF therapy as a potent weapon in the armamentarium against the relentless scourge of MPS-associated pain.

In the realm of pain medicine, the rapid advancement of RF technology has been a catalyst for transformative therapeutic modalities. Among these, RF therapy has emerged as a cornerstone approach, particularly renowned for its effectiveness in addressing the intricate complexities of MPS.[15] This syndrome, characterized by localized muscular pain and dysfunction, presents a significant clinical challenge, necessitating innovative treatment strategies. RF therapy operates on a sophisticated mechanism, leveraging controlled thermal energy to selectively target and disrupt abnormal peripheral nerves. By modulating hyperplastic tissue, releasing soft tissue contractures, and enhancing microcirculation, RF therapy orchestrates a comprehensive therapeutic response.[16]

Within the spectrum of RF therapies, PRF treatment has garnered considerable attention for its potential in alleviating MPS-related symptoms. However, existing PRF treatment studies often entail invasive procedures, leading to a constellation of post-procedural complications. These complications, ranging from mild discomfort to more severe tissue damage, underscore the inherent risks associated with invasive interventions. In stark contrast, PRF therapy has demonstrated a remarkable safety profile, characterized by its non-invasive nature and minimal risk of adverse effects.[17,18.]

TCRFT, as a non-invasive variant of RF therapy, holds promise in circumventing the pitfalls associated with invasive procedures. Given its non-invasive nature, TCRFT is anticipated to offer a safer and more accessible therapeutic avenue for individuals grappling with MPS. In a meticulous study involving 30 participants, our investigation aimed to evaluate the safety and efficacy of TCRFT in managing MPS symptoms. Throughout the course of treatment and a 12-week follow-up period, careful monitoring revealed no instances of complications or adverse effects.

This observed absence of complications underscores the inherent safety and tolerability of TCRFT as a non-invasive therapeutic modality for MPS. Furthermore, it highlights the potential of TCRFT to serve as a valuable addition to the armamentarium of pain management strategies, offering a safe and effective alternative to invasive interventions. As the field of pain medicine continues to evolve, the burgeoning role of non-invasive modalities such as TCRFT heralds a promising era of patient-centered care and improved treatment outcomes for individuals navigating the complexities of chronic pain conditions like MPS.

Upon conducting an extensive review of existing literature, it becomes evident that transcutaneous radiofrequency therapy (TCRFT) has primarily been investigated and utilized in the context of managing shoulder pain, demonstrating notable effectiveness as documented in previous studies.[12-18] A seminal study conducted by Lin et al., involving a cohort of 64 patients, stands out for its direct comparison of TCRFT and transcutaneous electrical nerve stimulation (TENS) in mitigating shoulder pain. [18] While both treatment modalities were deemed safe, TCRFT emerged as the superior option in terms of effectiveness, marking a significant stride in the therapeutic landscape.

Delving deeper into the mechanisms underpinning the efficacy of TENS and TCRFT, it is illuminating to note the differential impact of these modalities on pain management. TENS operates by leverag-

ing electrical currents to stimulate the release of endorphins and enkephalins, natural analgesic substances that inhibit the transmission of pain signals to the brain. This mechanism, akin to the action of traditional pharmaceuticals, offers a non-invasive and risk-free alternative for pain relief.[19]

However, despite the adjustability of electrical stimulation frequency and intensity in TENS, its penetration capacity remains constrained by the relatively low frequency (approximately 150 Hz) compared to TCRFT (approximately 500 kHz). This disparity in frequency profoundly influences the ability of these modalities to penetrate tissues, with TCRFT exhibiting superior tissue penetration capabilities owing to its higher frequency. This penetration capacity is particularly noteworthy considering the impedance barrier presented by human skin, which exhibits substantially higher impedance levels (approximately 1–2 MΩ) compared to underlying tissues (approximately 500–1.5 KΩ).[20]

Moreover, the electrical conduction dynamics of skin and tissues, flowing to a parallel circuit, further elucidate the superior efficacy of TCRFT in delivering energy to target tissues. The skin and tissues can be conceptualized as a parallel circuit, where impedance and capacitance significantly influence electrical conduction, particularly the capacitor impedance.[20,21] TCRFT's capacity to circumvent the impedance barrier of the skin enables more efficient energy delivery to underlying tissues, thereby enhancing its therapeutic efficacy compared to TENS.

This comprehensive understanding of the mechanisms underlying the differential efficacy of TENS and TCRFT underscores the pivotal role of tissue penetration in dictating therapeutic outcomes. By overcoming the impedance barrier of the skin and delivering a more substantial energy dose to target tissues, TCRFT emerges as a promising modality for effectively managing shoulder pain and potentially extending its application to other pain syndromes.

The principles of electrical theory underscore a fundamental relationship between stimulation frequency and capacitor impedance: a higher frequency leads to a lower impedance. This foundational theorem elucidates why TCRFT, characterized by a markedly elevated frequency compared to TENS, exhibits superior tissue penetration and conductivity.[18] TCRFT's enhanced frequency enables it to traverse deeper anatomical structures, including neuronal pathways, beyond the superficial layers of the skin, thereby eliciting more profound and comprehensive pain relief compared to TENS.

Expounding on this principle, it becomes evident that the distinctive efficacy observed between TENS and TCRFT stems from their respective frequency-dependent mechanisms of action. While TENS predominantly delivers electrical impulses through the skin, constrained by its lower frequency, TCRFT's higher frequency empowers it to engage with neuronal structures nestled within deeper tissues. This expanded reach enables TCRFT to influence a broader array of anatomical targets, thus offering a more holistic and potent approach to pain management.

Reinforcing this understanding, a thorough review conducted by Sara-Ahmed et al. systematically evaluated prior TENS studies focusing on myofascial pain and underscored the pivotal role of frequency in achieving optimal pain control outcomes. [22] Notably, higher frequencies were correlated with greater efficacy in mitigating pain, aligning with the underlying pathophysiological mechanisms of MPS. Crucially, the review highlighted TCRFT's potential to achieve enhanced pain control by accessing frequency ranges beyond the capability of conventional TENS devices.

While our study did not directly compare TCRFT with TENS, the observed trends in patient satisfaction provide corroborative evidence for the frequency-dependent efficacy of TCRFT. Despite an initial decrease in satisfaction levels post-4th week, significant satisfaction persisted at the 12th week compared to baseline. This sustained pain control over the 12-week period lends credence to the notion that TCRFT's higher frequency and deeper tissue penetration contributes to its enduring effectiveness in managing MPS-associated pain.

While our study contributes valuable insights into the potential efficacy of TCRFT for managing MPS, it is important to acknowledge several limitations that warrant consideration. Foremost among these is the absence of a double-blind, placebo-controlled trial, which is widely regarded as the gold standard in clinical research for rigorously evaluating treatment efficacy. Despite this, our decision to employ a single-arm study design was influenced by the established evidence supporting the mechanisms of action of TCRFT and its clinical utility in pain management settings.

Furthermore, our study specifically focused on evaluating the effects of a single session of TCRFT on MPS symptoms. This approach was guided by the limited existing literature exploring the use of TCRFT in MPS patients, particularly within the context of a single treatment session. While this allowed us to generate preliminary insights into the potential therapeutic benefits of TCRFT, the relatively small sample size of 30 participants and the absence of a control group are notable limitations.

Indeed, the modest sample size may have constrained the statistical power of our findings, potentially limiting our ability to detect subtle treatment effects or variations among different patient subgroups. Additionally, the absence of a control group precludes direct comparisons with alternative treatments or placebo interventions, which could provide valuable context for interpreting the observed treatment effects.

## CONCLUSION

Despite these limitations, it is important to recognize that our study serves as an exploratory pilot investigation, laying the groundwork for future, more robust studies to further elucidate the efficacy and applicability of TCRFT in the management of MPS. Future research endeavors should aim to address these limitations by incorporating larger sample sizes, randomized controlled designs, and comparative effectiveness analyzes to provide a more comprehensive understanding of the role of TCRFT in MPS management. Furthermore, while our study did not explicitly assess the cost-effectiveness of TCRFT compared to traditional pulsed radiofrequency therapy or other treatment modalities, this represents an important avenue for future research. Evaluating the economic implications and cost-effectiveness of TCRFT in comparison to existing treatments would offer valuable insights for healthcare decision-makers and when considering treatment options for MPS patients.

**Conflict of Interest:** The authors declare no conflict of interest.

Author Contributions: Mustafa Karaoğlan conceived and designed the study. Suna Akın Takmaz and Mustafa Karaoğlan collected and analyzed the data. Mustafa Karaoğlan wrote the paper.

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