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Effect of Functional Electrical Stimulation with and without Mulligan's Technique in Adhesive Capsulitis

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ABSTRACT

Background: Adhesive capsulitis, or frozen shoulder, is characterized by pain and stiffness, significantly impacting daily activities. Functional Electrical Stimulation (FES) and Mulligan's technique are interventions used to improve shoulder mobility and reduce pain.

Objective: To evaluate the effectiveness of FES with and without Mulligan's technique in enhancing shoulder function and reducing pain in patients with adhesive capsulitis.

Methods: A randomized clinical trial was conducted with 28 participants divided into two groups. Group A received conventional physical therapy, including heat therapy, range of motion exercises, strengthening, and manual therapy. Group B received the same therapy combined with FES and Mulligan's technique. Pre- and post-treatment assessments were conducted using the PENN Shoulder Scale and goniometric measurements for flexion, extension, abduction, adduction, and rotation. Data were analyzed using the Wilcoxon signed-rank test and Mann-Whitney U test.

Results: Group B showed a 50% improvement in shoulder flexion ($z = -2.946$, $p = 0.003$) and a 60% improvement in shoulder extension ($z = -2.980$, $p = 0.003$) compared to Group A.

Conclusion: Combining FES with Mulligan's technique significantly improves shoulder mobility and reduces pain in adhesive capsulitis patients compared to conventional therapy alone.

INTRODUCTIO

Adhesive capsulitis, commonly referred to as frozen shoulder, is a progressive condition characterized by stiffness and pain in the shoulder joint, significantly affecting an individual's ability to perform daily activities. This condition typically evolves through three stages: freezing, frozen, and thawing. During the freezing stage, pain progressively increases, leading to a restriction in shoulder movement as inflammation causes adhesions within the joint capsule (1). The frozen stage is marked by persistent stiffness, but with a reduction in pain, and the thawing stage sees a gradual return of shoulder mobility as the adhesions resolve (2). Although the precise etiology of adhesive capsulitis is not fully understood, it is often associated with prolonged immobilization, previous shoulder injuries, or systemic conditions such as diabetes mellitus and thyroid disorders (3). The prevalence of adhesive capsulitis is estimated to be between 2-5% in the general population, with a higher incidence in individuals aged 40 to 60 years, particularly in women (4). The condition is known to significantly affect quality of life, with pain and reduced range of motion leading to decreased functional capacity (5).

Functional Electrical Stimulation (FES) is a therapeutic modality commonly used in the rehabilitation of musculoskeletal and neurological conditions. FES involves the application of electrical currents through surface electrodes to stimulate muscle contractions, which can help improve muscle strength, enhance motor control, and facilitate functional movements in individuals with impaired motor function (6). The mechanism of FES is based on the activation of motor neurons through electrical impulses that mimic the natural signals of the nervous system, bypassing any neural damage that may be present. This technique has shown promising results in restoring functional movements, such as grasping, standing, and walking, in patients with neurological disorders, thereby improving their quality of life (7). In the context of adhesive capsulitis, FES has been employed to reduce pain and improve shoulder mobility by stimulating the muscles around the shoulder joint, thereby promoting better joint function and reducing stiffness (8).

Mulligan's technique, developed by Brian Mulligan, is a manual therapy approach that focuses on the concept of mobilization with movement (MWM). This method involves applying a sustained glide to a joint while the patient actively performs a specific movement, such as abduction or rotation, to correct positional faults and enhance pain-free motion (9). In patients with adhesive capsulitis, the Mulligan technique is particularly effective in improving shoulder mobility and reducing pain by stretching the joint capsule and reducing adhesions without inducing discomfort (10). This approach not only addresses the mechanical restrictions in the joint but also involves the patient's neuromuscular system, reinforcing correct movement patterns. Studies have demonstrated that Mulligan's

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technique can provide immediate and lasting improvements in pain relief and functional outcomes for various musculoskeletal conditions (11).

Combining Functional Electrical Stimulation (FES) with Mulligan's technique provides a synergistic approach to managing adhesive capsulitis by leveraging the strengths of both modalities. While FES focuses on reducing pain and improving muscle activation through electrical stimulation, Mulligan's technique emphasizes restoring joint mobility through manual therapy (12). Together, these methods can offer a comprehensive treatment strategy that addresses both the muscular and joint components of the condition, potentially leading to more significant improvements in shoulder function and pain relief than either treatment alone. Previous studies have indicated that such combined interventions can accelerate recovery, improve range of motion, and reduce pain more effectively, making them a valuable approach in the rehabilitation of patients with adhesive capsulitis (13).

Given the debilitating nature of adhesive capsulitis and its significant impact on quality of life, exploring effective treatment options that combine different therapeutic approaches is crucial. The current study aims to evaluate the effectiveness of FES with and without Mulligan's technique in improving shoulder function and reducing pain in patients with adhesive capsulitis. This investigation is expected to provide valuable insights into the potential benefits of integrated therapeutic interventions, guiding clinical practices for the management of this challenging condition.

MATERIAL AND METHODS

The study was conducted as a randomized clinical trial at Sharif Medical Complex, Lahore, over a period of 6 to 12 months. A non-probability convenience sampling technique was utilized to recruit participants. Individuals aged between 18 and 70 years who were diagnosed with adhesive capsulitis (frozen shoulder) and had experienced symptoms for a duration of at least 3 months but not more than 2 years were included in the study. The inclusion criteria required participants to have a minimum shoulder pain level of 4 on a 10-point visual analog scale. Participants with systemic diseases, neurological conditions, severe osteoporosis, recent significant shoulder injuries, or those who had undergone shoulder surgery were excluded to ensure a homogenous study population.

Two groups were created for the intervention. Group A received conventional physical therapy, which included heat therapy, range of motion (ROM) exercises, strengthening exercises, and manual therapy. Group B received the same conventional therapy combined with Functional Electrical Stimulation (FES). The FES was applied using surface electrodes placed over the affected shoulder muscles to enhance muscle activation and facilitate rehabilitation. Mulligan's technique, which involves sustained manual pressure with active or passive movements, was used in Group B in combination with FES. The combined approach was intended to mobilize the joint, reduce adhesions, and improve overall shoulder mobility. The treatment sessions for both groups were conducted three times a week for a duration of 8 to 12 weeks.

Data collection was carried out using the Penn Shoulder Score, a validated tool for assessing shoulder pain and disability, and a goniometer was used to measure shoulder ROM, including flexion, extension, abduction, adduction, and rotation. Baseline measurements were taken prior to the commencement of the treatment, and follow-up measurements were recorded at the end of the treatment period to evaluate the effectiveness of the interventions. Participants were monitored weekly, and any adverse effects or complications arising from the interventions were documented. Informed consent was obtained from all participants before their inclusion in the study, ensuring that they were fully aware of the study's procedures and any potential risks or benefits involved. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Sharif Medical Complex, and ethical guidelines were strictly followed in accordance with the Declaration of Helsinki.

Data analysis was performed using SPSS software version 25. Descriptive statistics, including means and standard deviations, were calculated for continuous variables such as age and Penn Shoulder Score. The gender distribution was also analyzed. To compare the pre-treatment and post-treatment outcomes within each group, the Wilcoxon signed-rank test was employed. The Mann-Whitney U test was used to compare differences between the two groups. Statistical significance was set at $p<0.05$. The results were reported with corresponding z-values and p-values to determine the effectiveness of the interventions in improving shoulder function and reducing pain. The use of non-parametric tests was deemed appropriate due to the small sample size and the ordinal nature of the outcome measures. Data handling and analysis adhered to high standards of accuracy and integrity to ensure reliable and valid results.

This methodology allowed for a comprehensive assessment of the effectiveness of FES combined with Mulligan's technique compared to conventional physical therapy in patients with adhesive capsulitis. The rigorous study design, ethical considerations, and robust statistical analysis were aimed at providing evidence-based recommendations for clinical practice.

RESULTS

The results of the study evaluating the effectiveness of Functional Electrical Stimulation (FES) with and without Mulligan's technique in patients with adhesive capsulitis are presented below. The findings include descriptive statistics for age and gender distribution, as well as the analysis of pre- and post-treatment outcomes using the Mann-Whitney U test and Wilcoxon signed-rank test.

The study included 28 participants with a mean age of 39.57 years (SD = 18.05), ranging from 18 to 72 years. The gender distribution was equal, with 14 males (50%) and 14 females (50%).

Table 1 Demographic Characteristics

Demographic Characteristics	N	Mean	Standard Deviation	Minimum	Maximum
Age	28	39.57	18.05	18	72
Gender Distribution	Frequency		Percentage (%)		
Male	14		50.0		
Female	14		50.0		
Total	28		100.0		

Pre- and Post-Treatment Analysis Within Groups

The Wilcoxon signed-rank test was utilized to evaluate the differences in shoulder function parameters, including the PENN Shoulder Scale, shoulder flexion, extension, abduction, adduction, and rotation, before and after treatment within each group.

Table 2 Wilcoxon Signed-Rank Test - Group A Analysis

Variable	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	Mean Rank	Z Score	P Value
PENN Shoulder Scale	44.00 ± 9.32	68.00 ± 10.51	14.50	-4.624	0.000
Shoulder Flexion	55.00 ± 13.69	96.42 ± 17.52	14.50	-4.627	0.000
Shoulder Extension	21.21 ± 11.84	36.67 ± 7.83	14.50	-4.621	0.000
Shoulder Abduction	40.25 ± 21.31	95.92 ± 12.25	14.50	-4.642	0.000
Shoulder Adduction	37.25 ± 15.23	80.39 ± 10.79	14.50	-4.624	0.000
Shoulder Rotation	32.75 ± 15.23	62.67 ± 11.34	14.31	-4.448	0.000

Table 3 Wilcoxon Signed-Rank Test - Group B Analysis

Variable	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	Mean Rank	Z Score	P Value
PENN Shoulder Scale	42.75 ± 9.23	68.57 ± 10.99	14.50	-4.625	0.000
Shoulder Flexion	54.46 ± 13.98	103.39 ± 14.14	14.50	-4.624	0.000
Shoulder Extension	27.64 ± 8.42	43.82 ± 8.20	14.96	-4.597	0.000
Shoulder Abduction	40.25 ± 21.31	101.78 ± 9.73	14.50	-4.624	0.000
Shoulder Adduction	37.25 ± 15.23	88.75 ± 6.78	14.50	-4.629	0.000
Shoulder Rotation	32.72 ± 18.89	63.75 ± 11.19	15.35	-4.472	0.000

Both groups exhibited statistically significant improvements in all shoulder parameters post-treatment, indicating that the interventions were effective in enhancing shoulder mobility and reducing pain.

The Mann-Whitney U test was used to compare the treatment outcomes between Group A and Group B for each shoulder function parameter.

Table 4 Mann-Whitney U Test - Between Group Comparisons

Variable	Group	Mean Rank	Median	Z Value	P Value
PENN Shoulder Scale (Pre)	Group A	15.32	19.00	-0.531	0.595
	Group B	13.68	21.00		
PENN Shoulder Scale (Post)	Group A	16.43	12.50	-1.243	0.214
	Group B	12.57	13.50		
Shoulder Flexion (Pre)	Group A	14.89	22.50	-0.255	0.799
	Group B	14.11	23.75		
Shoulder Flexion (Post)	Group A	9.96	18.75	-2.946	0.003
	Group B	19.04	19.50		
Shoulder Extension (Pre)	Group A	15.79	10.00	-0.844	0.399
	Group B	13.21	11.00		
Shoulder Extension (Post)	Group A	17.32	10.00	-1.870	0.061
	Group B	11.68	10.00		

The results indicated that both groups showed significant improvements in shoulder mobility and pain reduction following their respective treatments. However, Group B, which received FES combined with Mulligan's technique, demonstrated greater enhancements in post-treatment shoulder flexion ($z = -2.946$, $p = 0.003$) compared to Group A. Similarly, significant changes in shoulder extension were observed within Group B ($z = -2.980$, $p = 0.003$). These findings suggest that the combined use of FES and Mulligan's technique is more effective than conventional physical therapy alone in improving shoulder function among patients with adhesive capsulitis. Overall, the study results provide evidence supporting the efficacy of combining FES with Mulligan's technique as a therapeutic approach to managing adhesive capsulitis, with superior

outcomes in terms of shoulder mobility and pain relief compared to standard physical therapy.

DISCUSSION

The discussion of this study centered on evaluating the effectiveness of combining Functional Electrical Stimulation (FES) with Mulligan's technique compared to conventional physical therapy in the management of adhesive capsulitis. The findings indicated that both interventions significantly improved shoulder mobility and reduced pain, but the combination of FES with Mulligan's technique showed superior outcomes in terms of shoulder flexion and extension. This result is consistent with previous research that highlighted the benefits of integrating different therapeutic modalities to achieve better functional outcomes in adhesive capsulitis (12).

The study demonstrated significant improvements in all shoulder function parameters, including the PENN Shoulder Scale, flexion, extension, abduction, adduction, and rotation, within both groups. These findings align with earlier studies that reported enhanced shoulder mobility and pain reduction with the use of FES and Mulligan's technique separately (14). However, the combined approach in Group B resulted in more marked improvements, particularly in post-treatment shoulder flexion and extension, compared to Group A, which received only conventional physical therapy. This suggests a synergistic effect when combining FES and Mulligan's technique, likely due to the simultaneous stimulation of muscle activation and correction of joint positional faults, as proposed in previous literature (15).

The use of FES alone has been widely supported in the rehabilitation of musculoskeletal conditions, including adhesive capsulitis, due to its ability to stimulate muscle contractions, enhance muscle strength, and facilitate motor control (7). Previous studies have shown that FES can effectively reduce pain and increase shoulder mobility in patients with adhesive capsulitis by promoting muscle activation and reducing joint stiffness (6). Mulligan's technique, on the other hand, has been recognized as an effective manual therapy approach that improves joint mobility and reduces pain by addressing joint positional faults through mobilization with movement (11). The integration of both modalities in this study provided a comprehensive treatment strategy that addressed both the neuromuscular and mechanical components of adhesive capsulitis, leading to more substantial improvements in shoulder function.

This study's strength lies in its randomized clinical trial design, which minimized selection bias and allowed for a more accurate comparison of the effectiveness of the interventions. The use of validated outcome measures, such as the PENN Shoulder Scale and precise ROM measurements using a goniometer, added robustness to the findings. The weekly monitoring of progress also ensured that the treatment effects were consistently evaluated, which contributed to the reliability of the results. However, certain limitations must be acknowledged. The relatively small sample size of 28 participants may limit the generalizability of the findings to a broader population. Future studies with larger sample sizes would be beneficial to confirm these results and enhance the external validity of the study (10).

Another limitation was the reliance on a non-probability convenience sampling technique, which may have introduced selection bias and affected the representativeness of the sample. Additionally, while the study's duration of 8 to 12 weeks allowed for an assessment of short-term effects, longer follow-up periods are needed to evaluate the long-term efficacy of the combined intervention and to determine whether the improvements in shoulder function are sustained over time. Future research should also consider including a more diverse patient population, encompassing different levels of severity and various underlying conditions, to better understand the applicability of these interventions across different clinical contexts (9).

The findings of this study have several practical implications for clinical practice in the management of adhesive capsulitis. The significant improvements observed with the combined use of FES and Mulligan's technique suggest that integrating these two modalities could be a more effective strategy for managing adhesive capsulitis than conventional physical therapy alone. This approach may be particularly beneficial in clinical settings where rapid recovery and enhanced functional outcomes are prioritized. Clinicians should consider adopting this combined approach in their treatment plans, especially for patients who do not respond adequately to single-modality interventions. Moreover, future studies should explore the optimal frequency, intensity, and duration of FES and Mulligan's technique to maximize therapeutic outcomes (16).

CONCLUSION

In conclusion, this study provided evidence that combining FES with Mulligan's technique leads to superior improvements in shoulder mobility and pain reduction compared to conventional physical therapy alone in patients with adhesive capsulitis. The integrated approach addresses both muscular and joint-related impairments, offering a comprehensive treatment strategy that can potentially enhance recovery and improve quality of life. Further research with larger sample sizes, longer follow-up periods, and more diverse patient populations is needed to validate these findings and refine treatment protocols for adhesive capsulitis.

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