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Effects of muscle energy technique on pain, range of motion and function in patients with post-surgical elbow stiffness: A randomized controlled trial

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Background: Elbow is a very functional joint. Elbow stiffness is a significant cause of disability hampering the function of the upper extremity as a whole. Muscle Energy Techniques (METs) are relatively pain-free techniques used in clinical practice for restricted range of motion (ROM).
Objective: To study the effects of MET on pain, ROM and function given early in the rehabilitation in post-surgical elbow stiffness.
Methods: An RCT was conducted on 30 patients post elbow fracture fixation. Group 1 was given MET immediately post removal of immobilization while Group 2 received MET 1 week later along with the rehabilitation protocol. Pain (Visual Analogue Scale), ROM (goniometry) and function (Disability of Arm, Shoulder and Hand questionnaire) were assessed pre and post 3 weeks.
Results: Group 1 showed greater improvement than Group 2, mean flexion and extension change between groups being 11.7 ± 2.8, 95%CI(5.9,17.4) and 8.5 ± 2.0, 95%CI(4.4,12.7), respectively. VAS and DASH scores improved better in Group 1, mean change being 1.2 ± 0.2, 95%CI(0.6,1.8) and 18.2 ± 2.2, 95%CI(13.5,22.8) for VAS and DASH scores, respectively.

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Conclusion: MET can be used as an adjunct to the rehabilitation protocol to treat elbow stiffness and can be given safely in the early stages of post elbow fracture rehabilitation managed surgically with open reduction and rigid internal fixation.

Keywords: Muscle energy technique; range of motion; elbow stiffness.

Introduction

The elbow being a highly constrained synovial hinge joint has a high propensity for degeneration and stiffness. There could be functional losses seen with even less severe loss of range of motion (ROM) at the elbow. A stiff elbow has been defined as the one with loss of extension of greater than 30° and flexion of less than 120°.[1] Restriction of joint mobility is a common complication that is seen post elbow surgery.[2] This could be due to immobilization, pain, muscle guarding, etc. All these may lead to reduced joint function and may hamper the patient's ability to perform functional tasks, thereby affecting his activities of daily living.[3,4] There is controlled trauma to the tissues around the elbow post elbow surgeries. This could also cause stiffness post operatively.[1]

Anatomical reduction of the fractures should be done and active and active-assisted ROM should be initiated as early as possible so as to minimize the development of stiffness.[5] For allowing early ROM, rigid internal fixation is necessary.[6,7]

Distal humerus fractures account for 30% of all the humeral fractures.[6] Elbow stiffness could arise due to various reasons, trauma being the most common cause. There can be voluntary or involuntary muscle guarding of the elbow during motion due to prolonged pain. This could lead to contractures in the elbow joint capsule and also to the muscles around it.[1] Contractures which may develop post trauma can impair activities of daily living and may also cause functional limitations in children and adults.[8] The elbow has shown to have high chances to go into stiffness post elbow fractures. Hence, early mobilization should be encouraged for better outcomes post fracture fixation.[9]

There are different interventions which are practiced for the management of elbow stiffness which include therapeutic exercises, stretching, strengthening exercises, continuous passive motion (CPM), use of electrotherapeutic modalities, static progressive splinting, etc.[1,8,10–12] There is less evidence to support rehabilitation of elbow post elbow fractures.[12]

Effectiveness of Muscle Energy Technique (MET) and its therapeutic mechanisms lacks high quality research but recent evolving researches support the clinical use of this technique.[13] Hence, there should be additional evidence to support its therapeutic mechanism to apply this technique for various musculoskeletal conditions.

METs are soft tissue or joint techniques that are employed in the treatment of musculoskeletal dysfunctions. Post-operative pain is one of the factors that reduce the patient's compliance and does not allow optimal joint and muscle mobilization. Also, passive rehabilitation techniques may cause adverse effects to the fragile tissues in the post-operative period in elbow joint. METs are a group of relatively pain free mobilization techniques that are used to regain mobility, reduce tissue edema, reduce muscle spasm, stretch fibrous tissue and retrain stabilizing function of the intersegmentally connected muscles.[14]

According to Sherrington's law of reciprocal inhibition, hypertonic antagonists can reflexively inhibiting their agonist muscle. Therefore, in the presence of short and/or tight antagonist muscles, restoring normal muscle tone and/or length should be first addressed.[15]

MET involves the subject to voluntarily contract the muscle in a precisely controlled direction against the therapist's counter force. Its therapeutic effects are to reduce pain, reduce muscle tone, stretch tightened muscles, strengthen the weak muscles, improve local circulation and mobilize joint restrictions.[16] Johns and Wright in their study on anatomical structures that contribute to stiffness at the joint states that the joint capsule, surrounding inter-muscular fasciae and muscles, tendons and skin tissue account for restriction at the joint.[17]

Relaxation of the antagonist muscle occurs due to actively contracting the agonist muscle. This facilitates mobility at the joint due to reciprocal inhibition.[18]

There was dearth in the literature on the use of METs in rehabilitation post elbow surgeries especially in the acute stage of rehabilitation. Hence, this study focused to see the effects with early intervention of MET and compared the effects with MET given 1 week later in the stage of rehabilitation on pain, ROM and function in patients with post-surgical elbow stiffness. Our research hypothesis was to investigate whether the group that received MET earlier did better or worse than the group which received MET later on the outcome variables in patients with post-surgical elbow stiffness.

Methods

A Randomized Controlled Trial was done in a period of 1 year and 6 months on subjects aged between 18–50 years who fulfilled the following criteria: (1) Patients with post-operative elbow stiffness after distal end extra-articular or intra-articular humerus fractures and/or proximal radius ulna fractures without any ligament injury. (2) Minimum immobilization period of 3 weeks. Patients who had pathological fractures, revision surgeries, associated ipsilateral injuries and neuro-vascular disorders were excluded from the study.

Ethical approval was sought by the Institutional Review Board of the hospital prior to the commencement of the study. A patient information sheet and an informed consent form were signed by the subjects.

Randomization

Subjects who met the inclusion criteria were randomly allocated to Group 1 or Group 2. The method of sampling used was stratified random sampling for group allotment using the chit method. Stratified randomization was done on the basis of the type of fracture. The subjects were divided into 2 strata — (1) Subjects with intra-articular fractures. (2) Subjects with extra-articular fractures. A random sample was then taken and allocated in the groups. The allocation was done by the primary investigator prior to the baseline assessment.

Outcome measures

The Visual Analogue Scale (VAS) was used to assess change in the pain intensity. Elbow ROM was measured using the universal half goniometer. Upper extremity function was assessed using the Disability of the Arm, Shoulder and Hand (DASH) questionnaire.

The VAS is a reliable and good tool and is widely used in clinical research to measure pain. Its usefulness has been validated by several researchers and is used for measuring both acute and chronic pain.[19–21]

To measure the ROM at the elbow, a universal goniometer is a simple and reliable clinical tool.[22]

The DASH is a self-administered questionnaire that can be used to measure the disability for any region in the upper limb.[23] It has an acceptable validity and sensitivity to change in case of elbow pathologies.[24]

Sample size

Sample Size was calculated using the formula[25]:

$$\text{Sample Size} = \frac{2\text{SD}^2(Z\alpha/2 + Z\beta)^2}{\delta^2}$$

SD — 3.71, Standard deviation from pilot study
$Z\alpha/2$ — 1.96 (from Z table) at type 1 error of 5%
$Z\beta$ — 0.84 (from Z table) at 80% power
$\delta^2 = 4.2$, effect size (difference between 2 mean values) from the pilot study.

$$\text{Sample Size} = \frac{2(3.71)^2(1.96 + 0.84)^2}{(4.2)^2} = 12.32$$

Thirty patients were included in the study. Fifteen patients were allotted to the Group 1 in which MET was started immediately post removal of immobilization. Fifteen patients were allotted to Group 2 in which MET was started after 1 week post removal of immobilization.

GROUP 1 Intervention: Total duration — 3 weeks, 6 days a week. Active and active assisted ROM exercises.[8,26] (1) Active flexion and extension in supine 10 repetitions × 2 sets. (2) Active assisted flexion and extension with wand 10 repetitions × 2 sets. (3) Active and active-assisted exercises for the wrist- flexion, extension, pronation, supination and shoulder flexion, extension, abduction, adduction and rotations 10 repetitions × 2 sets. (4) MET was given by a trained physiotherapist in the form of post isometric relaxation and/or reciprocal inhibition for 6 days a week with 5–7 s hold for 8–10 repetitions followed by a gentle passive stretch post removal of immobilization.[14] Only 20% resistance was offered to the isometric contraction.

GROUP 2 Intervention: The same above-mentioned protocol was given along with MET which was started 1 week later, post removal of immobilization.

Patients were asked to report (if any) increase in pain and/or discomfort during the treatment in both the groups. A home exercise program was given to the patients of both the groups to be done twice a day.

Home exercise program

(1) Active flexion and extension in supine. (2) Active assisted flexion and extension with a wand. (3) Active and active-assisted exercises for the wrist-flexion, extension, pronation, supination and shoulder flexion, extension, abduction, adduction and rotations. All the exercises for 10 repetitions × 2 sets each.

The parameters were re-assessed pre and post 3 weeks. The assessor was blinded. Measurements were taken by another trained physiotherapist pre and post the intervention.

Statistical analysis

Data was analyzed using the IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY (IBM Corp). Level of significance was set at $p \leq 0.05$. A two-tailed test of significance test should be conducted. For pain (VAS) and function (DASH score), within the group analysis was done using the Wilcoxon Signed Rank Test and between the groups by the Mann Whitney U test. For ROM, within the group analysis was done using the paired t test and between the groups was done using the unpaired t test. The normality of the data was tested by the Kolmogrov–Smirnov test

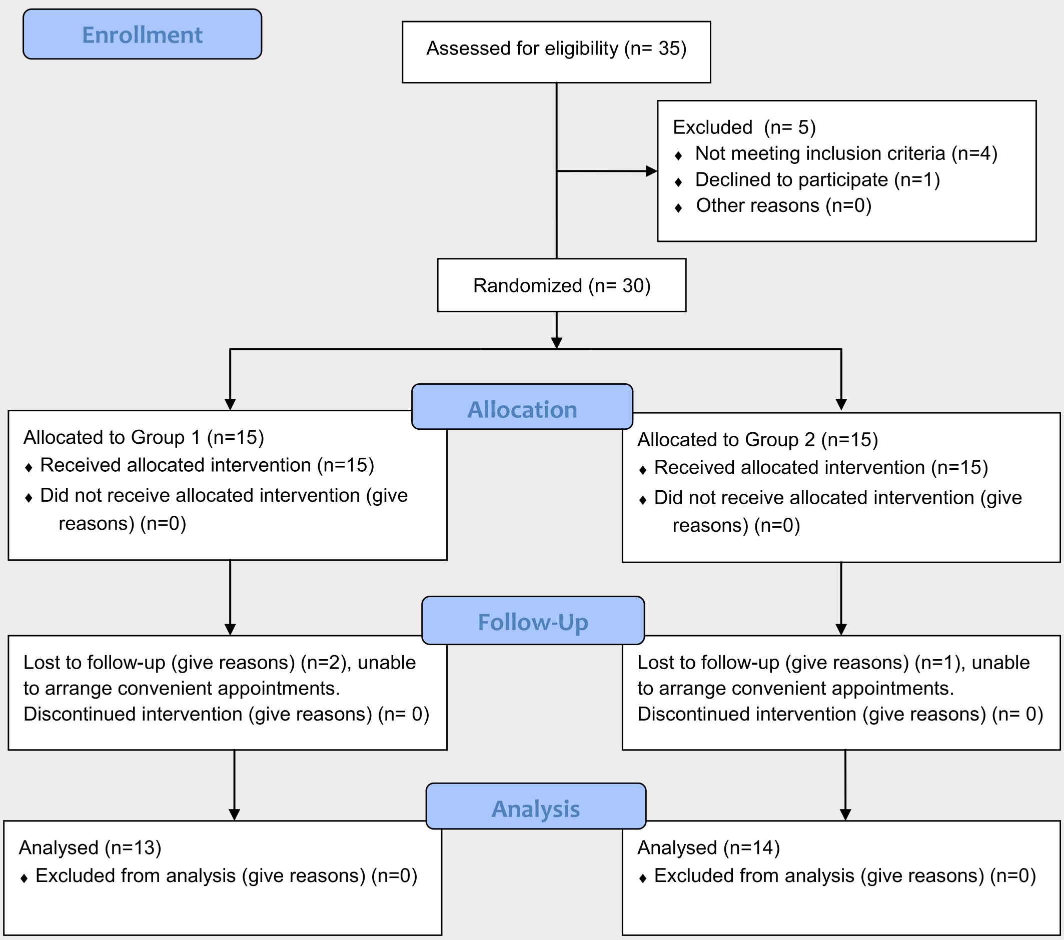

Fig. 1. Flow diagram showing the progress of participants at each stage of the study.

Table 1. Baseline characteristics of both the groups.

	Group 1 ($n = 13$)		Group 2 ($n = 14$)		
	mean	SD	mean	SD	p value
Pain (VAS)	6.6	0.7	6.9	0.9	0.2
ROM (flexion)	84.4	4.2	82.2	5	0.2
ROM (extension)	−46	7	−44	4.1	0.3
DASH score	81.9	7	87	6	0.0

Table 2. Change in pain intensity (VAS), range of motion (ROM) and function (DASH score) between the two groups.

Group	N	Mean	SD	Mean change (confidence interval)	Z value/t value	(2 tailed test) p value
Pain-group 1	13	5.6	0.9	1.2 ± 0.2, 95%CI(0.6,1.8)	−3.2	0.0013*
Pain-group 2	14	4.3	0.4			
ROM (Flexion)-group 1	13	47.8	5.7	11.7 ± 2.8, 95%CI(5.9,17.4)	4.1	0.0003*
ROM (Flexion)-group 2	14	36.1	8.4			
ROM (Extension)-group 1	13	−40.2	5.3	8.5 ± 2.0, 95%CI(4.4,12.7)	4.2	0.0002*
ROM (Extension)-group 2	14	−31.6	5.1			
DASH-group 1	13	45.9	6.7	18.2 ± 2.2, 95%CI(13.5,22.8)	−4.2	<0.00001*
DASH-group 2	14	27.7	4.7			

*$\alpha = 0.05$. The result is significant at $p < 0.05$.

and found that the data was normally distributed. Also, the Levene's test of homogeneity was used for the outcomes. The authors have used the per protocol analysis for interpreting the data.

Results

Figure 1 depicts the study profile. Thirty-five subjects were screened for eligibility. Thirty subjects were randomly assigned to Groups 1 and 2. There were 2 drop outs in Group 1 and 1 drop out in Group 2 as they could not arrange for convenient appointments. These data were not included for analysis. The intention to treat analysis was not used. Instead, per protocol analysis was used.

Table 1 represents the baseline characteristics of the groups. The groups did not differ much at the baseline.

Table 2 represents within group comparisons. There was an improvement in all the outcomes post 3 weeks in both the groups. ($p < 0.05$)

It also shows change in the pain intensity on VAS between the groups. The groups showed statistical significance with $p < 0.05$. The mean change was 1.2 ± 0.2, 95%CI(0.6,1.8) between the groups. The MCID for VAS is a 10 mm change on the 100 mm scale, thereby, showing clinical significance.[27]

Table 2 shows the change in the flexion and extension ROM between the groups. The groups showed statistical significance with $p < 0.05$. Group 1 showed greater improvement than Group 2 in ROM, mean flexion change being 11.7 ± 2.8, 95%CI(5.9,17.4) and mean extension change being 8.5 ± 2.0, 95%CI(4.4,12.7) which maybe clinically significant.

Table 2 shows the change in the DASH score between the groups. A statistical significant difference was seen with $p < 0.05$. The mean change for DASH was 18.1 ± 2.2, 95%CI(13.5,22.8) between the groups. The MCID for DASH is a 10.2 point change, thereby, indicating clinical significance.[28]

Hence, Group 1 showed greater improvement than Group 2 in pain, elbow ROM and DASH scores.

Discussion

The present study was undertaken to study the effects of MET when applied immediately post 3 weeks of immobilization and after 1 week post removal of immobilization in elbow rehabilitation on parameters such as pain, elbow ROM and function in patients with post fracture elbow stiffness. MET was given to Group 2 after 1 week post removal of immobilization as per the protocol in the tertiary healthcare center.

MET has shown to be effective in various stages of rehabilitation. However, its application in immediate post fracture rehabilitation needed to be addressed.

In this study, during the intervention for both the groups, there were no adverse reactions i.e., increase in pain, discomfort, etc. reported on application of MET-immediate post removal of immobilization and 1 week later post removal of immobilization.

A prospective, double-blinded, randomized study was done to see the effect of isolytic contraction and passive manual stretching on pain and knee ROM post hip surgery by Parmar *et al.* MET was given as early as the 3rd post-operative day up till the 12th post-operative day along with other therapeutic exercises. The study concluded that MET was more effective in improving knee ROM in patients who had restricted knee ROM in the acute duration in post-operative hip fractures.[3] No adverse reactions were documented with application of MET in the immediate post-operative period in this study. Hence, it is safe to use MET in the early stages of fracture rehabilitation.

Effect of immobilization

In synovial joints due to deprivation of stress, there is alteration in their biomechanical, biochemical and morphological characteristics. The protean changes that saliently occur are fibrofatty proliferation of connective tissue in the joint space and its adherence to the cartilage surface, synovial fold adhesions, cartilage atrophy, cellular and fibrillar ligament disorganization, osteoclastic resorption of bone leading to weakening of the ligament insertion and Sharpey's fibers, etc.[29] The muscles surrounding the joint go into inhibition and are prone to develop tightness.

For the management of distal humerus fractures, open reduction and internal fixation are considered as the treatment of choice. Rigid internal fixation is required for allowing early ROM exercises.[6]

From this study, we infer that both the groups — Groups 1 and 2 showed improvement in the outcome variables.

Reduction in Pain

The pain intensity (VAS) reduced significantly, p value < 0.05 in both the groups pre and post 3 weeks as seen. The group in which MET was started immediately showed better improvement, p value $= 0.0013$ in the pain intensity (Table 2). The MCID for VAS is a 10 mm change on the 100 mm scale showing clinical significance. Hence, a mean difference of 1.26 observed between the groups and 5.61 and 4.35 in Groups 1 and 2 respectively is clinically significant.

The reduction in pain intensity in the groups is attributed to the hypoalgesic effects of MET which is explained by the inhibitory Golgi tendon reflex, activated during the isometric contraction that in turn leads to the reflex relaxation of the muscles. Also, the muscle and joint mechanoreceptors were activated leading to sympatho-excitation evoked by somatic afferents and localized activation of the periaqueductal gray matter. This plays a role in the descending modulation of pain.[3] On application of MET, there maybe a reduction in proinflammatory cytokines and it may also desensitize the peripheral nociceptors. Blood and lymphatic flow rates may also be affected due to rhythmic muscle contraction and there could be changes in the interstitial pressure and increase in the transcapillary blood flow.[13]

Also, the hypomobility associated with reflex muscle guarding due to pain reduced as pain reduces.

Tolerance to stretching increases as the individual's pain perception reduces on application of MET. When isometric contraction and stretching occur simultaneously, the muscle and joint proprioceptors and mechanoreceptors are stimulated more strongly than with stretching alone.[30] This could in turn possibly attenuate the sensation of pain and also make the consecutive stretch more tolerable.

Improvement in Range of Motion

This study concluded that there was an improvement in elbow ROM — both flexion and extension in both the groups.

There was a gain in the ROM for both the groups. However, Group 1 showed greater improvement than Group 2 in ROM, mean flexion change being 11.703 ± 2.80 and mean extension change being 8.587 ± 2.03 which maybe clinically significant. The p value was also < 0.05 showing statistical significance. (Table 2)

MET can be used to improve joint ROM and has an advantage over standard stretching techniques to gain early ROM in post surgically treated fracture cases.[14]

MET also showed better improvement in elbow ROM. This could be explained by the hypothesis suggested by Taylor *et al.* in their study done in 1997, suggested that a combination of contractions and stretches (as used in MET) might be more effective in producing viscoelastic changes than passive stretching alone, because the greater forces produce increased viscoelastic change and passive extensibility.[31,32] Applications of MET to increase myofascial tissue extensibility seem to affect the viscoelastic and plastic tissue property as well as the autonomic-mediated change in extracellular fluid dynamics and fibroblast mechanotransduction.[13]

Lendermanin (1997) proposed that passive stretching would elongate the parallel fibers but have little effect on the 'in series' fibers; however, the addition of an isometric contraction would place loading on these fibers to produce viscoelastic or plastic changes above and beyond that achieved by passive stretching alone.[33] Active muscle contraction has been shown to have neuro-physiological effects, including pain inhibition, thus allowing the muscles to be stretched further.[18,31]

Shyam and Parmar (2011) did various case studies in which MET was given in the rehabilitation of various types of fractures fixed with internal fixation around the elbow, wrist and knee. They had significant gain in the ROM for all the cases.[14]

Application of MET has also showed significant improvement in pain and functional status in patients with non-specific neck pain.[34]

Our results of ROM improvement are supported with a study done by Stephanie (2011) titled the immediate effects of MET on post shoulder tightness in which they concluded that a single application of MET provides significant improvement in shoulder adduction and internal rotation ROM.[35]

Active ROM, active-assisted ROM, passive ROM and stretching would have helped in improving the ROM. This is supported by MacDermid *et al.* (2015) in their study on rehabilitation post fractures around the elbow which concluded that active ROM exercises, active-assisted ROM exercises, passive ROM exercises and stretching have high consensus as components in the rehabilitation post elbow fractures.[12]

MET and active ROM exercises are one of the many treatment techniques which have been used for managing the stiff elbow.[36]

Phadke and Bedekar (2016) in their study on the effect of MET and static stretching on pain and functional disability in patients with mechanical neck pain concluded that MET was better than stretching technique in improving pain and functional disability in people with mechanical neck pain.[31]

Improvement in function

This study also states that there was an improvement in the upper extremity function in both the groups. However, there was a significant improvement in the function in Group 1 compared to Group 2 by the end of 3 weeks (Table 2). The MCID for DASH is a 10.2 change. Hence, a mean difference of 18.19 observed between the groups and 45.98 and 27.79 in group 1 and 2 respectively is clinically significant.

There was a significant reduction in pain in both the groups and improvement in elbow ROM that in turn could have improved the function of the upper extremity as a whole.

This could be supported by a study done by Sharma *et al.* in sacro-iliac joint dysfunction in which they state that MET was effective to reduce pain and reduce disability in such patients.[37]

A research done by Kucuksen *et al.* concluded MET was better than cortico-steroid injection to improve pain (VAS), pain-free grip strength and function (DASH scores) in patients with chronic lateral epicondylitis.[38]

MET has helped to reduce disability and improve function in various other conditions.[32,35]

This study suggests that MET can be used as an adjunct to the rehabilitation protocol to treat elbow stiffness and can be safely given in the early stages of post elbow fracture rehabilitation managed surgically with open reduction and rigid internal fixation.

In this study, long-term effect of the treatment intervention was not studied. Also, the authors could have used the intention to treat analysis for the lost data. Future studies can be directed to assess the long-term effect of the intervention on a larger sample size. The authors would suggest a longer duration of the intervention so as to maximize the treatment effect.

Conclusion

There was an improvement in pain, elbow ROM and function when MET was started immediately post removal of immobilization and when MET was started a week later post removal of immobilization. However, the group in which MET was started immediately showed better improvement than the group in which MET was started a week later post removal of immobilization in pain, elbow ROM and function in post-operative patients of fractures around the elbow. MET can be used as an adjunct to the rehabilitation protocol to treat elbow stiffness and can be safely given in the early stages of post elbow fracture rehabilitation managed surgically with open reduction and rigid internal fixation.

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Conflict of Interest

The authors declare that there is no conflict of interest relavant to the study.

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Author Contribution

Study design and project management was contributed by Anood Faqih, Nilima Bedekar, Ashok Shyam and Parag Sancheti.

Data collection and analysis, manuscript writing, revision of manuscript were carried out by Anood Faqih and Nilima Bedekar.

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