The effect of isolytic contraction and passive manual stretching on pain and knee range of motion after hip surgery: A prospective, double-blinded, randomized study

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Abstract
Stretching has its impact on both contractile and noncontractile tissues and is the most important rehabilitation technique utilised used to prevent and treat joint stiffness. Passive manual stretch (PMS) and muscle energy technique (MET) are two of the most commonly used techniques. Our study evaluates the effectiveness of isolytic form of MET in gaining knee range of motion (ROM) and decreasing pain in acute knee involvement and comparing it with standard PMS. We used the clinical scenario of knee joint mobilization in patients operated for hip fractures. Fifty-two subjects were alternatively randomized to two groups, isolytic contraction (ILC) group (n = 26) and PMS group (n = 26). In both the PMS and ILC groups, significant improvements in pain score (measured by the visual analog scale) and knee ROM were reported after the treatment period (p < 0.001). The ILC had significantly better improvement in pain score than the PMS group (p = 0.003). The improvement in knee ROM, however, demonstrated no significant between-group difference (p > 0.05). Thus, isolytic form of MET may be a viable method to decrease pain and improve knee ROM in patients who had undergone surgery after a hip fracture.

Introduction
Restriction of joint mobility is a common impairment observed in clinical physiotherapy practice. These may be because of positioning, muscle guarding, pain, and relative joint immobility. Joint restriction if not dealt with early
intervention may lead to certain pathological changes. The elastic connective tissue is gradually replaced by fibrous tissue; and with prolonged immobility, they may result in extensive infiltration of less elastic fibrous tissue leading to permanent restriction of mobility [1]. This may be one of the causes of permanent disability hampering a person's functional and performance skills.

Knee joint effusions are a known complication following hip fractures [2,3]. They are called sympathetic effusions and the cause is unknown. The joint assumes a loose packed position to accommodate the increased volume of fluid within the joint space [3]. This helps to decrease pain and give comfort, which however leads to relative adaptative shortening of the soft tissue components anterolaterally. Joint effusions also cause inhibition of quadriceps with weakness and atrophy of the muscles [4]. These events cause disturbance in normal functioning of the joint and might set up a chain of events that eventually affects not only every part of the joint but also its surrounding joints and soft tissues leading to stiffness [5,6]. The passive insufficiency of the quadriceps (rectus femoris) may lead to relative shortening of the muscle. As muscle length is known to affect the contractile properties of the muscle as a whole, alteration in the resting length of the muscle alters its functioning capacity, which may also contribute to joint stiffness. A detailed study of various anatomical structures contributing toward joint stiffness was done by Johns and Wright [7]. They stated that joint restriction is contributed by joint capsule (47%), surrounding muscles and intermuscular fasciae (41%), tendons (10%), and skin tissue (2%). In these cases, stretching caused by normal movements may cause severe pain, and mobility may not spontaneously return without a specific stretching treatment [1,8].

Stretching has its impact on both contractile and noncontractile tissues. According to Magnusson et al [9] interfascial and fascial release occur following stretching, which play an important role in regaining the muscle length and extensibility. One form of technique, which is commonly and effectively used to improve muscle flexibility, is passive manual stretching (PMS). In this technique, an external force is applied to move the involved body segment slightly beyond the point of tissue resistance and available range of motion (ROM). Both contractile and noncontractile tissues can be elongated by passive stretching [1]. However, passive stretching has some limitations. First, it does not consider the subjects own muscle effort to gain ROM and is purely dependent on the therapist. Second, as the muscle is stretched in absence of contraction, there is some length at which the muscle begins to resist that stretch. This pull is attributed to the elastic recoil of the passive structures within the muscles, that is, intervening connective tissues [10]. This may lead to increased amount of associated pain and discomfort. There is also a risk of overstretching and may cause tissue damage [8].

Muscle energy technique (MET) is another such approach, which along with targeting the soft tissue primarily makes a major contribution toward joint mobilization. This technique is used in clinical practice to restore mobility of a segment, retrain global movement patterns, reduce tissue edema, stretch fibrotic tissue, reduce muscle spasm, and retrain stabilizing function of the intersegmentally connected muscles [11]. One form of this technique is isolytic contraction (ILC) (isotonic eccentric contraction). Here, the subject's contraction is resisted and overcome by the operator thereby involving stretching and breaking down of fibrotic tissue present in the involved muscle [11]. This is postulated to promote orientation of collagen fibers along the lines of stress and direction of movement, limit infiltration of cross bridges between collagen fibers, and prevent excessive collagen formation preventing any muscle stiffness [8]. Also, active contraction of the agonist causes relaxation of the antagonist thereby facilitating joint mobility-reciprocal inhibition [8]. ILC is also known for their hypoalgesic effects especially in acute painful conditions [12]. These features of ILC may be useful in early mobilizing acutely involved joints.

Various studies have compared several methods of stretching [13-17]. However, despite extensive literature, there have been no reports of use of ILC in acute knee involvement. Also, there are no comparative studies comparing PMS and ILC methods in acute joint conditions. We designed this research to study the effectiveness of ILC in gaining ROM and decreasing pain in acute knee involvement and comparing it with standard PMS.

**Methods**

A prospective, randomized, double-blinded study was performed at our institute between 2006 and 2008. We only included subjects with proximal femur fractures treated with standard lateral approach with fixation using four-hole dynamic hip screw-plate system. We excluded subjects with pathological fractures, revision surgeries, associated ipsilateral injuries and subjects with neurological and vascular disorder or subjects treated with extended approach or fixation. We also excluded subjects with previous or concurrent knee pain. Eighty-four consecutive subjects of proximal hip fractures were screened and 52 were selected according to inclusion criteria. Randomization was done by alternatively allotting the subjects to the two groups; ILC group and PMS group (Fig. 1). There were 18 males and 8 females in the ILC group and 16 males and 10 females in the PMS group with average age of 64.35 (±18.40) in the ILC group and 58.19 (±19.18) in the PMS group. Primary mechanism of injury was slip and fall (43 subjects) and the remaining were vehicular accidents (9 subjects).

The permission to carry out the study was obtained from the ethical committee, Sancheti Institute for Orthopaedics and Rehabilitation. A prior written consent was taken from each subject. Double blinding was done with the assessment therapist and the patient both being blinded with respect to treatment protocol followed. All fractures were exposed by standard lateral approach and internal fixation was performed using four-hole dynamic hip plate screw system. A preintervention assessment was carried out by the assessment therapist on third day postoperatively. Outcome measures were pain [on visual analog scale (VAS), score out of 10 on a 100 mm horizontal line] and knee ROM (in degrees with universal 360° goniometer tested for validity and reliability) [18]. The
intervention common to both groups included ankle pumping exercises, static quadriceps exercises, static hamstring exercises, assisted to active heel drags, assisted to active straight leg raising exercises, assisted to active abduction exercises in supine position to the affected extremity, free active ROM exercises to the opposite unaffected extremity and both upper extremities, and unilateral bridging exercises. Frequency of treatment for both the groups was once a day for the morning session. Duration of entire treatment session for both the groups was 20–25 minutes daily starting from 3rd day postsurgery till 12th day postsurgery. The ILC group received the isolytic form of MET, whereas the PMS group received PMS, both by the same interventional therapist.

**Technique**

**Isolytic contraction**
With patient in side lying position, the hip was maintained in neutral with adequate stabilization of pelvis. The knee was then taken to a range where the first resistance barrier was reached. The subject was then instructed to use 20–25% of the knee extensor force to resist the therapist applied flexion force. The knee was then moved to a new range till a second resistance barrier was reached and held in that position for 15 seconds and then returned back to full extension. This technique was applied for 5–7 repetitions once in the day [11].

**Passive manual stretch**
The subject was made to go into side lying position after taking permission from the operating surgeon with adequate pillow support between both the legs and necessary precautions. The hip was maintained in neutral position with adequate stabilization of pelvis. The knee was then passively taken to the point slightly ahead of tissue resistance and held in that position for 15 seconds and then returned back to full extension. The technique was applied for 5–7 repetitions once in the day.

A postintervention assessment was done, on 12th day postsurgery, by the assessment therapist for pain assessment and knee ROM measurements. Final readings were noted in the assessment form; master chart was prepared and data were analyzed. We compared the two groups with respect to preintervention factors, such as VAS score; knee ROM; and knee ROM deficit and postintervention factors, such as VAS score, ROM, ROM deficit, improvement in ROM deficit, percentage ROM improvement, and VAS difference. ROM deficit was calculated by comparing the ROM of the affected knee with ROM of the normal knee. This gave an idea about absolute deficit in ROM and is a measure of extent of normalization of the knee range in a given individual. We also calculated the percentage improvement in

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**Figure 1** Consort flow diagram.
knee ROM as compared with the preintervention ROM. This gave an idea about improvement in range for a given limb.

Statistical analysis

Because our sample size was total 52 with 26 subjects in each arm, a comparatively low sample size, we plotted the normality plots, which showed that the data were not normally distributed. So, we used nonparametric tests to analyze our data. Within-group analysis was done by using Wilcoxon sign rank test, whereas between-group analysis was done by Mann Whitney U test. The significance level was set at 0.025 (two tailed) to reduce the probability of making a Type-I error because of multiple comparisons. SPSS version 12 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

A total of 52 subjects (18 women and 34 men) participated in the study. All subjects completed the study with no dropouts. We had no complications associated with either of the techniques during our study with no subjects showing worsening of pain or preintervention ROM.

The mean age in PMS (n = 26) group and ILC group (n = 26) were 58.19 ± 19.18 (range, 22–86) years and 64.35 ± 18.4 (range, 35–90) years, respectively and the difference was not statistically significant (p = 0.3). The PMS group had 16 (61.5%) men, whereas the ILC group had 19 (73.1%) men, and the difference in male to female ratio between the two groups did not reach statistical significance (p = 0.372). Comparison between the values of VAS, ROM, and ROM deficit is presented in Table 1. At baseline, there was no significant difference in VAS between the two groups. However, ROM deficit was significantly more severe in the PMS group (p < 0.001).

In the PMS group, there was a significant improvement in VAS, knee ROM, and knee ROM deficit after the treatment period (p < 0.001) (Table 1). On the other hand, the ILC group also demonstrated significant improvement in all of these outcomes (p < 0.001).

The next line of analysis involved the change scores of each of the outcomes measured (Table 2). The results showed that the ILC group demonstrated significantly more improvement in VAS score than the PMS group (p = 0.003) (Table 2). The percentage improvement in the ROM (p = 0.107) and ROM deficit (p = 0.880) was not significantly different between the two groups.

Discussion

Among the various soft tissue mobilization techniques, MET and PMS are two major methods. There have been no studies to compare these two methods in acute stages of joint involvement. The present study was undertaken to evaluate effectiveness of ILC versus PMS to gain knee ROM in acute phase after hip surgery. Knee stiffness posthip surgery is mostly because of extra- and periarticular soft tissue involvement. During internal fixation of hip fracture, prolonged traction with
internal rotation is often applied to the limb, thereby, subjecting the knee to prolonged abnormal stresses. Furthermore, the transmission of vibratory and impact stresses to the knee during implant fixation at the hip is inevitable during the surgical procedure. These indirect stresses at the knee joint during the surgical procedure also contribute to the development of postoperative effusion at the knee joint [3]. Because there is no primary articular lesion in the knee joint, we consider this as an ideal scenario to compare between both our soft tissue mobilization techniques.

Mobilization in acute stage may be limited by pain. During stretching, intramuscular pressure increases compression in the blood vessels and decreasing circulation. Increased activity of the sympathetic system causes constriction of the small arterioles and thus also decreases circulation. Rise in muscle tension may also affect metabolism, which along with mechanical friction and decreased circulation can activate pain receptors located in the muscle tissue [8]. This irritation of nerve endings in muscles and also in connective tissues, such as skin and joint ligaments, can stimulate a reflex response leading to muscle contraction. Stretch of this contracted muscle and soft tissues may lead to increase in pain perception as seen during passive muscle stretching in acute settings. Our study shows significant improvement in the pain VAS score for both the groups. However, the ILC group had significantly more improvement in pain VAS when compared with PMS (p = 0.003). This may be because of hypoalgesic effects of MET [11]. This can be explained by the inhibitory Golgi tendon reflex, activated during the isometric contraction that leads to reflex relaxation of the muscle, as a result of postisometric relaxation. An alternative reflex effect has been suggested in which an isometric contraction of the antagonist(s) of affected muscle(s) induce relaxation via reciprocal inhibition. Neurological explanation for the analgesic effects of MET has been detailed in literature [19–22]. A sequence is suggested in which activation of muscle mechanoreceptors and joint mechanoreceptors occur, during an isometric contraction. This leads to sympathoexcititation evoked by somatic efferents and localized activation of the periaqueductal gray that plays a role in descending modulation of pain. Nociceptive inhibition then occurs at the dorsal horn of the spinal cord, as simultaneous gating takes place of nociceptive impulses in the dorsal horn because of mechanoreceptor stimulation.

Disease, injury, and surgery will cause changes in the tissue mobility [8]. The formation and breakdown of collagen is continuous in the tissues. PMS causes repair fibers to form in the same direction as the original fibers and the overproduction of the fibrous connective tissue with fibers running in all directions is prevented. It is important that the connective tissue in muscles should form in the same direction as contractile muscle fibers to improve force [8]. Proposed mechanisms by which PMS facilitates this laying down of collagen and regain of muscle length are (1) a direct decrease in muscle stiffness via passive viscoelastic changes or (2) an indirect decrease because of reflex inhibition and consequent viscoelasticity changes from decreased actin-myosin cross bridging [23]. This would then allow for increased joint ROM.

In our study, the preintervention ROM was not significantly different in the two groups and the range improved significantly by use of both the techniques implying effectiveness of both the techniques. However, ILC tended to have better postintervention ROM when compared with PMS (p = 0.037). This can be explained by following hypotheses. The active muscle contraction in ILC before stretching activates muscle spindle receptors, which decreases their sensitivity, reducing muscle tension and resistance to stretch facilitating movement [8]. According to the theory of neuromuscular relaxation, this reduced muscle tension also in turn inhibits the motor neuron activity (autogenic inhibition) leading to further decrease in active muscle tension before muscle contraction. Thus, the muscle-tendon system can be stretched further facilitating movement. Active muscle contraction has been shown to have neurophysiological effects, including pain inhibition, thus allowing the muscles to be stretched further [8]. However, it should be noted that the baseline ROM tended to be better in the ILC group, although the between-group difference did not reach was statistical significance (p = 0.060). In fact, the change score in knee ROM and knee ROM deficit failed to show any significant difference (p > 0.05). Thus, a larger sample study will be needed to fully establish whether the ILC is superior to PMS in improving knee ROM.

Our study had few limitations. Sample size was small. The study did not measure muscle strength changes but the acute setting of our study would have confounded this finding because of pain and limitation of postoperative mobilization. The study did not consider the long-term effects of stretching at end of 4 weeks and 6 weeks post-surgery to evaluate the carry over effects of stretching.

In conclusion, the ILC technique and the PMS technique of stretching are effective in improving knee ROM in subjects with ROM restriction in the acute phase after a hip surgery with a lateral approach. The ILC technique was

### Table 2  Comparison of change scores between the two treatment groups

| Comparison of scores | PMS          | ILC          | p            |
|----------------------|--------------|--------------|--------------|
| VAS change           | 3.54 ± 0.85  | 4.35 ± 0.79  | 0.003*       |
| ROM % change         | 332 ± 118    | 287 ± 121    | 0.107        |
| ROM deficit change   | 90 ± 10.48   | 91.92 ± 8.49 | 0.880        |

Data are presented as mean ± SD (range).

*p < 0.025 (between-group comparison, Mann Whitney U test).

ILC = Isolytic contraction; PMS = passive manual stretch; ROM = range of motion; SD = standard deviation; VAS = visual analog scale.
more effective in reducing pain; and although a trend toward better ROM was seen with this group, a larger sample study will be required to establish the clinical efficacy of this treatment technique.

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