Effectiveness Of Mirror Therapy In Adjunct To Conventional Physiotherapy On Pain, Instability, Joint Mobility And Proprioception In Patients With Post Anterior Cruciate Ligament Reconstruction Surgery: A Randomized Controlled Trial

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Abstract.

Introduction: Anterior cruciate ligament (ACL) is the most commonly injured ligament at knee. Anterior cruciate ligament reconstruction rehabilitation always commences during the acute in-patient period. Mirror therapy is relatively a new approach during maximum protection phase of ACL reconstruction rehabilitation for pain reduction, improving joint mobility and proprioception. Previous studies have shown its positive effects on pain and joint mobility in patients with adhesive capsulitis and orthopaedic hand. In view of assessing the short-term effects of mirror therapy in adjunct to conventional physiotherapy protocol on pain, instability, joint mobility and proprioception in patients with post ACL surgery, the present study was carried out.

Aim: To find out the effectiveness of mirror therapy in adjunct to conventional physiotherapy on pain, instability, joint mobility and proprioception in patients with post ACL reconstruction surgery in early stage of rehabilitation.

Method: This randomized, controlled, single blind study included 30 patients with post ACL reconstruction surgery. Participants were equally divided into two groups of interventions. First group received conventional physiotherapy along with Mirror therapy exercises once in a day for total 6 sessions. Other group received only conventional therapy. Effectiveness was assessed using the change in outcome measures – pain (VAS), knee range of motion, joint proprioception and joint instability (Lysholm knee score)

Results: Statistical comparison of within group and in between group analysis revealed significant differences ($p<0.001$) in all the outcomes except Joint proprioception confirmed using paired and unpaired t test.

Conclusion: Mirror therapy as adjunct to conventional therapy was effective in reducing pain, improving joint mobility and improving the instability in patients with post anterior cruciate ligament reconstruction surgery compared to conventional Therapy alone.

Keywords: Mirror Therapy, Anterior Cruciate Ligament Reconstruction, Lysholm Knee Score, proprioception.

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Introduction:

Anterior cruciate ligament (ACL) is the most commonly injured ligament in knee which accounts for approximately 50% of all ligamentous injuries in sports which results in significant functional impairment [1]. ACL injury may result in knee instability, which can commonly produce further progressive changes such as decreased postural balance and subsequently diminished daily motor activities [1,2]. Therefore, a surgical reconstruction is advocated as the treatment of choice.

It has been seen that lack of full recovery of knee function after ACL reconstruction is a result of deficits in behaviour of sensory and motor [1]. Anterior cruciate ligament reconstruction rehabilitation typically commences during the acute in-patient period. Early objectives include restoration of knee range of motion, reduction of swelling, pain management, early ambulation and improving muscle strength [3,4]. Quadriceps exercises are advocated during the acute postoperative period, in terms of muscle strengthening or atrophy prevention and tissue-healing physiology.[5] A variety of modalities have been used during acute period including cryotherapy, gait education, range of motion exercises, continuous passive motion machines, strengthening exercises, electrical stimulation and bracing [4,5]. There have been many approaches used earlier to fasten the healing process and to improve the rehabilitation and proprioception after ACL surgery. During the postoperative rehabilitation of patients after ACL reconstruction proprioceptive re-education exercises have shown to be one of the constituent elements of the rehabilitation protocol and also the proprioceptive training is conducted in all phases of rehabilitation in postoperative patients [6].One of the alternate approaches could be the Mirror therapy as an adjunct to conventional physiotherapy which might have additional positive effects on various functional outcomes along joint proprioception after ACLR surgery.

Mirror therapy is a technique that involves placing the affected limb behind the mirror (out of sight) while placing the non-affected limb in front of the mirror to generate a reflection that the patient can see, basically, it is primarily based on the activation of the mirror neuron system[7]. Previous studies demonstrated the benefit of mirror therapy in reducing musculoskeletal related pain and also improving the joint mobility in patients with orthopaedic hand, adhesive capsulitis and post-operative immobilization stiffness of distal end radial fractures. [8, 9, 10]. In the present study, we are expecting a positive effects of mirror therapy on joint proprioception as well. This hypothesis could be justified by corrective sensory feedback provided by mirror therapy to restore congruence between motor output and sensory input.[11] In this setup, movement of the non-affected limb create the illusion of normal movement of affected limb [12].

To our knowledge there have been scarce of evidence on effectiveness of mirror therapy as adjunct to conventional physiotherapy in post ACL surgery patients. Therefore, the aim of this study is to check short term effects of mirror therapy in adjunct to conventional physiotherapy protocol on pain, instability, joint mobility and proprioception in patients with post ACL surgery.

Material And Methodology:

The present randomized controlled trial was carried out in the department of musculoskeletal in- patient department, at MGM Institute of Physiotherapy, Aurangabad, and Maharashtra, India between July 2021 to July 2022 and also registered in National Clinical Trial Registry of India. Study was approved by the Institutional Ethics Committee (IEC) of MGM Institute of Physiotherapy (MGM/IOP/IEC/PG/2021/10). The written informed consent was obtained prior to the recruitment of subjects.

Inclusion criteria: Participants of both genders between age group of 18-40 years, Operated patients of ACL reconstruction surgery using hamstrings graft, Post operated pain on VAS should be between 3-6, Day 2 post -operative active ROM of knee flexion minimum 30 degrees (supine lying)

Exclusion criteria: H/O patients with any previous major trauma/ surgery to knee in past 6 months, H/O patients with cardiovascular, neurological and mental disorders and systemic illness excluded, H/O presence of knee deformities because of any past trauma, H/O patellar instability.

Sample size calculation: Minimum necessary sample size of 15 patients in each group was determined using G Power. The alpha error used to determine the sample size was 0.05, the ideal power was considered to be 80%.

Subjects and study design:

Thirty patients were randomized equally into control (Convention PT) and experimental group (Mirror therapy + Convention PT) using chit method with concealed allocation. Demographic data like age, BMI, gender, side affected were taken. Routine assessment of knee joint including pain and mobility and joint proprioception was assessed as per data collection sheet. The qualified therapist/ researcher delivered the therapy and also assessed all the outcome measures. All the outcome measures were taken pre-intervention (baseline) on the 2nd day post operated ACL reconstruction surgery and post-intervention on 6th day.

Pain was evaluated through Visual analog scale, Knee (ROM) was assessed through universal goniometer, proprioception (joint position error) was measured by active reproduction test Lysholm knee scores a self-administered questionnaire was completed by the patients for evaluation of instability. Patients were blinded in the study for the therapy which they are receiving in control and experimental group.

Intervention procedure:

Total 6 sessions of intervention and conventional physiotherapy was administered to the patients in both the group.

Following instructions were given before performing mirror therapy:

1) Patient was in comfortable while performing the exercises
2) A self- made mirror was placed in between the legs (parallel to both the legs)
3) Affected leg was placed behind the mirror (non- reflecting side) and non- affected leg was placed in front of the mirror (reflecting side)
4) Both the legs were placed at same distance from the mirror.
5) Patients were instructed to observe the reflected leg into the mirror while performing the exercises and then attempt the same exercises with the involved leg.
6) Therapist should make sure that the patient should simultaneously move both the legs with each repetition.

Day wise protocol	**Conventional Therapy**	**Mirror Therapy**
Day 1 **Minimum of 30 degrees should be achieved**	• Icing for 10 mins followed by ATMs 10 reps • Static Quadriceps and Hamstrings 10 reps 1set bilaterally • Passive Knee Flexion and extension 10 reps 1 set	• Quadriceps and hamstrings co- contraction 10 reps 1 set • Active heel slides10 reps 1 set
Day 2	• Same as above exercises would be given	• Same as above exercises would be given
Day 3 **Followed by above exercises** **Minimum of 60 degrees should be achieved**	• Active assisted SLR with brace in sagittal and frontal plane bilaterally 10 reps and 1 set each • Progress to Active knee flexion bilaterally 10 reps 1 set	• Isometrics for hamstrings using wobble board bilaterally 10 reps 1 set
Day 4 **Followed by above exercises**	• Knee flexion in high sitting position passively 10 reps 1 set	• Active knee extension on VMO board 10 reps 2 sets bilaterally
Day 5 **Followed by above exercises** **90 degrees should be achieved**	• Dynamic Quadriceps 10 reps 2 sets • Positioning for capsular stretch 2 mins • Partial weight bearing in the ward with assistive device	• Ball press VMO exercise 10 reps 1 set
Day 6 **Atleast 90-100 degrees should be achieved**	• All above exercises	• All above exercises

Statistical Analysis:

For all the data sets, Kolmogorov- Smirnov test of normality was used to confirm the distribution of values was normal (p> 0.05). A chi- squared test was used for comparison of gender, side operated between groups. Mean and Standard deviation was calculated for all the outcome measures at baseline and after intervention. For within group analysis paired t test was used for both control and intervention group. For between group analysis unpaired t test was used. Data Analysis was carried out using SPSS 20.

Results:

Table No 1: Baseline Characteristics

VARIABLES	CONTROL GROUP (Mean ± SD)	INTERVENTION GROUP (Mean ± SD)	p VALUE
AGE(y)	32.4 ± 5.66	33.13±6.988	>1.000
BMI (kg/m2)	25.41 ±3.221	25.02±3.073	>1.000
GENDER(M/F)	M= 9;F = 6	M=10; F =5	0.7048
SIDE AFFECTED	L= 7; R= 8	L=9;R=6	0.4642

No between group differences regarding the baseline characteristics were seen(p>0.05)..

Table No 2: Pre-Post test values of Intervention and Control Group

Outcome Measure	INTERVENTION GROUP			CONTROL GROUP		
	Baseline	Post-Treatment at 6th day	p-value	Baseline	Post-Treatment at 6th day	p-value
PAIN (VAS)	5.8 ± 0.414	2.26 ±0.45	**<0.0001***	5.73±0.45	3.2 ±0.94	**<0.0001***
AROM KNEE FLEXION (in degrees)	38.3 ±9.56	88.06 ± 4.94	**<0.0001***	26.66±7.47	71.26 ±8.68	**<0.0001***
PROM KNEE FLEXION (in degrees)	52.73±12.02	101.8 ±7.071	**<0.0001***	40.26 ±8.77	84.6 ±12.99	**<0.0001***
PROPRIOCEPTION (Joint position error)	5.071 ± 3.47	4.93 ±2.93	0.8881	5.45 ±3.19	7.6 ±4.15	0.0694
LYSHOLM KNEE SCORE	54.66 ±17.7	77.53 ±11.62	**<0.0001***	54.4 ±13.4	69.93 ±7.72	**<0.0001***

VAS=Visual analog scale; AROM=Active Range of Motion; PROM= Passive range of motion; ART= Active reproduction test. Change values are expressed for mean (SD),Bold values indicate statistical significance p < 0.05 Within group Comparison of Control group and Intervention group at Pre-test(baseline) and Post-test (at 6th day) was found to be statistically significant (p<0.05) in all outcome measures except in proprioception.

Table No 3: Between group Comparison of Control and Experimental Group Post Intervention

	POST TEST		
Outcome Measure	**Control Group (Mean ± SD)**	**Intervention group (Mean ± SD)**	**p- value**
VAS	3.2 ±0.94	2.26 ±0.45	**0.0018**
AROM Knee Flexion (in degrees)	71.26±8.68	88.06 ± 4.94	**0.0004**
Passive Knee Flexion (in degrees)	84.6±12.99	101.8 ±7.071	**0.0011**
Proprioception (ART-Joint position error in degrees)	7.6±4.15	4.93±2.93	**0.0520**
Lysholm Knee Score	69.93±7.72	77.53 ±11.62	**0.0440**

Between group comparison of both the control and experimental group post intervention difference was found to be statistically significant (p<0.05).

Table No 4: Percentage Improvement of Outcome Measures in Both groups compared to pre-intervention

Outcome Measures	**Control group (%)(Mean±SD)**	**Intervention (%) (Mean±SD)**
VAS	45.77±14.61	62.21±7.625
LYSHOLM KNEE SCORE	15.53±7.308	22.86±8.6091

Table No 5: Mean change of Outcome Measures in both groups compared to pre- intervention

Outcome Measures	**Control group (%) (Mean ± SD)**	**Intervention (%) (Mean ± SD)**
AROM(in degrees)	44.6±11.70	49.53 ±13.41
PROM(in degrees)	44.33 ±14.90	49.06 ±13.20
PROPRIOCEPTION (Mean Change) (ART-Joint position error in degrees)	3.733±3.239	2.133±2.850

Discussion:

Mirror Therapy (MT) is a relatively new approach for pain management and increasing the joint mobility in musculoskeletal related conditions. The purpose of this study was to know the effectiveness of mirror therapy in adjunct to conventional physiotherapy on pain, knee joint mobility, instability and proprioception in patients with post Anterior Cruciate Ligament reconstruction surgery in short term.

Our study findings have shown significant improvement in reducing pain (62%), increasing joint mobility (AROM, PROM) (mean change of 49.53and 49.06 respectively) and improving the instability (22%) post-treatment compared to pre-treatment, except for proprioception (joint position error)within the group. Few studies conducted in patients with orthopaedic hand injuries and adhesive capsulitis patients also confirmed the effectiveness of MT along with conventional PT on pain and joint mobility.[8,9] In our study, using MT the joint position error was found to be 5 and according to previous study 5 or more than 5 degrees (joint position error) has been found to be affected [17]. Therefore, in our study we did find marginal improvement in proprioception using MT but it was not very significant, moreover, only 6 sessions were administered in the acute stage, in which the pain intensity was more and also fear of movement was commonly seen in patients with immediate post ACL-R.

Knee instability was found to be improved using mirror therapy in addition to conventional therapy post-treatment as compared to pre-treatment and this result is supported by Alicja Molka et al. in which they found improved instability at the end of 4- week program in post ACL-R patients.[18] Similarly, we have also witnessed significant reduction in pain (45%), improved knee joint mobility (AROM, PROM) (mean change 44.6 and 44.3 respectively), improved instability (15%) seen in post-treatment compared with the pre-treatment probably attributable to accurate management of conventional therapy in this study except for joint proprioception.

Further on comparison between groups - MT in addition to conventional therapy was found to be more beneficial than conventional therapy alone. Pain was found to be reduced significantly using MT along with conventional therapy (62%) compared to conventional therapy alone (45%). Minimal Detectable change value for VAS score is considered to be 0.08 for suggesting clinical important improvement in pain intensity [19] however, in the present study, the mean change in VAS score after intervention was found to be 0.9. This change found is seen to be relevant in clinical practice. Our finding is supported by a study done by Burcu Dilek et al. in which graded motor imagery was found to be more beneficial as compared to traditional rehabilitation in reducing pain[10]. The possible mechanism of pain relief with MT results from manipulation of sensory and motor integration within the central nervous system. Motor signals associated with intended movement are sent not only to muscles but also to higher centres within the central nervous system, as an efference copy, to compare the results of the motor output with sensory data resulting from actual movement. It has been suggested that some painful conditions can be mediated, in part, by incongruence of sensory and motor information.[11]

We also found significant improvement in joint mobility (AROM, PROM) between the two groups respectively. Our study is supported by the studies in which MT was found to be beneficial as compared to traditional rehabilitation in patients with adhesive capsulitis, orthopaedic hand and DRFx and it was found that there was improved AROM [8,9,10]. Immobilization of short or long period can affect the somatosensory representations and functional organization of the brain. People with ACL-R surgery, because of acute nature and reoccurring impairment, learn to guard their affected limb and voluntarily keep them in immobilization. Fear and anxiety can restrict movement. A probable reason for improvement of joint mobility in our study could be decreasing fear and anxiety using the affected limb when patient watches the movement during exercise [9.10]. In our study, we did not find any significant difference using MT in addition to conventional therapy on joint proprioception (joint position error) compared to the conventional therapy. But, previous researchers had analysed the proprioception (joint position error) using the active angle reproduction test and they found that (≤5º) was graded as good, (≥5º) was graded as poor.[17] Similar to previous study findings, we did not find any improvement in proprioception and this could be due to fewer sessions which were administered in our study (6 sessions). In our study, knee joint proprioception (joint position error) was found to be 5 degrees which indicates that the joint proprioception is been affected but marginally improved when compared to the conventional therapy. The reason for this marginal improvement could be visual feedback from the mirror helps to learn accurate movements by correcting observed errors during exercise.[20] Knee joint instability was found to be improved using mirror therapy in addition to conventional therapy as compared to conventional therapy in short-term. Minimal Detectable change value for LKS is considered to be 8.9 for suggesting clinical important improvement in instability [21] however, in the present study, the mean change in LKS after intervention was found to be 7.6. It has found to be improved, but has less clinical relevance. Therefore, there has been significant improvement using MT in addition to conventional therapy on reducing pain, improving joint mobility and instability as compared to conventional therapy alone in patients with post ACL-R.

Limitations Of The Study:

1) Risk of Bias:

- Assessor who evaluated the outcome measures was not blinded and also the therapist who administered the therapy was not blinded.
- Small sample size was used

2) Only 6 sessions were administered to the patients.

3) Additional benefit of Mirror Therapy on joint proprioception was not observed in the present study may be because of inaccurate measurements of joint position error due to manual error or may be significantly affected by presence of pain at rest at baseline and during movement on day 6 which is not considered in this study.

Future Scope Of Study:

More randomized controlled trials with large sample size with long term follow up should be conducted for better understanding and clinical recommendations

Conclusion:

Our study findings have suggested that short term effects of mirror therapy as adjunct to conventional therapy have found to be effective in reducing pain, improving joint mobility and improving the instability in patients with post anterior cruciate ligament reconstruction surgery compared to conventional Therapy alone.

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Declaration of interest

None to report

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