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The Effectiveness of Mirror Therapy in Stroke Rehabilitation: Current Perspective Review

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Abstract

As compared to the other stroke-related therapies Mirror therapy (MT) in the stroke rehabilitation can be used in all type of stroke survivors (severe and non-severe) visual stimulus is being used for initiating a desirable motor response in limbs of the stroke patient. Literature shows that MT has considerable measurable effects on the motor impairments, visuospatial neglect, sensory impairment and pain/discomfort. This paper is a review of the current perspective and understanding on the MT in the rehabilitation of the stroke survivors. An electronic data base search across the Pub Med, Google Scholar, and Science direct, Cochrane etc. generated 3871 result. Based on the inclusion criteria's set for the study, 35 studies were included in this review after the systematic filtration of the papers. The collected data were divided on the basis of the it's (MT) application in the stroke rehabilitation, its intervention's mode, dosage, type of control and outcome assessment. We found that majority of the selected studies were intervened for motor impairment mostly in the stroke survivors within the upper limb. Studies were categorized in to groups based on the intervention between chronic and acute phase stroke with the therapy duration 1 - 8 weeks. Across all the selected studies MT showed significant motor improvement than the sensory improvement in the stroke survivors. The effectiveness and feasibility of MT has been reported (both for the patients and staff) and commonly used therapeutic approach in the rehabilitation of the post-stroke survivors in all stroke's stages. However, ADLs based longer term effectiveness of MT and on overall health needs to be further investigated and documented.

Keywords: *Mirror Therapy; Stroke Rehabilitation; Motor Impairment; Sensory Impairment; Pain; Unilateral Neglect; Hemi-Neglect*

Introduction

Stroke is the 3rd cause of death globally; from 1990 - 2007 age standardized year of life lost (YLL) increased by 12.9% (10.6 - 15.2) and from 2007 - 2017 by 12.1%, while the stroke incidence increased 5.29 Million (5.22 - 5.40) to 6.17 Million (6.4 - 6.33) from 2007 - 2017 [1], thus, it increased disability adjusted life years (DALYs) due to multifaceted morbidity and effects of longevity from 3.54 to 9.66% in the

period 1990 - 2013 as reported GBD statistic (Global burden of the Diseases) [2]. Countries with high income (HIC) recorded a forty-two % (42%) decline in CVA patients while on the other hand low and middle income countries (LMIC) showed 100% increased in the last 3 - 4 decades [3]. The statistics records that there are around 62 millions stroke survivors globally while 1/3rd among them are living with severe disabilities. It has been estimated that more than 80% DALYs occurs in LMIC [2].

In stroke rehabilitation (acute phase), 60 - 80% of the stroke survivors presented and recorded clinically with the motor impairment in the upper and lower limb [1]. It has been recorded that only twenty % of the severely of stroke patients with severe motor impairments in limbs recover complete UL functions (upper limb) as compared to eighty percent of mild -impairments stroke patients [7]. 50% of the stroke survivors with the pelagic upper and lower limbs re-gained partial motor functions. In the 50% of stroke survivors experienced neither CRPS-type-1 (complex-regional pain syndrome-type-1) nor pain around the shoulder in the post-stroke 1st year, this affected their ADLs immensely 11 - 14. Forty percent (40%) with the right hemiplegic acute stroke patients and 20% of the stroke patients presented with hemi-neglect which subsequently reduced to fifteen percent (15%) to five percent (5%) respectively in the third month of rehabilitation. Visual spatial neglect has been shown to be vital predictor in the stroke rehabilitation [8] and it's also a predictor of with reduced quality of life for stroke survivors [9]. Severity of stroke is the leading determinant of post-stroke recovery [10].

Rehabilitation interventions need to be ADLs-task-specific, highly intense and repetitive in order to produce desirable recovery [11]. Rehabilitation with Augmented exercise is very effective if started in the 16Hrs-6months period of post-stroke [13]. As compared to the other therapeutic approaches MT can be utilized even for the severe stroke patients as MT is a physiotherapeutic intervention which is based on visual stimulus as opposed to the physiotherapeutic interventions which are based on somatosensory stimuli for producing the desired motor response in stroke patients with motor impairments. MT is a type of physiotherapeutic intervention where the visual input of a moving limb (non-affected) gives perceptions/illusion of movement in the involved limb by placing a mirror between inter-lower limbs or inter-upper limbs. MT showed significant motor improvement than the sensory improvement in the stroke survivors. The effectiveness and feasibility of MT has been reported (both for the patients and staff) and commonly used therapeutic approach in the rehabilitation of the post-stroke survivors in all stroke's stages [14]. However, ADLs based longer term effectiveness of MT and on overall health needs to be further investigated and documented. This study is a review of the MT current perspective with respect to its application for stroke patients, its dosage, feasibility, acceptability and functionally effectiveness.

Methods

The inclusion criteria used for this study were; 1) Studies conducted on stroke patients in all phases, acute (> 3 weeks), sub-acute (3 - 6 weeks) and chronic (< 6 weeks) 2) MT-Studies conducted on stroke patients with motor, sensory and perceptual impairments 3) Only randomized controlled trials were included on the subjects 4) Papers published in the period January 2010 - 2019 December and the exclusion criteria were; 1) RCTs Studies carried out in the given duration written in the language other than the English language 2) Synergistic studies; studies that combined MT with other rehabilitation approaches 3) MT- Studies carried out on stroke patients targeting the mirror-Neuron system.

We conducted this review based on the PRIMSA protocol. On line search based on the specified data based was carried. The database Pub Med, Google Scholar, and Science direct, Cochrane etc. were used. The search strategy utilized included keywords with different Boolean MeSH words: such as: a) Mirror therapy AND stroke rehabilitation b) Mirror therapy AND rehabilitation etc. Figure 1 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) based flow chart is given below [15]. The selected MT-papers were reviewed by 3 competent and independent reviewers based on the study's purpose. RCTs-MT studies were selected based on the inclusion criteria were included for the review. Full articles were then downloaded. In case of the disagreement between the two reviewers, the final decision that withers study should be included or not was made by the third reviewer as per rule set before conducting

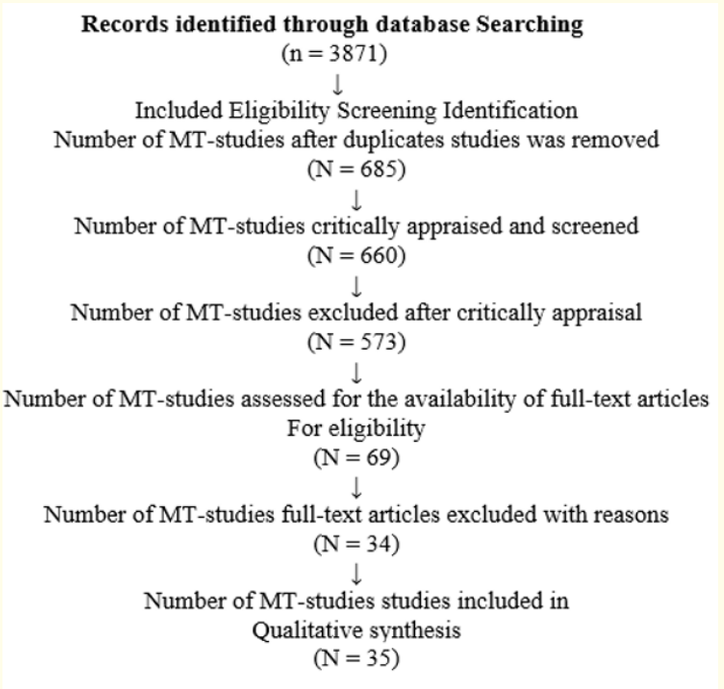

Figure 1: *PRISMA flow chart. --> (a) Identification --> b) Screening --> c) Eligibility --> d) Included in the review*

the electronic search. The data were extracted from the selected studies; data were extracted for information on title, criteria for inclusion and exclusion, study methodology, sample size, type of interventions, secondary and primary outcome, feasibility, study limitation and the study's adherence to the study protocol. The collected data were divided on the basis of the it's (MT) application in the stroke rehabilitation, its intervention's mode, dosage, type of control and outcome assessment. For the bias-free conduction of the review the COCHRANE bias tool for risk assessment was used. and each selected study was critically appraised using the PEDro scale [16].

Results

Applications in motor-Upper limb rehabilitation

Out of 35 MT-stroke researches included in 28 studies (80% of researches were about the effectiveness of mirror therapy on motor impairments of UL while the remaining 20% (7 researches) were about motor and sensory impairments [17] while 9 researches were about ADLSs and QOL. We noticed reduction in the motor impairments and improvement in motor functions recorded by the FMA in almost all researches except seven (7) researches. Upper limb functional improvement was reported in the form of improved dexterity, co-ordination between gross and fine motor of both upper and lower extremities, UL- improved grip force, decreased reaction/movement time or UL-proximal functional control in ten (10) studies [18,23]. Two other studies carried out in the same line reported no significant difference with mirror therapy in ADLs, sensory and motor components [1,24]. Four (4) Researches studied MT effectiveness on the stroke's spasticity, 3 out of which reported no considerable functional improvement recorded on the MAS scale [17,28] while One study reported improved score on the modified Ashworth scale [1] as combination therapy (MT) along with the conventional rehabilitation for the duration of 6 weeks, while on the other hand sensory and tactile impairments were studied in six (6) researches in which four (4) reported improvement to either painful, kinesthetic or tactile or thermal stimuli. 12 of the researches studies [23] used MT in chronic stage patients for the UL motor impairments while the used in other-than chronic stage (acute or sub-acute phases). Time of intervention/ Duration ranges 3 - 8 weeks with the MT sessions lasting 20 minutes - 45 minutes while 4 out of these studies provided no additional rehabilitation therapies [27].

Applications in motor-upper limb rehabilitation/balance/gait

Six (6) research studies among the selected showed the effectiveness of mirror therapy on the LE- motor impairments or improvement in its functions in term of gait -variables which includes a) co-ordination b) strength c) improved walking speed d) single limb stance,

e) step length f) stride length g) balance (static and dynamic balance) h) decreased sway (medio-lateral and anterior-posterior) on the Brunnstorm stages [22]. Two researches studies reported significant reduction in LE- impairments. Secondary improvement such as: reach in standing (forward reach) and co-ordination were reported but no considerable improvement in other gait variables such as a) cadence b) stance phase velocity c) swing phase velocity were observed.

Unilateral neglect

Another research study intervened MT in stroke-sub-acute phase for pusher-syndrome, these patients showed considerable functional improvement and reduction of the symptoms pusher-syndrome on the FMA [28]. Another study intervened in the chronic phase recorded the pain reduction (shoulder pain) and improvement in the upper extremity functions as result. A study carried out by Michielsen., *et al.* [21] has reported improvement in the affected motor-cortex activation as an outcome measure with the six week of the mirror therapy training which included both indoor and out-door therapy sessions.

Two other studies carried out by Pandian., *et al*. and Thiem., *et al*. [14,31] have reported functional recovery with the use of MT in the acute/sub-acute stages of stroke patients with visuospatial neglect for the 4 and 5 weeks respectively. These patients were improved in the extra-personal space neglect and representational neglect. Thiem., *et al*. studied only visuospatial neglect in the stroke patients with small sample size and furthermore the recruited stroke patients were not blindly assessed, however Pandian., *et al.* reported improved mean score for cognitive functions such as a) star cancellation b) line bisection c) picture-identification tests after 6 months MT session as follow up. The same papers have also reported meta-analysis based on 2 researches with the conclusion that MT was effective in treating unilateral neglect in patients with stroke.

Activities of daily living (ADLs) and quality of life (QoL)

Eight of the 22 studies (20,37) have reported the effectiveness of MT on ADLs and QOL via the Euro-QoL-5 Domain (EQ5D) scale among stroke patients [27] while three other papers have reported no considerable improvement in the ADLs and QOL domain. All other selected studies showed improved in ADL/QOL on the FIM scale mainly or the Barthel index and Repty's functional index. However, it is important to note that all these studies haven't reported the long term effectiveness of MT among stroke patients.

Sensory

There are very few studies which has been carried out treating and recording sensory impairments in the stroke patients, however 6 studies reported considerable improvement in the reduction of symptoms such as; a) sensory impairments like pain b) tactile discrimination c) thermal sensation (hot and cold) while only one study has reported improvement in response to touch [19] used MT for sensor-impairments through the interventions of varied texture stimulus during MT-sessions to the affected UL in the stroke patients. Improved response to the temperature and tactile sensation [17] has been recorded. Another study observed sensory symptoms in UL such as: a) tingling b) movement c) flicker d) mild pain e) pinprick and associated movement after MT-session for the duration of 6 - 8 weeks, although this study didn't actively intervened sensory intervention such as; varied texture stimulus.

Intervention: Stages of intervention

The selected studies reported MT as interventions in the 3 stages (phases) of the stroke rehabilitation; chronic stage (21 studies) and acute and sub-acute stage (14 studies). MT was intervened in only two studies for eight weeks (the longest duration) in the stroke patients for UL-motor impairments.

First Author/Year/ Reference	Stroke stage	Targeted area/ impairments	MT-Duration (Weeks)	Mode of MT	Sample size (N)
Rodrigues, 2015 [27]	C*	UL- motor impairments	4	b/l MB	N = 16
Arya, 2018 [29]	C	UL- sensory impairments	6	b/l MF	N = 31
Samuelkamalesh kumar, 2014 [33]	SA*	Wrist and hand motor impairments	3	b/l, MB	N = 20
Mohan, 2013 [34]	A*	LL- motor impairments and balance	2	MF	N = 22
Xu, 2017 [35]	SA	LL-motor impairments, ambulation and spasticity	4	MF	N = 46
Vural, 2015 [17]	C	CRPS, UL-motor impairments, ADLs and spasticity	4	b/l, MR	N = 30
Wu, 2013 [28]	C	UL -motor and sensory impairments	4	b/l, MF	N = 23
Cristina, 2015 [36]	SA	UL- motor impairments	6	b/l, MF	N = 15
Thieme, 2012 [14]	SA	UL -motor impairments, ADLS, QOL, visuospatial neglect	5	b/l, MF	N = 60
Colomer, 2016 [2]	C	UL- motor and sensory impairments	8	b/l, MB,	N = 31
Michielsen, 2011 [27]	C	UL motor impairments, pain and QOL	6	b/l, MF,	N = 40
Pandian, 2014 [31]	A	Unilateral neglect	4	b/l, MB	N = 47
Antoniotti, 2019 [37]	A	UL -motor impairments	4	U/l, MF,	N = 35
Tyson, 2015 [22]	A	UL and LL, motor and, sensory impairments	1	MF	N = 85
Chan, 2018 [24]	A	UL -motor impairments	4	b/l, MF	N = 35
Arya, 2015 [29]	C	UL- motor impairments	8	u/l, MB	N = 33
Park, 2015 [20]	C	UL-motor, ADL impairments	4	u/l, MF	N = 30
Radajewska, 2013 [32]	SA	UL and hand motor impairments and ADL	3	b/l, MF	N = 60
Park, 2015 [38]	C	UL- motor impairments and ADL	6	u/l, MF	N = 30
Lee, 2012 [39]	A and SA	UL- motor impairments	4	b/l, MB	N = 26
Harmsen, 2015 [30]	C	UL- motor impairments	1	u/l, Action-observation	N = 37
Lin, 2014 [40]	C	UL- motor impairments, ambulation and ADL	4	b/l, MB	N = 29
Amasyalı, 2016 [23]	C	Hand motor impairments	3	u/l, MF	N = 17
Gurbuz, 2016 [41]	SA	UL- motor impairments	4	u/l, MF	N = 31
In, 2016 [42]	C	Balance and gait impairments	4	VRRT, MB	N = 25
Yang, 2015 [43]	SA	Pusher's syndrome	3	MF	N = 12
Jan S., *et al*. 2019 [44]	A, SA, C	UL -motor impairments	3	MF	N = 66
Junyi Guo., *et al*. 2019 [45]	A, SA, C	UL- motor impairments	5	MF	N = 120
Donge Lee., *et al*. 2019 (46)	A, SA, C	UL- motor impairments	5	MF	N = 30
Choi., *et al*. 2019 [47]	A, SA, C	UL- motor impairments r and QOL	3	MF	N = 36
Liding., *et al*. 2019 [48]	A, SA, C	Motor impairments	5	MVF	N = 90
Fong., *et al*. 2019 (49)	C	UL- motor impairments	2	MF	N = 101

Table 1: *Summary of the research studies included in this review.*

Abbreviations: a) C: Chronic Stage, A*: Acute Stage, AS*: Acute Stage; b) QOL: Quality of Life; c) VRRT: Virtual Reality Reflection Therapy d) UL: Upper Limb; e) u/l: Unilateral; f) ADLs: Activities of Daily Living g) MB: Mirror Box; h) b/l: Bilateral; i) MF: Mirror Frame; J) LL: Lower Limb; K) CRPS: Complex Regional Pain Syndrome.*

The mode of interventions delivery

Mirror boxes or mirror frame were used in the 92.8% studies to administer Mirror therapy sessions. A mirror box is a 3-D structure which is designed for placing the involved limb within it in order to avoid direct viewing by the patient, where as a 2-D mirror frame is kept between arms either inclined so that the patient is able to view the reflections of the uninvolved arm/leg in the mirror without viewing the involved arm/leg or placed vertically. The size and dimension of the frame varies, depending on the size of the extremity targeted such as: upper or lower extremity. 13 studies among the selected used this mode MT session [25,27] as in contrast to the 22 researches intervened MT with unilateral movement of the of the un-involved limb.

Harmsen., *et al*. [30] administered a modified-form of therapy using the participants -specific videos with reaching movement from the unaffected arm that were mirrored and videotaped, which created maximal postural familiarity and the perceptual illusion that the affected arm/limb actually perform the task (the reaching task) in the normal movement pattern. This intervention (action-observation mode) showed improved speed of the upper extremity in the stroke patients but the long term effects of these interventions were not documented.

A study by the In., *et al*. used another form of modified-mirror therapy as intervention, called virtual reality reflection therapy (VRRT) for the treatment of the balance and gait impairments. VRRT is actually the enhanced and intense form of the MT in which patients in a high sitting placed their involved extremity in the VRRT- box and watched projected movements of the un-involved limb without visual asymmetry, which would otherwise tilt patient head and trunk. The movements of the un-involved limb were videotaped and displaced over the affected limb as the virtual reality. VRRT study has reported improved stroke -patient balance score, decreased sway (anterior -posterior sway and medio-lateral with eyes open and closed) and considerable improvement walking speed on a 10MWT.

ADL-based functional task were used in the 4 selected studies for the review during MT sessions [19,29,38] while the other studies used functional activities such as; reaching activities or simple graded movements of the limbs for the treatment of the stroke related motor impairments. 2 among the selected also included home based therapeutic session for the MT. we have noted that in the 4 studies apart from the MT, no conventional stroke-oriented therapy was used. Out of these 2 studies showed recognizable functional improvement in motor score [20,33]. One study among the selected noted that there are no long terms of effects of mirror therapy as per their 6-month long follow up study.

Dosage/intensity

Among the selected studies the total duration of the MT interventions varied from 1 - 8 weeks. 50% of the selected studies which makes up 17 studies had an MT as interventions for 4 weeks duration and frequency varied from 3 - 5 sessions/week. The duration of the each session ranges from 20 - 90 minutes; in some studies excluding the 20 - 30 minutes of the control/conventional therapies. Studies on UE reported MT effectiveness with treatment session ranges from 20 - 60 min/day for 5days/week with the exception of 2 studies have reported no improvement in motor score in both groups (control group vs. experimental group). Lower extremity treatment session varied from 15 - 60 min/day for 5 times/week. It is important to note that one study reported effectiveness of 1 session of action-observation based mirror with highly intensive 70 repetitions within the 10 MT sessions [30].

Type of control

We noted in almost all studies two broad categories of the control arm appeared; a) Sham mirror therapy 53.57% of studies include for review b) Conventional therapies in the rest of the studies- 46.43% of the studies. Sham MT was provided to stroke patients either by using non-reflecting surface which would be placed intra-limbs or by covering the mirror with the piece of cloth or by displaying static

images or by placing no mirror between intra-limbs, while on the other hand conventional therapies varied across the selected studies from passive/strengthening movements of the involved limb to the holistic therapy which includes PT, OT and speech therapy. In few studies functional and ADL based activities were introduced in as component of the control program. All the conventional rehabilitation was tailored-made to the enrolled patients needs and the duration lasted between 45 min-5hrs/day for 5 days/week.

Outcome measures-Types

Selected studies have used a range of outcome measuring scale which includes: a) motor b) sensory c) perceptual impairments d) Balance/gait e) QOL f) ADLs. In the table 2, we have tabulated in into different categories such as: impairment, disability (activity limitation) and participation restriction or handicapped (ICIDH scales).

Domain	OMS Used		
	Impairment	**Activity Limitation**	**Participation Restriction**
Motor: Upper and lower extremity	FMA, MCSI, myometer Myoton 3, PROM, MAS, Movement Time, MSS, Grip force Wrist extension Bhakta test Tardieu scale Motricity index Brunnstrom stages	WMFT BBT Stroke-ULAM 10-metre walk test ARAT MFT Upper extremity performance test for the elderly	BI FIM
Sensory	FMA, RASP, RNSA TDT, VAS	NA	NA
Unilateral neglect	SCT, PIT, LBT	NA	NA
Balance	Postural sway (reach test)	BBS, BBA	FRT, TUG
Others	Scale for Contraversive Pushing	Motion analysis device, FAC, FAT	RFI, SIS, mRS ABILHAND EQ 5D

Table 2: *Outcome measuring scale (OMS)-types.*

Abbreviations: a) MCSI: Modified Composite Spasticity Index; b) MSS: Motor Status Score; c) MFT: Manual Function Test; d) ULAM: Upper Limb Activity Monitor; e) BI: Barthel Index; f) FIM: Functional Independence Measure; g) FMA: Fugl Meyer Assessment; h) MAL: Motor Activity Log; i) PROM: Passive Range of Motion; k) EQ-5D: EuroQOL-5 Domains; l) RNSA: Revised Nottingham Sensory Assessment; m) NSA: Nottingham Sensory Assessment; n) LBT: Line Bisection Test; o) RFI: Repty Functional Index; p) VAS: Visual Analog Scale; q) mRS: Modified Rankin Score; r) PIT: Picture Identification Task; s) FAC: Functional Ambulation Categories; t) BBS: Berg Balance Scale; u) FAT: Frenchay Arm Test; v) TDT: Tactile Discrimination Test; w) BBA: Brunel Balance Assessment; x) SCT: Star Cancellation Test; y) FRT: Functional Reach Test; z) TUG: Timed Up and Go Test; a1) RASP: Rivermead Assessment of Sensory Perception; b2) SMT: Semmes-Weinstein Monofilament Test.

Feasibility, adherence and acceptability

We noted that 16 among the selected studies contained no information about adherence or feasibility at all [12,17,37,39,42]. Almost all stroke patients in the selected studies MT as interventions were well tolerated [22,25,27,38,41,42] apart from the commonly expected symptoms such as; short-duration of fatigue in the involved limb [22,24]. The majority of the study intervened directly as MT which were highly tolerated by the enrolled stroke patients [22], 2 studies stated 100% participants rate [27,51]. The highest dropout rate (18.6%) was observed in a comparative study for MT-effectiveness in a group and individual-setting. This study recorded effectiveness of mirror

therapy for both setting was comparable and thus the MT sessions can be possible for the chronic group of stroke patients in the home setting [14]. Another study comparing MT vs. LL conventional exercises have reported that both interventions were feasible with the 90% adherence rate, however, the participants in the both group performed less therapy sessions than the recommended sessions. It has been noted that participants in the MT group were reluctant for MT as compared to conventional exercise; furthermore patients with the neglect performed 69% less MT than those without and this difference has not been observed in the exercise group [22]. Another research -study carried out at chronic stroke's patients home-based added object-related bilateral symmetrical training to MT in order to increase the patient's participation rate. Despite 16% of the session not being performed, all enrolled patients for study received identical sessions and finished in time [40], with severe arm impairments 14.6% drop out rate was recorded [42]. Overall, it has been reported that stroke patients demonstrated higher level of motivations as compared to sham therapy group.

Risk of bias and methodological quality of studies

The risk of the bias score on the Cochrane tool was calculated. The average PEDro score was 6+ 0.83 and no study showed poor score (less than 4), 2 of the study (7.2%) showed fair quality (score 4 - 5) while most of the selected studies have methodological quality, only one study showed excellent quality (score 9 - 10).

Limitations of the Study

It includes the following:

1. Small sample size was the most evident limitations noted among the selected studies [2,22,40].
2. In some studies due to lack of follow up the long term retentions of the functional improvement due to MT was not recorded and reported [2,17,22,33].
3. Some of the selected studies reported difficulties in generalization of their studies due to specific pre-selection criteria [12,21]. Some other studies observed the baseline difference between control and experimental group which posed again threats generalizations of these studies results. Most of the study except the one [27] didn't use fMRI due too which the cortical impact (cortical reorganization) of MT can't be determined.
4. Some other limitations beside the above mentioned included:
    a. The interactive character of the experimental conditions excluded the blinding of the studies at any level [33].
    b. The design of the mirror box preclude upper extremity movement, which may have resulted in the less pronounced upper extremity improvement due to MT [19].
    c. In 2 studies the lack of qualitative movement were observed [29] or AROM [35].
    d. Rehabilitation therapies that demands attention and cognitions, a comprehensive cognitions and depression evaluations for both group before, during at the end of the trial would be value [17,37]. Thus, in some studies role of MT in patients with cognitive impairments needs to be analyzed, which was/is the outside the scope of this review.
    e. Recommendations of these selected studies include: Further study should involve greater sample, homogenous distribution in relation to sensory impairment and motor paresis among study participants [23]. Furthermore, new studies ought to be executed on optimal duration, optimal mode of intervention, ADLs/QOL, content and intensity [41].

Discussion

There are various hypothesis for the neurophysiologic basis of the MT. one of the hypothesis states that that due to mirror neuron system (MNS) in the fronto-temporal region and superior temporal gyrus STG which generate signals with the hand - functional-actions

through merely the observation of a similar functional actions of another persons [8]. This phenomenon facilitate the corticospinal pathways, which results in improvement of the motor- functions by eliciting mental imagery and inducing motor re-learning in stroke patients [10]. It has been reported that observation a biological movement also aid the motor learning and improvement in the neglected by STG activation mechanism [31]. The second theory suggests mechanism such as: heighten self awareness and spatial-oriented attention by STG activation and posterior cingulated cortex (PCC) pathways. It has been recorded the feedback MT increases primary and secondary visual and somatosensory areas which results in a) improved attention b) avoidance of the learned non-use of the affected limb c) conscious awareness of sensory [42]. The 3rd hypothesis states that role of MT in activation of dormant, ipsilateral motor pathways originating in un-involved hemisphere and projecting further in same side to involved limb [43]. According to the 4th hypothesis role of MT is in promoting the normalization of balance within hemisphere post-stroke by modulating the excitability of PMC (primary motor cortex) [42].

In the current review MT-effectiveness in post-stroke rehabilitation has been observed. Almost half of the studies intervened and recorded improvement in the motor, sensory and perceptual impairments in the acute phase of stroke, which is consistent with the review carried out by Gandhi., *et al*. This finding has an important clinical implications as MT can potentially change stroke's rehabilitation protocol by MT intervention in the completely flaccid stage unlike other rehab approaches such as; a) CIMT (constraint induced movement therapy) b) Therapy with the computer games c) virtual simulation etc. where a minimal amount of voluntary movement is prerequisite for the initiating of these therapies.

Few researches have reported that MT plus bilateral arm therapy increases visual imagery feedback of the stroke patients which in turn enhanced upper limb motor functions [21]. Our finding in this review is consistent with the aforementioned study [21]; we have found that bilateral arm training shows positive results in all stroke stages (chronic and acute/sub-acute phases of the stroke rehabilitations) in the upper limb and for the patients with the hemi-neglect symptoms.

A future scope for the mirror therapy in the stroke rehabilitation would most probably be to identify precisely its relations to the varied clinical presentation of stroke across the gender (man and women). The varied risk factors, neurological outcome among genders and severity of the stroke may demand a modified application of mirror therapy). Further research is also recommended to look into the effects of MT in different stages of stroke such as: acute, sub-acute and chronic phases. We also recommend that MT effects and its relations to the improvement of the motor vs. sensory vs. perceptual impairments needs to be determined. Similarly, the role of MT in the lacunar strokes for the associated impairments needs to investigated in large sample size.

Conclusion

Mirror therapy is feasible therapeutic approach for the rehab of the stroke patients for conditions such as; sensory impairments, motor impairments and perceptual deficits in all stroke phases (Acute to Chronic). Inclusion of the bilateral arm training (combined with MT) improves patients response to mirror therapy, dosage, intensity, duration and the mode of the MT intervention needs to investigated and analyzed extensively in the larger population.

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