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Original Research

Prism Adaptation Treatment Improves Inpatient Rehabilitation Outcome in Individuals With Spatial Neglect: A Retrospective Matched Control Study

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KEYWORDS
Brain injury;
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Abstract *Objective:* To determine whether prism adaptation treatment (PAT) integrated into the standard of care improves rehabilitation outcome in patients with spatial neglect (SN).
Design: Retrospective matched control study based on information extracted from June 2017-September 2019.
Setting: Inpatient rehabilitation.
Participants: Patients from 14 rehabilitation hospitals scoring >0 on the Catherine Bergego Scale (N=312). The median age was 69.5 years, including 152 (49%) female patients and 275 (88%) patients with stroke.

List of abbreviations: ANOVA, analysis of variance; CBS, Catherine Bergego Scale; CMS, Centers for Medicare and Medicaid Services; IRB, institutional review board; KF-NAP, Kessler Foundation Neglect Assessment Process; KF-PAT, Kessler Foundation Prism Adaptation Treatment; LOS, length of stay; MCID, minimal clinically important difference; OR, odds ratio; OT, occupational therapist; PAT, prism adaptation treatment; RCT, randomized controlled trial; SN, spatial neglect.

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Interventions: Patients were matched 1:1 by age (±5 years), FIM score at admission (±2 points), and SN severity using the Catherine Bergego Scale (±2 points) and classified into 2 groups: treated (8-12 daily sessions of PAT) vs untreated (no PAT).
Main Outcome Measures: FIM and its minimal clinically important difference (MCID) were the primary outcome variables. Secondary outcome was home discharge.
Results: Analysis included the 312 matched patients (156 per group). FIM scores at discharge were analyzed using repeated-measures analyses of variance. The treated group showed reliably higher scores than the untreated group in Total FIM, F=5.57, P=.020, partial η^2=0.035, and Cognitive FIM, F=19.20, P<.001, partial η^2=0.110, but not Motor FIM, F=0.35, P=.553, partial η^2=0.002. We used conditional logistic regression to examine the odds ratio of reaching MCID in each FIM score and of returning home after discharge. No reliable difference was found between groups in reaching MCID or home discharge.
Conclusions: Patients with SN receiving PAT had better functional and cognitive outcomes, suggesting that integrating PAT into the standard of care is beneficial. However, receiving PAT may not determine home discharge.

The prevalence of spatial neglect (SN) is approximately 20%-40% among survivors of stroke in acute and postacute inpatient settings and it is more common after right brain damage than left brain damage.[1] SN can also occur in individuals with other types of brain injury[2,3] because the disorder results from damage to the neural networks critical to spatial processing and attention control.[4,5] Affected individuals typically demonstrate ipsilesional bias and hence pay no or insufficient attention to the contralesional side of space.[6-9] This cannot be attributed to primary sensory or motor defects.[6,10] The deficits associated with SN disrupt basic self-care activities (eg, dressing, grooming)[11,12]; impair at-rest positions of the eye, head, and trunk[9,13,14]; interfere with reading ability[15-17]; affect spatial memory retrieval and mental imagery[8]; and impede navigation (eg, colliding into furniture or walls when walking or using a wheelchair).[18-20] Furthermore, many individuals with SN are unaware of their own symptoms or the consequences of their deficits,[21-25] which can delay their seeking appropriate treatment or learning compensatory strategies. For decades, SN has been reported to hinder rehabilitation progress and outcomes.[26-29]

Prism adaptation treatment (PAT)[30] is a promising treatment for ameliorating SN and improving performance in activities of daily life.[31] The latest American Heart/Stroke Association Guidelines for Adult Stroke Rehabilitation and Recovery recommend PAT because it is supported by level A evidence (multiple populations evaluated using randomized controlled trials or meta-analyses) and class IIa effect size (benefit outweighs the risk).[32] However, it is unknown whether PAT is effective in the real world where patients and clinical practices vary more than in a well-controlled research context. In clinical trials where participants received PAT during their inpatient rehabilitation stay,[33-37] PAT was provided as an extra treatment. Thus, the effectiveness of PAT integrated as part of the standard of care is unknown. The present study aimed to examine the effectiveness of PAT on rehabilitation outcome in a real-world clinical setting.

Methods

Study design

We conducted a retrospective matched control study.

Participating sites and procedures

Fourteen rehabilitation hospitals across 10 different states in the United States participated in the study through an agreement that included occupational therapist (OT) training and deidentified clinical information sharing. The project was approved by the research center's institutional review board (IRB) and the local IRB of each hospital that had a research infrastructure. No informed consent was necessary because of the nature of the study. Hospitals without a research infrastructure were attached to the research center's IRB protocol through a federal assurance agreement. Information shared was dated from June 2017-September 2019.

This study was part of an ongoing multisite dissemination and implementation project in which OTs learned to assess patients for SN during daily activities and treat them using PAT when SN was detected, following standardized protocols provided by the research team. OTs were encouraged to assess all patients with neurologic disorders (ie, stroke and other types of brain injury) under their care and to provide 10 sessions of PAT during patients' inpatient stays. Specifically, OTs assessed patients using the Catherine Bergego Scale (CBS) via the Kessler Foundation Neglect Assessment Process (KF-NAP)[38,39] and delivered PAT following the Kessler Foundation Prism Adaptation Treatment (KF-PAT) protocol.[40] The KF-NAP is a method to administer the 10-item CBS.[38,39] The items include gaze orientation, limb awareness, auditory attention, personal belongings, dressing, grooming, navigation, collisions, meals, and cleaning after meals. Each item is scored from 0 (no neglect) to 3 (severe neglect). Calculated with the formula: (sum score ÷ number of scored items) × 10,[41] the final score ranges from 0-30. OTs were instructed to provide PAT to patients who scored above 0 on

the CBS (indicating the presence of SN). Importantly, OTs implemented the assessment and treatment protocols during regular hours as part of rehabilitation care, rather than during extra experimental sessions. OTs provided the research team deidentified clinical information on patients assessed using the KF-NAP and those treated using the KF-PAT.

Athough multiple rehabilitation hospitals participated in the project, hospitals joined at different times. Some implemented both assessment and treatment protocols around the same time, and others started assessment but did not deliver PAT for several months. After therapists in a given hospital were trained in the KF-NAP, patients were screened for SN using the CBS. Once the therapists were trained in the KF-PAT and obtained the necessary equipment, patients with SN started receiving PAT. Thus, among participating hospitals, some patients with SN (CBS>0) received PAT; others were not treated because of a delay in rollout of PAT implementation.

Prism adaptation treatment

Trained OTs used the KF-PAT Portable Kit,[a] which included goggles fitted with 20-diopter wedged prism lenses, which shift the visual field 11.4° horizontally. The prism goggles were used only during PAT (for detailed procedures, see the KF-PAT manual[40] or previous reports).[2,42,43] PAT was delivered once a day during an OT session, mostly at the beginning of the session. Some sites followed the recommendation of delivering PAT over 10 consecutive days or weekdays (skipping weekends), and others completed as many PAT sessions as possible, depending on individual patients' condition and length of stay (LOS). It was shared with the research team that LOS was usually determined soon after hospital admission and might not be long enough to complete 10 daily PAT sessions once patients were confirmed as having SN. Although the national average LOS for neurorehabilitation was 2-3 weeks, some patients stayed longer, and their OTs delivered a few more sessions after the 10th session. The recommended dosage of 10 sessions over 2 weeks demonstrated mixed results.[34,35,44] While there was no evidence-based guideline in terms of PAT dosage, we reasoned that patients must have received more than 1 week of treatment, which translated to receiving at least 8 sessions. For the purpose of the present study, we categorized patients who received 8-12 PAT sessions as being treated with a complete course of PAT (ie, the treated group) and patients who received 0 sessions as being untreated (ie, the untreated group).

Inclusion/exclusion criteria

The research team retrospectively reviewed the provided clinical information and included patients who scored greater than 0 on the CBS, indicating the presence of SN. Patients who did not complete inpatient rehabilitation and were discharged back to an acute care hospital were excluded. This data set was then reviewed by a member of the research team (N.D.S.), a resident physician, to match the treated and untreated groups.

Matching procedure

The treated and untreated groups were matched by the resident physician who was not involved in SN screening or PAT administration. Patients were matched in a 1:1 ratio using age (±5 years), FIM score at admission (±2 points), and SN severity measured using the CBS score (±2 points). Sample selection bias could have occurred if the resident physician was able to identify anyone from their site in the de-identified data set. However, the chance of any patient being identified was minimal.

Primary outcome measures

All participating hospitals used the same scale to measure rehabilitation outcome: the FIM, independent of the present study. The FIM was designed to be discipline-free. OTs, physical therapists, speech-language pathologists, and nurses usually share the responsibility of assessing patients using the FIM at admission and at discharge. The FIM consists of 13 motor items and 5 cognitive items, generating 3 scores: Total FIM, Motor FIM, and Cognitive FIM. Each item was scored 0 (activity did not occur) to 7 (complete independence) at admission and 1 (total assistance) to 7 at discharge, following the Inpatient Rehabilitation Facility—Patient Assessment Instrument versions 1.4-2.0 provided by the US Centers for Medicare and Medicaid Services (CMS).[45,b] Total FIM, Motor FIM, and Cognitive FIM scores at discharge and the ratios of reaching the minimal clinically important difference (MCID) from admission to discharge were considered primary outcome measures. The MCID is 22 points for Total FIM, 17 points for Motor FIM, and 3 points for Cognitive FIM.[46]

Secondary outcome measure

The rate of home discharge was examined as a secondary outcome because studies have shown that SN reduces the likelihood of returning home after inpatient rehabilitation[3,28,29] and that better FIM scores at discharge are associated with higher rates of home discharge.[47,48] This variable was derived from the discharge status codes as defined by the CMS.[49]

Analysis methods

All analyses were performed using STATA/SE 16.1.[c] The patient characteristics were described using median and interquartile range for continuous variables and counts and percentages for categorical variables. Each of the FIM scores was examined using a repeated-measures analysis of variance (ANOVA) with group as the predictor and matched pair as the repeated variable. The effect size of the group (treated vs untreated) was indicated by the value of the partial η^2 calculated after each ANOVA model result. The odds ratio (OR) of reaching MCID in each FIM score was analyzed using conditional logistic regression. Another conditional logistic regression analysis was conducted to examine the OR of being discharged home. The Benjamini-Hochberg method was used to minimize false discovery due to multiple comparisons,[50] and the false discovery rate was set at 0.05.

Results

Among the 1568 patients who had SN (ie, CBS score > 0) and completed inpatient rehabilitation without being discharged to acute care, 666 (42.5%) received at least 1 session of PAT and 902 (57.5%) received no PAT. Of the PAT-treated patients, 231 (34.7%) patients received 8-12 PAT sessions: 34 (14.7%) received 8 sessions, 28 (12.1%) 9 sessions, 162 (70.1%) 10 sessions, 7 (3.0%) 11 sessions, and 1 (0.4%) 12 sessions. A total of 312 patients (156 in each group) were matched and included in the planned analysis. See Table 1 for the summary of patient information in each group.

A summary of descriptive data is presented in Table 2. The ANOVAs revealed the effect of group on Total FIM reached significance with a small effect size, $F(1311)=5.57$, $P=.020$, partial $\eta^2=0.035$, and the effect of group on Cognitive FIM was also reliable with a medium effect size, $F(1311)=19.20$, $P<.001$, partial $\eta^2=0.110$. However, group showed no effect on Motor FIM, $F(1311)=0.35$, $P=.553$, partial $\eta^2=0.002$. Adjusted means of FIM scores are summarized in Table 3. Thus, the treated group had reliably better rehabilitation outcomes than the untreated group, measured using FIM, especially Cognitive FIM.

The planned logistic regression analyses revealed that no reliable effect of group was found on reaching MCID in Cognitive FIM (OR=1.74, $P=.055$), Total FIM (OR=1.15, $P=.600$), or Motor FIM (OR=0.85, $P=.523$). The 2 groups did not differ in home discharge, either (OR=1.33, $P=.258$). Thus, receiving PAT did not appear to determine the likelihood of reaching clinically meaningful improvement in functional independence or discharge disposition.

Table 2 Descriptive summary of outcome measures

Outcome Variables	Treated group (n=156)	Untreated group (n=156)
Score at discharge		
Total FIM	66.9±17.5	63.8±18.6
Motor FIM	43.5±14.4	42.7±15.0
Cognitive FIM	23.4±5.7	21.2±6.2
No. of patients reaching MCID		
Total FIM	105 (67.3)	101 (64.7)
Motor FIM	102 (65.4)	107 (68.6)
Cognitive FIM	123 (78.8)	109 (69.9)
No. of patients returning home*		
Without home care arranged	40 (25.6)	29 (18.6)
With home care arranged†	51 (32.7)	53 (34.0)
Total	91 (58.3)	82 (52.6)

NOTE. Values are presented in mean ± SD or counts (%).

* This includes private houses, private apartments, assisted living, and group home.

† Organized home health services were arranged to be delivered to patients once they returned home, based on the definition of the discharge status code "06" provided by CMS.

Discussion

This retrospective matched control study demonstrated that patients with SN receiving PAT as part of their rehabilitation care had greater functional outcomes than patients with SN who did not receive PAT, particularly in the cognitive domain. However, receiving PAT did not determine whether a patient with SN would return home after inpatient rehabilitation.

Although practice guidelines recommend the use of PAT,[32,51,52] clinical implementation of PAT can be challenging. As shown in the present study, only 34.7% of patients received the recommended or close to the recommended number of sessions. Although OTs cited having limited time (eg, predetermined LOS), there is a need to understand the efficacy of dosage through prospective studies. The only randomized controlled trial (RCT) that demonstrated improved rehabilitation outcomes was a study that provided 2 PAT sessions a day to patients over 2 weeks in addition to the standard of care.[33] A secondary data analysis suggested that 4-6

Table 1 Patient characteristics

Variable	Treated Group (n=156)	Untreated Group (n=156)	All (N=312)
Age (y)*	69 (61.5-77)	70 (61-77.5)	69.5 (61-77)
Female	82 (52.6)	70 (44.9)	152 (48.7)
Time between diagnosis and admission to hospital (d)	7.5 (5-14)	7 (5-13)	7 (5-13.5)
Diagnosis			
Stroke	139 (89.1)	136 (87.2)	275 (88.1)
Traumatic brain injury	0	10 (6.4)	10 (3.2)
Nontraumatic brain dysfunction	12 (7.7)	9 (5.8)	21 (6.7)
Others	4 (2.6)	1 (0.6)	5 (1.6)
Total FIM score at admission*	38 (30.5-46)	37 (30-46)	37.5 (30-46)
CBS score*	10 (6.68-15.85)	10 (6.43-15.86)	10 (6.66-15.86)
Left-sided neglect	126 (80.8)	95 (60.9)	221 (70.8)
Length of stay (in days)	23 (19-27)	23 (17-26)	23 (18-27)

NOTE. Values are presented in counts (%) or medians (interquartile range).

* Variable used for matching.

Table 3 Summary of the ANOVA results on adjusted FIM scores at discharge in means (SE) and 95% confidence interval

Outcome variables	Treated group (n=156)	Untreated group (n=156)
Total FIM	66.9 (0.94)	63.8 (0.94)
	95% CI, 65.0-68.7	95% CI, 61.9-65.6
Motor FIM	43.5 (0.85)	42.7 (0.85)
	95% CI, 41.8-45.1	95% CI, 41.1-44.4
Cognitive FIM	23.4 (0.35)	21.2 (0.35)
	95% CI, 22.7-24.1	95% CI, 20.5-21.9

Abbreviation: CI, confidence interval.

daily sessions may be effective in improving visuospatial abilities measured using paper-and-pencil–based neuropsychological tests.[53] However, studies showed no effect after 4 sessions over 4 days[54] or over 4 weeks.[55] In 1 RCT, PAT was delivered in 7 sessions over 7-12 days and found to improve visuospatial abilities[36]; other RCTs that offered 10 sessions over 2 weeks demonstrated mixed results.[34,35,44] Thus, more research is needed to determine the PAT regimen that balances clinical feasibility with maximal effectiveness.

It is worth noting that, in the present study, PAT improved the rehabilitation outcome measured using the Cognitive FIM score with a medium effect size but not that using the Motor FIM score. It might be surprising that the Motor FIM did not improve after PAT because research has shown that PAT improves the motor symptoms of SN[56,57] and functional abilities that require integration of spatial processing and movement control (eg, walking[58] and wheelchair navigation).[59,60] However, the Motor FIM measures not only locomotion and transfer abilities (ie, transferring between different surfaces such as transferring from a wheelchair to toilet seat) but also self-care activities (eg, eating, grooming, dressing) and sphincter control (bowel and bladder management). These Motor FIM items may not be sensitive to difficulties in daily life related to SN[39] and thus in this study the Motor FIM score did not demonstrate improvement as a result of PAT. Cognitive FIM quantifies 5 constructs, including comprehension, expression, social interaction, problem solving, and memory, based on clinicians' interactions with patients. SN and related deficits can lead to poor social interaction[24] and misunderstanding of printed or written words due to reading difficulties[15-17] (for examples, see the opening paragraph and the appendix of Chen et al.[28]). Additionally, spatial memory (ie, mental representation of spatial information) supports many aspects of higher-level cognitive function such as problem solving and can be affected by SN.[8] For example, being able to locate personal belongings or objects in a familiar environment depends on not only attention and perception but also spatial memory, which is measured by a CBS item called "personal belongings" in the KF-NAP.[38] Given that Cognitive FIM improved more in the treated group than in the untreated group in the present study, it is possible that PAT specifically improved daily activities that require cognitive functions affected by SN.

Home discharge was a secondary outcome in the present study. An effect of PAT on the likelihood of being discharged home after inpatient rehabilitation did not reach statistical significance in this analysis. Many factors affect the decision to return home, including age, functional status at admission and at discharge, availability of a live-in family caregiver, and sociodemographic characteristics.[28,61,62] Receiving PAT for SN may improve functional independence, but the improvement may not be sufficient to change discharge disposition. More efforts beyond treating SN are needed to increase the likelihood of home discharge.

Study limitations

This is a retrospective study based on reviews of clinical outcomes. The data set included different sources of noise. Different centers had different clinical routines into which the recommended protocols were integrated. Individual OTs also may have developed different levels of proficiency in using either tools. In addition, although all OTs were instructed to provide PAT to patients who scored above 0 on the CBS, different therapists might have perceived certain patients as better candidates for the treatment and other patients may not have received PAT owing to therapists' clinical judgment that factored in various aspects of patient characteristics. However, this information was not included in the present analysis. Another source of data noise is the sampled population: 88% of the patients included in the retrospective analysis were survivors of stroke, and others had traumatic or nontraumatic brain dysfunction. However, the matched control design should have minimized the influence of noise, which reflects the reality of neurorehabilitation care.

Another limitation of the study was that we collected no information detailing "the standard of care" such as minutes of therapy, total number of OT sessions, or sessions by other disciplines. Thus, the standard of care may be defined or operationalized differently in different rehabilitation hospitals. Because of the lack of information, we are unable to comment whether the groups differed significantly in the time spent in therapy or usual care, although the LOS was comparable between groups.

Yet another limitation was that we had no information on patients after discharge. It is not a universal practice of inpatient rehabilitation facilities to collect information after patients are discharged from the service. Thus, the lasting effects of the implemented SN care on functional improvement or on other aspects of functional recovery in the community are unknown.

Conclusions

Although aligning with the practice guidelines that recommend the clinical implementation of PAT,[32] the findings suggest that integrating PAT into the standard of care may reduce the adverse effect of SN on rehabilitation outcomes.[26-29] Clinical trials and implementation science studies are needed to determine the optimal dosage of PAT that can be feasibly delivered in current clinical practice settings.

Suppliers

a. KF-PAT Portable Kit, Kessler Foundation.

b. Inpatient Rehabilitation Facility—Patient Assessment Instrument, versions 1.4-2.0; US Centers for Medicare and Medicaid Services.
c. STATA/SE 16.1, StataCorp.

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