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Rehabilitation Medicine

对侧控制功能性电刺激镜像反馈治疗偏瘫手功能疗效观察

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摘要 **目的：**探讨对侧控制功能性电刺激镜像反馈治疗对脑卒中偏瘫患者手功能疗效影响。**方法：**选取符合本研究标准的 60 例脑卒中偏瘫患者，随机分为 A 组、B 组和 C 组，每组 20 例。在常规康复治疗的基础上，A 组患者接受镜像治疗，B 组患者接受对侧控制功能性电刺激治疗，C 组患者接受对侧控制功能性电刺激镜像反馈治疗，3 组治疗均每次 20 min，每天 1 次，每周治疗 5 d，连续治疗 4 周。于治疗前及治疗 4 周后，采用表面肌电图（sEMG）、Fugl-Meyer 量表上肢运动功能测试部分（U-FMA）、组块测试（BBT）、腕关节主动活动角度（AROM）对患者手功能进行评定，并进行统计学分析。**结果：**治疗前，3 组时域指标——平均肌电值（AEMG）、频域指标——中位频率值（MF）、U-FMA 评分、BBT 评分以及腕关节 AROM 比较，差异均无统计学意义（$P>0.05$）。治疗 4 周后，3 组 AEMG 值、MF 值、U-FMA 评分、BBT 评分以及腕关节 AROM 均比治疗前有明显提高（$P<0.05$）；组间比较，C 组 AEMG 值、MF 值、BBT 评分以及腕关节 AROM 分别为（73.17±29.12）μV、（95.67±26.54）Hz、（9.50±3.28）分、（41.75±17.19）°优于 A 组（57.33±18.47）μV、（77.62±31.10）Hz、（7.15±3.13）分、（26.75±14.53）°和 B 组（55.61±20.17）μV、（74.45±23.22）Hz、（6.50±3.78）分、（31.50±16.47）°，差异均具有统计学意义（$P<0.05$）；3 组 U-FMA 评分分别为 A 组（25.85±8.38）分、B 组（25.40±9.25）分、C 组（27.20±9.21）分，差异无统计学意义（$P>0.05$）。**结论：**对侧控制功能性电刺激镜像反馈治疗可改善脑卒中偏瘫患者的手功能，且优于单一的对侧控制功能性电刺激以及镜像治疗。

关键词 脑卒中；偏瘫；对侧控制功能性电刺激镜像反馈治疗；手功能

脑卒中后约 69%幸存者留有不同程度上肢功能障碍[1]。同时，50%～80%急性期患者以及约 40%慢性期患者存在不同程度的手部运动功能障碍[2]。偏瘫患者手功能的恢复对其重新回归家庭、工作和社会具有重要意义。镜像治疗（mirror therapy，MT）可促进脑卒中后手与上肢功能的恢复[3-5]，但在大部分镜像疗法中，患者由于功能受限和主观意识较弱，他们的患侧肢体并没有真正参与活动，造成患者视觉与本体感觉输入的不协调，干扰疗效[6]。对侧控制功能性电刺激（contralaterally controlled functional electrical stimulation，CCFES）[7]是一种新型的功能性神经肌肉电刺激疗法，在患者主动运动时，输入通道采集健侧上肢的肌电信号，输出通道同步产生的电流作用于患侧上肢相同部位的肌肉，从而使患侧上肢同步做出与健侧相似的动作，该治疗方法可与镜像疗法相结合，提高镜像疗法中患者的主动参与度。因此，本研究尝试基于镜像反馈进行对侧控制功能性电刺激治疗，探讨其对偏瘫患者手功能的疗效。

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1 临床资料

1.1 病例选择标准

1.1.1 纳入标准 ① 经CT或MRI确诊为脑卒中，经临床相关科室治疗后，生命体征稳定；② 初次发病，伴有一侧上肢瘫痪；③ 年龄40～70岁；④ 病程＜3个月；⑤ 手部Brunnstrom分期Ⅰ～Ⅲ期；⑥ 可配合治疗和评估；⑦ 自愿签署知情同意书。

1.1.2 排除标准 ① 各种重要脏器疾病急性进展期和危重期；② 瘫痪侧前臂及手部有金属异物或严重的骨关节疾病；③ 治疗期间病情恶化，出现新的脑梗死灶或脑出血灶；④ 双侧前臂皮肤过敏、破损、感染、皮疹等。

1.2 一般资料

选取2018年4月—2020年3月在复旦大学附属上海市第五人民医院行康复治疗的脑卒中偏瘫患者60例，按照随机数字表法将60例患者分为A组（镜像治疗组）、B组（对侧控制功能性电刺激组）和C组（对侧控制功能性电刺激镜像反馈治疗组），每组20例。3组一般资料比较，差异无统计学意义（$P>0.05$），见表1。

表1 3组一般资料比较

Table 1 Comparison of general data in three groups

组别	n	性别		年龄（$\bar{x}\pm s$，岁）	脑卒中类型		平均病程/（$\bar{x}\pm s$，d）	偏瘫侧别	
		男	女		脑出血	脑梗死		左侧	右侧
A组	20	17	3	59.30±7.11	4	16	24.30±12.87	9	11
B组	20	14	6	58.90±8.52	1	19	23.60±10.36	12	8
C组	20	15	5	56.65±7.34	3	17	26.35±15.69	11	9
χ^2或F值		1.304		0.691	2.019		0.236	0.937	
P值		0.521		0.505	0.364		0.790	0.626	

本研究经复旦大学附属上海市第五人民医院伦理委员会批准（2019伦审第122号），所有患者均签署知情同意书。

2 方 法

2.1 治疗方法

所有患者均接受脑卒中常规的康复治疗。常规康复治疗主要包括脑卒中后康复宣教、体位转移训练、关节活动度训练、神经肌肉促进技术、平衡功能训练、步行能力训练，以及物理因子治疗、作业治疗等。常规康复治疗由对分组不知情、工作经验相仿的治疗师实施。在常规治疗基础上，A组给予镜像治疗，B组给予对侧控制功能性电刺激，C组给予对侧控制功能性电刺激镜像反馈治疗，以上治疗均每次20 min，每天1次，每周治疗5 d，连续治疗4周。

2.1.1 镜像治疗 采用三角形镜像治疗箱，三角形边长为35 cm×35 cm×35 cm，箱体长40 cm，平面镜固定于一侧箱体木板上。将镜箱置于作业台面上，镜面朝向内侧，患手伸入镜箱内，健手完成抓握、伸指、屈伸腕等动作，可配合抓握球、堆叠积木、拿放杯子等任务性活动；要求患者观察镜中健手，形成视错觉，想象成患手执行相关的动作。

2.1.2 对侧控制功能性电刺激 采用南京伟思医疗科技有限公司S4Plus生物刺激反馈仪，选择“对侧控制功能性电刺激-垂腕”模块。分别在患者健侧产生轻微幅度动作（＜10%完全动作幅度）、中等幅度动作（50%完全幅度动作）、完全幅度动作3个点位标定健侧腕伸肌表面肌电，等比分别设置患侧腕伸肌收缩所需要的刺激电流强度，从而使得双侧上肢产生相同幅度或相似的动作，电流强度以患者耐受为宜。根据治疗仪指令完成“抓握”-“伸展”-“放松”循环训练。

2.1.3 对侧控制功能性电刺激镜像反馈治疗 将患手伸入三角形镜像治疗箱内，遮挡患手运动，同时进行CCFES治疗。根据CCFES治疗仪指令执行“抓握”-“伸展”-“放松”等动作，配合抓握球、拿放杯子等任务性活动。要求患者在治疗时，注视镜中健手镜像想象患手执行相关动作，并感知箱体内CCFES刺激时患手的活动，如图1所示。

2.2 评估方法

于治疗前及治疗4周后，采用表面肌电图（surface electromyography，sEMG）、Fugl-Meyer量表上肢运动功能测试部分（upper extremities motor function test of Fugl-Meyer movement assessment，U-FMA）、组块测试（box and block test，BBT）、腕关节主动活动角度（active range of motion，AROM）对患者手功能进行评估。

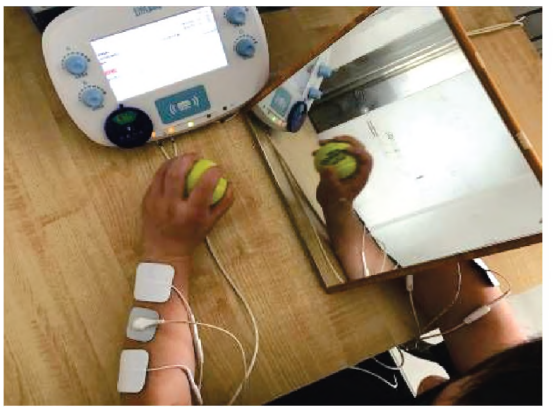

图 1　对侧控制功能性电刺激镜像反馈治疗

Figure 1　Contralaterally controlled functional electrical stimulation mirror feedback therapy

2.2.1　sEMG　采用上海诺诚电气股份有限公司生产的 XRHK 型肢体功能评定与康复训练系统进行表面肌电评估。受试者取坐位,将电极片粘贴于受试者患侧桡侧腕伸肌的位置,测试前给予 3～5 min 的训练,让其理解整个测试过程,测试时要求患者用最大力气做腕背伸肌的等长收缩,坚持 5 s,然后休息 10 s,重复 3 次。设置灵敏度 500 μV/D、扫描速度 2 S/D 采集表面肌电信号,波形 RMS 平滑处理,进行信号频谱分析,提取 sEMG 信号的时域指标——平均肌电值(average EMG,AEMG)以及频域指标——中位频率值(median frequency,MF)。AEMG 是指一定时间内瞬时肌电振幅的平均值,主要反映肌电信号的强度与参与活动的运动单位数目、类型及其放电频率同步化程度;MF 是指骨骼肌收缩过程中肌纤维放电频率的中间值[8]。

2.2.2　其他手功能评定方法　① U-FMA:该部分共 33 个项目,每项的评分范围为 0～2 分,总分为 66 分,总分越高表示上肢运动功能越好[9]。② BBT:要求受试者尽可能快速地将 1 英寸大小的方块从一侧盒子跨过隔板放至另一侧目标盒子内,记录 60 s 内移动的数量,这是一种用来衡量手部灵活性的评估方法[10]。③ AROM:受试者取坐位,使用通用型量角器,轴心位于桡骨茎突,固定臂与桡骨平行,移动臂与示指掌骨平行,测量腕关节掌屈角度(参考范围 0°～80°)及背伸角度(参考范围 0°～70°)[11]。本研究取两者之和作为 AROM,数值越大,腕关节主动活动度越好。

2.3　统计学方法

采用 SPSS 19.0 版软件进行统计分析。计数资料(如患者性别、病变性质及偏瘫侧别)以频数表示,组间比较采用 χ^2 检验。计量资料以($\bar{x}\pm s$)表示,组间比较采用单因素方差分析,进一步两组间互相比较采用 *LSD-t* 检验;组内比较采用配对样本 *t* 检验。$P<0.05$ 认为差异有统计学意义。

3　治疗结果

3.1　3 组治疗前后 AEMG、MF 值比较

见表 2。

表 2　3 组治疗前后 AEMG、MF 值比较($\bar{x}\pm s$)

Table 2　Comparison of AEMG and MF values in three groups before and after treatment ($\bar{x}\pm s$)

组 别	*n*	AEMG 值/μV				MF 值/Hz			
		治疗前	治疗后	*t* 值	*P* 值	治疗前	治疗后	*t* 值	*P* 值
A 组	20	37.38±19.72	57.33±18.47	-6.044	<0.001	52.85±17.11	77.62±31.10	-5.577	<0.001
B 组	20	32.92±17.03	55.61±20.17	-8.166	<0.001	48.79±16.76	74.45±23.22	-5.426	<0.001
C 组	20	39.06±21.99	73.17±29.12[1)2)]	-6.834	<0.001	49.50±19.22	95.67±26.54[1)2)]	-6.384	<0.001
F 值		0.519	3.522			0.399	3.682		
P 值		0.598	0.036			0.692	0.001		

注:与 A 组比较,1) $P<0.05$;与 B 组比较,2) $P<0.05$。

Note: Compared with group A, 1) $P<0.05$; Compared with group B, 2) $P<0.05$.

3.2　3 组治疗前后 U-FMA、BBT 评分比较

见表 3。

3.3　3 组治疗前后腕关节 AROM 比较

见表 4。

表3 3组治疗前后U-FMA、BBT评分比较($\bar{x}\pm s$) 分

Table 3 Comparison of U-FMA and BBT scores in three groups before and after treatment ($\bar{x}\pm s$) Scores

组别	n	U-FMA				BBT			
		治疗前	治疗后	t值	P值	治疗前	治疗后	t值	P值
A组	20	14.75±6.54	25.85±8.38	-11.252	<0.001	5.10±2.53	7.15±3.13	-5.779	<0.001
B组	20	12.80±8.73	25.40±9.25	-9.764	<0.001	4.20±2.38	6.50±3.78	-6.692	<0.001
C组	20	13.80±5.67	27.20±9.21	-11.467	<0.001	4.45±2.23	9.50±3.28[1)2)]	-10.809	<0.001
F值		0.393	0.219			0.760	4.286		
P值		0.482	0.804			0.473	0.018		

注:与A组比较,1) $P<0.05$;与B组比较,2) $P<0.05$。

Note: Compared with group A, 1) $P<0.05$; Compared with group B, 2) $P<0.05$.

表4 3组治疗前后腕关节AROM比较($\bar{x}\pm s$) °

Table 4 Comparison of wrist AROM in three groups before and after treatment ($\bar{x}\pm s$) °

组别	n	治疗前	治疗后	t值	P值
A组	20	15.25±10.32	26.75±14.53	-6.206	<0.001
B组	20	16.50±10.65	31.50±16.47	-7.815	<0.001
C组	20	18.75±12.86	41.75±17.19[1)2)]	-9.114	<0.001
F值		0.490	4.532		
P值		0.615	0.015		

注:与A组比较,1) $P<0.05$;与B组比较,2) $P<0.05$。

Note: Compared with group A, 1) $P<0.05$; Compared with group B, 2) $P<0.05$.

4 讨 论

CCFES作为一种在电刺激辅助下健侧触发患侧产生运动的功能性电刺激治疗方法,由KNUTSON等[12]于2007年提出,该学者团队对CCFES在脑卒中偏瘫上肢康复中的应用进行了一系列的临床研究[7,13-15],研究结果显示CCFES对改善脑卒中患者上肢和手部运动功能的恢复有着积极的作用。其中,在KNUTSON等[15]进行的临床随机对照试验中,CCFES的治疗效果优于常规的神经肌肉电刺激,因为CCFES刺激是由意图驱动的,患者控制刺激强度,从而控制患手的张开程度。运动意图与运动反应的时间性重复耦合可能促进神经可塑性与重组,而后者是脑卒中患者功能恢复的基础。ZHENG等[16]对早期脑卒中(<15 d)患者进行CCFES治疗,结果显示:CCEFS组21例患者中有19例在治疗期间恢复了主动伸腕动作,且Fugl-Meyer上肢运动功能、伸腕肌肌力、伸腕主动关节活动度等比治疗前有明显提高。提示CCFES缩短了腕部恢复主动背伸的时间,并改善了早期脑卒中患者的上肢功能。

在临床治疗中,由于个体对CCFES刺激反应的差异性,大部分患者双侧上肢不能达到治疗所需理想的对称效果。随着时间的延长,肌肉对低频电刺激逐渐耐受,肌肉收缩效应也会有所减弱[17]。基于CCFES的疲劳性和非完全对称性,以及镜像疗法中主动参与度的缺乏[6],本研究提出采用镜像反馈进行对侧控制功能性电刺激治疗,以改善两者的不足之处。

本研究结果显示,治疗前各组AEMG值、MF值、U-FMA评分、BBT评分以及腕关节AROM均无统计学意义($P>0.05$);治疗4周后C组AEMG值、MF值、BBT评分以及腕关节AROM优于A组和B组($P<0.05$),表明对侧控制功能性电刺激镜像反馈治疗效果优于这2种疗法的单独使用。该方法有别于这2种治疗措施单纯时间上的叠加,而是基于镜像反馈技术同时进行对侧控制功能性电刺激治疗。治疗中,CCFES需要患者注意力集中于双侧的肢体,尽自己最大的努力移动患侧去配合健侧的动作,这样患者的运动意向和刺激效应可最大限度地同步化,充分调动患者的主观能动性[18]。同时,镜像装置将患侧肢体正常运动的镜像错觉代替患侧肢体本体感觉输入,通过镜子使视觉信号不断输入相对应的运动脑区,增强视觉输入和运动脑区的联系,建立对患侧肢体运动的视觉反馈,从而有助于患侧肢体功能的恢复[19]。MT作用于"中枢"与CCFES作用于"外周"形成双途径干预,"外周干预"与"中枢干预"的功能互补,作用于患者特定脑区或功能相关脑区,以大脑的可塑性以及神经通路的重塑为基础,促进中枢重塑和外周控制,进而促进功能恢复[20]。

本研究中,3组患者治疗4周后,U-FMA评分3组之间未显示出明显的差异($P>0.05$),可能是因为U-FMA的权重更多地用于评估近端上肢运动而不是远端手部功能,而CCFES可能对肢体远端功能具有更大的作用。这与KNUTSON等[15]、黄崧华等[21]研究结果相一致。另外,也可能与样本量偏少、有效治疗时间不足等因素相关,有待进一步的探讨。

综上所述,对侧控制功能性电刺激镜像反馈治疗可有效地改善脑卒中偏瘫患者的手部运动功能,且该方法操作简便,可在临床中推广应用。

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Effect of Mirror Feedback Therapy of Contralaterally Controlled Functional Electrical Stimulation on Hand Function of Apoplectic Hemiplegic Patients

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ABSTRAT **Objective:** To investigate the effects of mirror feedback therapy of contralaterally controlled functional electrical stimulation on hand function of apoplectic hemiplegic patients. **Methods:** A total of 60 apoplectic hemiplegic patients were randomly divided into group A, group B and group C, with 20 cases in each group. All three groups received treatment for 20 minutes each time, once a day, for 5 days a week, and for 4 weeks. On the basis of conventional rehabilitation treatment, patients in group A received mirror therapy (MT), patients in group B received contralaterally controlled functional electrical stimulation (CCFES), and patients in group C received mirror feedback therapy of CCFES. Surface electromyography (sEMG), upper extremities motor function test of Fugl-Meyer movement assessment (U-FMA), box and block test (BBT) and wrist active range of motion (AROM) were used to evaluate hand function of patients before and after treatment. **Results:** Before treatment, average EMG (AEMG) value, median frequency (MF) value, U-FMA scores, BBT scores and wrist AROM of all three groups showed no significant differences ($P>0.05$). After 4 weeks of treatment, the AEMG value, MF value, U-FMA scores, BBT scores and wrist AROM improved significantly in all three groups ($P<0.05$). The AEMG value, MF value, BBT scores and wrist AROM for group C were: (73.17±29.12), (95.67±26.54), (9.50±3.28), (41.75±17.19), which were better than group A: (57.33±18.47), (77.62±31.10), (7.15±3.13), (26.75±14.53), and Group B (55.61±20.17), (74.45±23.22), (6.50±3.78), (31.50±16.47). The differences were statistically significant ($P<0.05$). The U-FMA scores of the three groups were (25.85±8.38) in group A, (25.40±9.25) in group B and (27.20±9.21) in group C. There were no significant statistical differences in U-FMA scores in the three groups ($P>0.05$). **Conclusion:** Mirror feedback therapy of contralaterally controlled functional electrical stimulation can improve hand function of apoplectic hemiplegic patients, and is superior to the single CCFES or MT.

KEY WORDS stroke; hemiplegia; mirror feedback therapy of contralaterally controlled functional electrical stimulation; hand function
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Effect of Vocational Rehabilitation Training Camp on Patients with Spinal Cord Injury Returning to Society

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ABSTRACT **Objectives:** To investigate the therapeutic effect of vocational rehabilitation training camp on patients with spinal cord injury (SCI) returning to society. **Methods:** A total of 34 patients with spinal cord injury who were hospitalized and received rehabilitation treatments in Xiangya Boai Rehabilitation Hospital from October 2017 to October 2019 were recruited and randomly divided into control group (16 cases) and observation group (18 cases) according to the random number table method. The control group received conventional rehabilitation treatment (including basic training, daily life activity training, traditional Chinese medicine therapy, etc.) for 6 hours a day, 5 days a week, for 12 weeks. The observation group added 2 weeks of vocational rehabilitation training camp on the basis of conventional rehabilitation treatment, 10 hours a day, 5 days a week, for 2 consecutive weeks, a total of 14 weeks. Patients in two groups were evaluated using general self-efficacy scale (GSES), community integration questionnaire (CIQ), and the lam assessment of stages of employment readiness (LASER) before and after treatment. The statuses of returning to work of patients were followed up by telephone six months after discharge. **Results:** There were no statistically significant differences between the two groups in GSES scores and CIQ scores before treatment ($P>0.05$). There were statistically significant differences in GSES scores (20.89±4.86:31.44±3.42), CIQ-family integration scores (4.39±1.24:10.50±1.72), CIQ-social integration scores (2.78±0.94:8.06±1.86), CIQ-production activity scores (0.50±0.62:3.06±0.80) and LASER scores of the observation group before and after treatment ($P<0.05$). There were statistically significant differences in GSES scores (22.06±5.53:28.63±4.54), CIQ-family integration scores (4.69±1.14:6.69±1.49), CIQ-social integration scores (3.75±0.93:6.19±1.17), CIQ-production activity scores (0.75±0.68:2.13±0.62) and LASER scores of the control group before and after treatment ($P<0.05$). After treatment, there were statistically significant differences in GSES scores (31.44±3.42:28.63±4.54), CIQ-family integration scores (10.50±1.72:6.69±1.49), CIQ-social integration scores (8.06±1.86:6.19±1.17), CIQ-production activity scores (3.06±0.80:2.13±0.62), and LASER scores between the two groups ($P<0.05$). Six months after discharge, the rate of returning to work of SCI patients in the observation group was significantly higher than that of the control group ($P<0.05$). **Conclusion:** Vocational rehabilitation training camp can significantly improve the general self-efficacy, community integration, willingness to work and the rate of returning to work of patients with spinal cord injury.

KEY WORDS spinal cord injury; vocational reconstruction training camp; general self-efficacy; community integration; willingness to work; return to work
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