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Original Research Article

The effects of EMG biofeedback therapy and facial nerve mobilization in Bell's palsy

Padmapriya Sridharan, Prathap Suganthirababu*, Vignesh Srinivasan

Department of Neurological Physiotherapy, Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

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***Correspondence:**
Dr. Prathap Suganthirababu,
E-mail: emailprathap@gmail.com

ABSTRACT

Background: Bell's palsy is a common neurological disorder characterized by sudden, unilateral facial nerve paralysis, leading to both functional impairments and cosmetic concerns. While conventional treatment approaches are frequently employed to alleviate symptoms, emerging rehabilitation techniques such as electromyographic (EMG) biofeedback and facial nerve mobilization have shown promising potential in enhancing recovery outcomes. This study aimed to evaluate the combined effects of EMG biofeedback therapy and facial nerve mobilization on facial symmetry and functional recovery in patients with acute Bell's palsy.

Methods: A total of 30 participants, aged 18–40 years, with unilateral Bell's palsy classified as Grade III–V on the Modified House–Brackmann (HB) Scale were recruited. Participants were allocated into two groups: the experimental group (n=15) received EMG biofeedback and facial nerve mobilization, whereas the conventional group (n=15) underwent traditional physiotherapy. Both groups participated in 45-minute treatment sessions, five days per week, for four weeks. Outcome measures included the Sunnybrook Facial Grading Scale (SFGS) and surface electromyography (sEMG).

Results: Statistical analysis revealed significant improvements within both groups; however, the experimental group demonstrated greater gains. SFGS scores improved significantly within groups ($p<0.001$), with the experimental group achieving superior results ($p<0.001$) and a large effect size ($r=-0.854$). Surface EMG analysis indicated significantly higher post-treatment muscle activation across all facial muscles in the experimental group ($p < 0.001$).

Conclusions: These findings suggest that EMG biofeedback combined with facial nerve mobilization is an effective intervention for enhancing facial symmetry and functional recovery in acute Bell's palsy, making it a promising addition to rehabilitation protocols.

Keywords: Biofeedback, Electromyography, Facial nerve mobilization, Facial rehabilitation

INTRODUCTION

Bell's palsy, also known as idiopathic peripheral facial nerve palsy, derives its name from Sir Charles Bell, a Scottish anatomist. It presents with a sudden weakness or paralysis on one side of the face due to facial nerve impairment. The condition affects roughly 11.5 to 53.3 people per 100,000 each year. On a global scale, the incidence among adults is estimated to be between 11 and 40 cases per 100,000 person-years, while in children, it ranges from 11.5 to 30 per 100,000.[1] Over a lifetime, the likelihood of developing Bell's palsy is approximately 1 in 60 individuals. Epidemiological data suggest that the disorder is more common among individuals aged 15 to 40, with the highest frequency observed near the age of 40. Additional studies support that the condition predominantly affects young to middle-aged adults. Although the exact cause is idiopathic, potential triggers of facial nerve inflammation include exposure to extreme cold, ear infections, and traumatic injuries.[2] These pathophysiological triggers are believed to induce inflammation, resulting in demyelination and conduction block along the facial nerve, ultimately impairing neuromuscular transmission and leading to facial muscle weakness or paralysis.[3]

The facial nerve is the 7th cranial nerve, originating from the facial nerve nucleus present in the brainstem. It contains the motor, sensory, and parasympathetic nerve fibers. The two roots (motor and sensory roots) are accompanied by the vestibulo-cochlear nerve and enter the internal meatus and then enter the facial canal. Within the facial canal, motor and sensory roots fused to form the facial nerve and the geniculate ganglion. Finally, the facial nerve exits the canal via stylomastoid foramen and divides into five motor branches (temporal, zygomatic, buccal, marginal mandibular, and cervical) to innervate the muscles of facial expressions. Given its long and narrow intratemporal course, the facial nerve is particularly susceptible to inflammatory compression, which can result in demyelination and even axonal degeneration, contributing to the diverse clinical presentation of Bell's palsy.[4]

Although 70–85% of cases recover spontaneously, about 15–30% of individuals experience incomplete recovery, residual asymmetry, synkinesis, or contractures.[5] The clinical presentation of Bell's palsy includes unilateral facial drooping, inability to close the eye or smile on the affected side, altered taste, hyperacusis, and sometimes pain behind the ear.[6] Associated symptoms may include retroauricular pain, hyperacusis, altered taste, and decreased salivation or tear secretion, depending on the extent and location of nerve involvement. These impairments not only cause cosmetic concerns but also significantly disrupt the psychosocial well-being of affected individuals.[7]

If untreated or poorly rehabilitated, Bell's palsy may lead to several complications. These include synkinesis (involuntary movements during voluntary action), hemifacial spasm, facial contractures, gustatory lacrimation ("crocodile tears"), and persistent asymmetry.[8] Such sequelae arise due to aberrant nerve regeneration and mismatched axonal reinnervation. Moreover, chronic facial disfigurement can cause emotional distress, depression, and reduced self-esteem, reinforcing the need for early, structured intervention.[9]

Initial management often involves corticosteroids, especially when administered within 72 hours of onset, as they have been shown to reduce nerve inflammation and improve outcomes. Antiviral medications may be added, although their efficacy remains controversial.[10,11] Adjunctive physical therapies are frequently employed to enhance neuromuscular control, prevent complications, and expedite recovery. Despite medical management, many patients require rehabilitation to restore neuromuscular coordination and address residual dysfunction. Conventional physical therapy plays a pivotal role in the rehabilitation of Bell's palsy, aiming to restore facial muscle function, symmetry, and expression while minimizing complications such as synkinesis, contractures, and psychosocial distress. Among the widely practiced physiotherapeutic interventions are Proprioceptive Neuromuscular Facilitation (PNF), electrical stimulation, and facial exercises and facial massages.[12]

More recent developments in rehabilitation have focused on neuromuscular re-education techniques, including EMG biofeedback and facial nerve mobilization. EMG biofeedback offers real-time visual or auditory cues regarding muscle activity, aiding in neuromuscular retraining and promoting cortical reorganization.

EMG biofeedback (EMG-BFB) therapy is a non-invasive intervention that uses surface electromyography to facilitate neuromuscular re-education through real-time auditory or visual cues derived from muscle activation signals.[13] This real-time feedback allows patients to consciously control and retrain weak or misfiring muscles, thereby facilitating targeted muscle re-education and improving neuromuscular control.[14] EMG biofeedback works by detecting and amplifying the body's neuromuscular electrical signals and transforming them into visual and auditory cues. These signals help the patient become aware of their muscle activity and make adjustments, such as enhancing muscle contraction, based on the feedback received. Studies have demonstrated its efficacy in enhancing facial symmetry and reducing synkinesis in both acute and chronic facial nerve dysfunction.[15,16]

Facial nerve mobilization, a manual therapy technique aimed at improving nerve gliding and reducing adhesions along the nerve's path, is another innovative strategy. This technique may improve axonal conduction, reduce mechanical restrictions, and facilitate nerve regeneration.[17] A randomized controlled trial evaluating the addition of facial nerve mobilization to conservative treatment in patients with acute Bell's palsy reported greater improvements in facial movement and symmetry compared to conservative treatment alone.[18]

While biofeedback and manual therapy are gaining attention in facial nerve rehabilitation, there is still a lack of high-quality clinical trials comparing these methods to traditional treatments. Given the significant burden of residual facial dysfunction, synkinesis, and psychosocial distress associated with Bell's palsy, this study aims to evaluate the synergistic effects of EMG biofeedback and facial nerve mobilization as an integrated physiotherapeutic approach. By utilizing validated outcome measures such as the Sunnybrook Facial Grading Scale (SFGS) and surface electromyography (sEMG), this research seeks to develop evidence-based rehabilitation protocols that enhance functional recovery, support neural regeneration, and ultimately improve the quality of life for individuals affected by Bell's palsy.

METHODS

Study design

This was an experimental study conducted to determine the combined effects of EMG biofeedback therapy and facial nerve mobilization in patients with Bell's palsy.

Study setting and period

The study was carried out at Saveetha Medical College and Hospital, Thandalam, from August 2024 to January 2025.

Selection criteria

A total of 30 patients clinically diagnosed with acute unilateral Bell's palsy were recruited according to predefined inclusion and exclusion criteria.

Inclusion criteria

Subjects of both genders

Age group 18 to 40 years

Subjects diagnosed with unilateral Bell's palsy

Moderate to severe acute Bell's palsy using the Modified House-Brackmann scale.

Exclusion criteria

Upper Motor Neuron (UMN) facial palsy

Any open wound or ulcer over the face

After any surgery of the dental, ear, nose

Any traumatic injury to the face

Non-cooperative patients or those unable to follow instructions.

Materials

Electrical stimulation, powder, pen and pencil, pen and pad electrode, paper, hand gloves, bowl of water, plinth, NeuroTrac MyoPlus 4 Pro EMG device.

Study procedure

Participants were recruited and screened for eligibility according to predefined inclusion and exclusion criteria. Detailed information regarding the study objectives, procedures, and potential risks was provided to all participants, and written informed consent was obtained. Participants (n=30) were randomly allocated to an experimental group (Group A, n=15) and a conventional group (Group B, n=15). Group A received EMG Biofeedback therapy combined with facial nerve mobilization, whereas Group B received conventional therapy. Both groups underwent 45 minutes of treatment sessions (including rest periods) five times per week for four consecutive weeks. Baseline assessments using the Sunnybrook Facial Grading Scale and Surface electromyography (sEMG) were conducted before the initial treatment session, and the same assessments were repeated after the four-week intervention period to obtain post-intervention measurements.

Intervention group

EMG biofeedback

Equipment: Electromyographic biofeedback was administered using the NeuroTrac MyoPlus 4 Pro. The device features two channels for EMG and four channels for NMES with a touch-screen interface and wireless data capabilities.

Electrode placement: Surface electrodes were placed over the frontalis, orbicularis oculi, zygomaticus major, orbicularis oris and mentalis muscles on the affected side of the face. A reference electrode was placed on the contralateral mastoid region. Electrode placement was guided by manufacturer diagrams and standard facial EMG protocols. Skin preparation was conducted using alcohol wipes to reduce impedance, and electrodes were checked for proper adhesion and signal quality before each session.

Protocol: Each EMG biofeedback session lasted approximately 40 minutes and was designed to promote voluntary facial muscle activation and motor relearning. Participants were guided through a structured series of facial movements targeting the specific muscle groups being monitored by the surface EMG electrodes. These movements included tasks for the frontalis, orbicularis oculi, zygomaticus major, orbicularis oris, and mentalis muscles. During the exercises, the biofeedback device provided real-time visual feedback in the form of graphical EMG waveforms displayed on the screen, allowing participants to observe the amplitude and duration of muscle contractions. In addition, audio cues (such as beeps or tones) were used to reinforce correct muscle activation and relaxation, supporting motor learning through multisensory feedback. The EMG biofeedback therapy was administered with a frequency of five sessions per week over four weeks, ensuring consistent stimulation and monitoring of facial neuromuscular activity. Within each session, facial movements were performed in sets of 5 to 10 repetitions per muscle group, depending on each participant's tolerance and level of fatigue. This dosage allowed for effective neuromuscular training while preventing overuse or strain, thereby optimizing recovery outcomes in patients with Bell's palsy.

Facial nerve mobilization

Participants were positioned supine with the head supported in slight extension and rotated contralaterally to expose the affected side of the face.

Mobilization technique: Gentle horizontal traction and rhythmic oscillatory movements were applied in a posterior-to-anterior direction, aiming to mobilize the facial nerve at the external auditory meatus. Care was taken to ensure movements were within the patient's comfort range, avoiding any discomfort or pain.

Duration and frequency: Session lasted approximately 5 minutes and was conducted 5 days per week, over a 4-week period, in conjunction with EMG biofeedback interventions.

Conventional group

Participants assigned to the conventional group received a standardized physiotherapy protocol designed to promote facial motor recovery through a combination of Proprioceptive Neuromuscular Facilitation techniques, electrical stimulation, facial exercises, and massage. The PNF component was based on the principle of irradiation, where stronger motions on non - affected side are resisted to stimulate and reinforce weaker motions on the affected side of the face. with conventional therapy (electrical stimulation, facial exercises, facial massage) for 45 minutes for 5 days per week for a period of 4 weeks.

Outcome measures

Pre- and post-intervention assessments were performed using:

Sunnybrook facial grading scale (SFGS): for subjective assessment of facial symmetry and voluntary movement.

Surface electromyography (sEMG): for objective measurement of facial muscle activation.

Statistical analysis

Statistical analyses were conducted using SPSS (IBM v.25), presenting all data as mean ± standard deviation. A p-value of less than 0.05 indicated statistical significance. The data were imported into a Microsoft Excel spreadsheet, organized, and analyzed. Statistical tests were utilized to compare the impact of treatment on outcome measures, including the Sunnybrook Facial Grading Scale and surface EMG. For the Sunnybrook Facial Grading Scale, the Wilcoxon signed rank test was employed to assess the probability of chance within the group, while between-group differences were examined using the Mann-Whitney U test. For the EMG, a paired t-test was employed to assess the probability of chance within the group, while between-group differences were examined using an unpaired t-test.

RESULTS

The study analyzed the combined effectiveness of EMG Biofeedback and facial nerve mobilization in Bell's palsy patients. The results were analyzed using both subjective (Sunnybrook Facial Grading System – SFGS) and objective (surface electromyography – sEMG) outcome measures. A total of 30 participants were included in the study, with 15 allocated to the experimental group and 15 to the conventional group. The overall mean age of the participants was 28.8±5.4 years, ranging from 18 to 39 years. The sample comprised 18 females (60%) and 12 males (40%), maintaining a similar distribution across both groups. In terms of the side affected, 18 participants (60%) presented with right-sided Bell's palsy, while 12 participants (40%) exhibited left-sided involvement. Based on the Modified House–Brackmann (HB) Scale, which classifies the severity of facial nerve dysfunction, 12 participants (40%) demonstrated Grade III (moderate dysfunction), 11 participants (36.7%) demonstrated Grade IV (moderately severe dysfunction), and 7 participants (23.3%) demonstrated Grade V (severe dysfunction). These findings indicate that the majority of participants presented with moderate to moderately severe facial nerve impairment at baseline (Table 1).

Within-group analysis using the Wilcoxon signed-rank test showed a statistically significant improvement in facial function in both the experimental and conventional groups. The experimental group A (n=15), which received EMG biofeedback and facial nerve mobilization, showed a notable increase in SFGS scores from a pre-test mean of 29.2±1.146 to a post-test mean of 62±2.236 ($Z = -3.423$, $p<0.001$). Similarly, the conventional group B (n=15), which underwent conventional therapy, improved from a pre-test mean of 29.27±1.486 to a post-test mean of 47.6±2.225 ($Z=-3.455$, $p<0.001$) (Table 2).

Between-group comparison using the Mann-Whitney U test revealed that the post-test improvement was significantly greater in the experimental group than in the conventional group ($p<0.001$), with a large effect size ($r=-0.854$), indicating the clinical relevance of the combined intervention (Table 3).

Table 1: Demographic and clinical characteristics of the participants.

Age (years)	28.8 ± 5.4 years (range: 18 to 39 years)
Gender	Female: 18 (60%) Male: 12 (40%)
Side affected	18 participants with right-sided Bell's palsy 12 participants with left-sided Bell's palsy
Severity (Modified House-Brackmann Scale)	Grade III: 12 (40%) Grade IV: 11 (36.7%) Grade V: 7 (23.3%)

Table 2: Within-group statistical analysis using the Wilcoxon signed rank test for SFGS.

Variable	Group	Pre-test Mean±SD	Post-test Mean±SD	Z value	P value
SFGS	Experimental	29.2±1.146	62±2.236	-3.423	< 0.001
	Conventional	29.27±1.486	47.6±2.225	-3.455	< 0.001

Table 3: Between-group statistical analysis using the Mann Whitney U test for SFGS.

Variable	Groups	Post–test Mean±SD	P value	r value	Effect size
SFGS	Experimental	62±2.236	<0.001	-0.854	Large
	Conventional	47.6±2.225			

Table 4: Within-group statistical analysis using paired t-test for EMG.

Groups	Muscles	Pre-test Mean±SD (mV)	Post-test Mean±SD (mV)	t value	P value
Experimental	Frontalis	1.63±0.086	2.74±0.143	-67.78	<0.001
	Orbicularis oculi	1.38±0.061	2.42±0.133	-51.6	
	Zygomaticus	1.26±0.04	2.18±0.146	-33.1	
	Orbicularis oris	1.46±0.041	2.52±0.136	-41.95	
	Mentalis	1.33±0.059	2.29±0.142	-43.44	
Conventional	Frontalis	1.56±0.074	2.33±0.150	-38.6	<0.001
	Orbicularis oculi	1.36±0.065	2.12±0.174	-19.0	
	Zygomaticus	1.23±0.046	1.98±0.115	-40.79	
	Orbicularis oris	1.43±0.046	2.18±0.110	-43.74	
	Mentalis	1.28±0.045	1.98±0.119	-35.51	

Table 5: Between-group statistical analysis using the independent t-test for EMG.

Muscles	Experimental Post mean (mV)	Conventional post mean (mV)	t value	P value
Frontalis	2.74	2.33	-8.57	<0.001
Orbicularis oculi	2.42	2.12	-5.85	
Zygomaticus	2.18	1.98	-4.59	
Orbicularis oris	2.52	2.18	-7.36	
Mentalis	2.29	1.98	-5.68	

Paired t-test analysis demonstrated a statistically significant improvement in muscle activity within both groups across all muscle sites ($p<0.001$). In the experimental group, EMG amplitudes increased substantially across all muscles, with the frontalis muscle improving from 1.63±0.086 mV to 2.74±0.143 mV, and the zygomaticus improving from 1.26±0.040 mV to 2.18±0.146 mV. Similar improvements were observed in the orbicularis oculi, orbicularis oris, and mentalis muscles. The conventional group also showed improvement, though to a lesser extent (Table 4).

Independent t-tests comparing post-test EMG values between groups confirmed significantly greater muscle activation in the experimental group for all facial muscles ($p<0.001$). For instance, the frontalis muscle showed a post-test mean of 2.74 mV in the experimental group versus 2.33 mV in the conventional group ($t=-8.57$, $p<0.001$), while the orbicularis oris recorded 2.52 mV in the experimental group versus 2.18 mV in the conventional ($t=-7.36$, $p<0.001$) (Table 5).

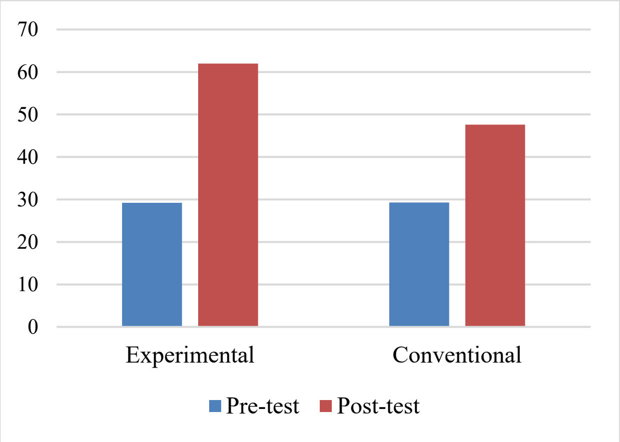

Figure 1: Comparison of mean Sunnybrook Facial Grading Scale (SFGS) scores between the experimental and conventional groups pre- and post-test.

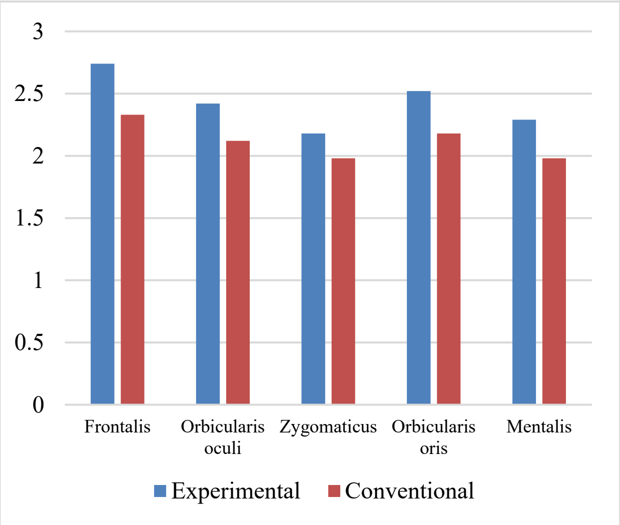

Figure 2: Comparison of mean electromyography (EMG) values between the experimental and conventional groups post-test.

Post-intervention mean scores are illustrated in Figures 1 and 2, highlighting improvements in SFGS and EMG in the experimental group.

Thus, EMG biofeedback therapy combined with facial nerve mobilization was found to be more effective than conventional physiotherapy in improving facial muscle activation and facial symmetry among Bell's palsy patients over a 4-week intervention period.

DISCUSSION

The present findings suggest that both EMG biofeedback training and facial nerve mobilization yielded measurable benefits in Bell's palsy recovery, albeit via different mechanisms. In our study, participants receiving surface EMG–guided neuromuscular re-education showed marked improvements in facial symmetry and motor control. This aligns with prior work indicating that EMG biofeedback enhances voluntary muscle activation and reduces aberrant synkinesis. Cardoso et al. (2008), in a systematic review of randomized controlled trials, reported that facial exercise and neuromuscular retraining approaches contribute to improvements in facial symmetry, motor control, and functional outcomes in patients with Bell's palsy.19 This updates the evidence from a single study to systematic review findings.[19] Johannes et al documented improved neuromuscular coordination and facial symmetry through EMG-triggered functional stimulation in patients with central facial palsy.[20] Ross et al also demonstrated that feedback training significantly improved voluntary facial movements in patients with long-standing facial paresis, underscoring the long-term applicability of EMG-based therapy.[21] Kaja et al although focusing on COPD patients, supported the broader efficacy of biofeedback-based devices in enhancing neuromuscular coordination, highlighting their potential translational use in other neuromotor impairments such as Bell's palsy.[22] These results corroborate our findings that EMG feedback boosts muscle coordination and enables reorganization of motor control through sensory-motor reinforcement.

In practical terms, patients in the EMG group achieved better neuromuscular control (as evidenced by more normalized sEMG amplitudes and faster voluntary movement onset) and reduced unintentional co-activation (synkinesis). Mirzakhani et al found that biofeedback therapy led to significant gains in facial function and patient-reported quality of life when compared with exercise therapy alone.[23] These effects were further reinforced in the present study, suggesting the utility of biofeedback in improving voluntary control, even in cases of residual paralysis. The Sunnybrook Facial Grading Scale, used to assess improvements, demonstrated higher post-treatment scores among EMG participants, supporting objective recovery.

Participants treated with facial nerve mobilization also showed marked improvements, particularly in measures of symmetry, functional expression, and voluntary activation. Alharbi et al reported significant gains in facial symmetry using neural mobilization techniques, which aligns closely with our mobilization group outcomes. Ahmed et al noted enhanced muscle recruitment and improved neuromotor responses when neural mobilization was combined with conventional therapy. These findings imply that mobilization reduces intraneural tension, restores neural glide, and promotes axoplasmic flow—mechanisms that can support motor recovery in facial palsy. These physiological effects were reflected in our study as increased EMG recruitment levels and improved balance in muscle firing patterns during expression.

The comparison of these interventions revealed distinctive patterns. While both groups improved significantly from baseline, the EMG biofeedback group exhibited superior gains in voluntary motor control and neuromuscular re-education. Bhagat et al reported similar findings, with EMG biofeedback showing greater control over synkinesis and muscle recruitment than mime therapy.[24] These findings are echoed in earlier studies such as Dalla Toffola et al, where patients receiving EMG feedback had reduced involuntary movements and better motor precision.[25] Furthermore, patients receiving biofeedback therapy exhibited improved motor learning over time, as repeated visual and auditory feedback helped reinforce the brain's sensory-motor circuits. In contrast, the mobilization group showed consistent but slightly slower recovery patterns, reinforcing the notion that mobilization alone is effective, but works best when integrated with active motor re-education.

Support for these therapeutic strategies is found in systematic reviews and meta-analyses. Nakano et al reviewed physical therapy modalities and concluded that biofeedback and neural mobilization significantly reduce long-term disability and enhance Sunnybrook Facial Grading scores.[26] This study aligns with our findings and reinforces the broader recommendation for evidence-based multimodal rehabilitation in Bell's palsy.

These viewpoints were validated by our study results, which support the integration of multiple physiotherapeutic techniques tailored to individual clinical presentations. Kandakurti et al supported the efficacy of combining physical modalities such as low-level laser with facial exercises, reinforcing the concept of multimodal synergy.[27] Similarly, the inclusion of structured EMG feedback in clinical routines can help personalize treatment and track muscle recruitment in real time, offering therapists objective data to guide interventions. Additionally, the combined use of EMG and mobilization therapies may address both central reprogramming and peripheral nerve dysfunction—providing a comprehensive, dual-approach to facial rehabilitation.

Despite promising findings, this study has several limitations. The duration of follow-up was limited, potentially overlooking long-term outcomes such as recurrence, late-onset synkinesis, or residual weakness. Exploring the combined effects of EMG biofeedback with other emerging modalities, such as virtual reality training or neuromodulation, could be beneficial. Standardizing protocols for both EMG biofeedback and facial nerve mobilization would aid in replication and comparison across studies. Finally, a cost-effectiveness analysis of incorporating EMG and nerve mobilization into standard care may further guide healthcare policy and clinical practice.

CONCLUSION

EMG biofeedback therapy combined with facial nerve mobilization appears to be a beneficial approach for patients with Bell's palsy, demonstrating superior improvements in facial muscle function compared to conventional physiotherapy. This method holds potential for optimizing recovery outcomes in facial nerve rehabilitation, emphasizing the importance of targeted neuromuscular re-education in improving facial symmetry and function.

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