The effect of two different rehabilitation treatments in cervical dystonia: preliminary results in four patients

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Summary

The most widespread approach to rehabilitation of cervical dystonia is electromyographic (EMG) biofeedback. However, consensus is lacking regarding the true effectiveness of this technique. The aim of this study was to evaluate how cervical dystonia was influenced by two rehabilitative treatments, namely a standard biofeedback program and a novel physiotherapy program consisting of postural reeducation exercises and passive elongation of myofascial cervical structures. Both programs were consecutively administered to 4 patients with cervical dystonia. The study design was a behavioral analysis of single cases. The main outcome measures were a head realignment test, a disability questionnaire and a pain visual analogue scale (VAS). Each patient's performance was evaluated before the study and after the first and second program. Furthermore, the disability questionnaire and the pain VAS were administered 3, 6, and 9 months after the end of the treatments. The physiotherapy program showed therapeutic effects comparable to those of EMG biofeedback. Reductions of disability and of pain were still present 3-9 months after the end of the treatments. These preliminary results suggest that the physiotherapy program proposed in the present study may be a promising method for rehabilitation of cervical dystonia.

KEY WORDS: biofeedback, dystonia, idiopathic torticollis, physio - therapy, rehabilitation.

Introduction

Idiopathic cervical dystonia (ICD) is the most frequent form of adult-onset focal dystonia (1). Its main clinical feature is torsion of the neck, which is the consequence of anomalous and involuntary contractions of the cervical muscles (2). ICD is often defined as "spasmodic torticollis". While this term recalls the main clinical feature of ICD, it does not provide any information about the nature of the disease. Indeed, torticollis can arise not only from peripheral or central nervous system alterations, but also from bone, joint, or muscle disease. Although the first descriptions of dystonia appeared early in the 1900s (3,4), more than half a century passed before physicians realized that this bizarre condition was linked to brain disease (5). Although the pathophysiology of ICD still remains unclear, a recent review by Berardelli et al. (6) suggests that dystonia may result from functional disturbance of the basal ganglia, possibly involving striatal control of the globus pallidus and, consequently, thalamic control of cortical motor planning and execution.
An epidemiological study involving the population of Rochester, MN, USA showed that the prevalence of ICD is about nine cases per 100,000 inhabitants (1). In 70-90% of cases, the onset of symptoms occurs around the third or fourth decade of life. Women are affected by ICD 1.5-1.9 times more than men. Patients with ICD do not show brain abnormalities when evaluated by computed tomography (CT) or magnetic resonance imaging (MRI). However, abnormalities of cortical and basal ganglia functions have been described in functional imaging and neurophysiology studies of patients with dystonia (6). Initial symptoms tend to be insidious and non-specific, often leading to incorrect diagnosis of arthritis, cervical radiculopathy, psychiatric disease, Parkinson's disease, or temporo-mandibular joint dysfunction. The increasing dystonic contraction of cervical muscles leads to the abnormal head posture characteristic of florid ICD. Depending on several factors, the clinical outcome of ICD may be either a worsening or an improvement (7). Common factors that lead to worsening of the disease include physical activity, fatigue, and emotional stress. By contrast, the disturbance can be attenuated by the use of particular gestures, called sensory tricks. These may comprise touching the mentum, face, or head controlateral to the direction of the dystonic movement, or supporting the head against the wall or the back of a chair. The effectiveness of these corrective maneuvers tends to decrease as the disease progresses. The symptoms of ICD usually get worse over a period of three to five years, but patients have also been described in whom the progression of dystonic symptoms has occurred in the space of only a month or continued for as long as 18 years (7).
Persistence of anomalous neck postures can induce

pain, myofascial contractures, cervical spondylosis with radiculopathy or myelopathy and dysphagia. The presence of ICD is often associated with various degrees of disability (8), ranging from subjective discomfort in social situations (with no major consequences on daily life activities) to alterations, qualitative and quantitative, of the subject's work situation. Depression, pain, and the avoidance of situations demanding social interaction are often associated with ICD.

Standard pharmacological treatments for ICD are ineffective in most cases. In the last decade, the introduction of chemical denervation through injection of botulinum toxin (9) has allowed selective reduction of the force of dystonic muscles and led to clinical improvements in most ICD patients (10).

To date, the few attempts to rehabilitate patients with ICD have given discouraging results. Informal interviews of ICD patients submitted to different therapeutic approaches suggest that physiotherapy was ineffective in most cases (10). Accordingly, in a recent review article concerning management of cervical dystonia, rehabilitation was not considered as a possible therapeutic approach (7).

Using the key words torticollis, torticollis-rehabilitation, torticollis-therapy, and dystonia-rehabilitation, we searched the scientific archives of Medline for papers on ICD published over the past 20 years. Out of more than 2,000 references found, only 11 articles were devoted to ICD rehabilitation. Ten of these papers concerned electromyographic (EMG) biofeedback techniques (11-20) and one article dealt with transcutaneous electrical nervous stimulation (TENS) (21). Briefly, these studies show that EMG biofeedback techniques can produce a symptomatic improvement of ICD that may last up to several months. None of those studies, however, systematically examined the influence of EMG biofeedback on disability in activities of daily living or modifications of pain related to ICD. Furthermore, none mentioned possible, alternative rehabilitation approaches to ICD.

The aim of the present study was to compare the effectiveness of a standard rehabilitation approach to ICD treatment, based on EMG biofeedback, with that of a novel physiotherapy program (PP). The latter consisted of: i) postural reeducation exercises (22) aimed at increasing voluntary control of head posture and inducing correct perception of head-trunk alignment; and ii) passive elongation maneuvers of myofascial structures to reduce possible contractures of muscles, ligaments, and joint capsulae of the cervical spine secondary to the prolonged dystonic postures (23). The rationale of postural reeducation in patients with ICD is supported by recent studies which show that chronic maintenance of abnormal head-trunk relations is likely to induce alterations of head- and trunk-centred coordinate systems (24), possibly leading to distorted perception of head-trunk alignment.

The study was carried out in four patients with cervical dystonia according to a design of behavioral analysis of single cases. The results, although preliminary, could be useful in order to plan further controlled studies in a large sample of patients with cervical dystonia.

Materials and methods

Patients

Four patients suffering from ICD participated in the study and were selected among the outpatients of the Functional Reeducation Center at the University Hospital of Verona, Italy, between August 2000 and June 2001. Patients 1, 3, and 4 suffered from rotational torticollis whereas patient 2 was affected by both rotational torticollis and retrocollis (Table I).

The main criteria for inclusion in the study were the presence of ICD, with an illness duration of at least one year, and freedom from any pharmacological (oral or in-

Table I - Demographic and clinical characteristics of patients with cervical dystonia.

Patients	Age	Sex	Illness duration	Type of abnormal posture	Dystonic muscles
1	40 yrs	F	46 mths	Rotational torticollis	Sternocleidomastoid, upper trapezius, splenius capitis (right)
2	54 yrs	M	12 mths	Rotational torticollis + retrocollis	Sternocleidomastoid, upper trapezius, splenius capitis (left)
3	38 yrs	F	15 mths	Rotational torticollis	Sternocleidomastoid, upper trapezius, splenius capitis (left)
4	35 yrs	F	12 mths	Rotational torticollis	Sternocleidomastoid, upper trapezius (left)

filtrative) ICD therapy at the time of the study. None of the patients were on any medication at the time of the study. Patients 1 and 3 had previously been treated with botulinum toxin, but with no significant improvement of their torticollis. In both these patients, botulinum toxin therapy had been terminated at least six months before our study. The other two patients had never received botulinum toxin therapy. None of the four patients showed tremor.

Neither neurophysiological (somatosensory evoked potentials, transcranial magnetic stimulation, EMG recording) nor radiological (cervical X-ray, MRI of the brain and spinal cord) investigations revealed any abnormalities of the spine, peripheral, or central nervous system to which the dystonic symptoms might be attributed. All the subjects gave their informed consent before entering the study.

Study procedure

According to the order in which they were referred to our rehabilitation center, the patients were submitted to two different sequences of treatment. Patients 1 and 3 underwent 15 sessions of PP followed by 15 sessions of EMG biofeedback, whereas the sequence of treatment was reversed in the other two patients. Since each session lasted approximately one hour, each patient received a total of 30 hours' therapy. Therapeutic sessions were carried out daily, from Monday to Friday, for six weeks. The two treatments were separated by a two-week interval, which was used for assessment.

The assessment procedure consisted of a head realignment test (HRT), a disability questionnaire (DQ) and a pain visual analogue scale (VAS). Performance was evaluated before treatment (T1), at the end of the first treatment (T2), and at the end of the second treatment (T3). Follow-up sessions were carried out at three (Fu3), six (Fu6), and nine (Fu9) months after the end of the second treatment. The outcome measures used in the follow-up evaluation were the DQ and the VAS. A performance baseline at T1 was obtained by repeating the HRT four times on four subsequent days. The stability of the pre-treatment baseline (T1 evaluation) was analyzed by means of the Friedman non-parametric test. Furthermore, the HRT was also applied, following the same procedure, at T2 and T3. The statistical analyses of the HRT were carried out on the averages of the four scores obtained at T1, T2 and T3. This procedure reduced variances related to possible spontaneous fluctuations in performance (7).

Statistical comparisons were carried out using the χ^2 test. The level of significance for multiple comparisons was adjusted according to the Bonferroni procedure (25). Comparisons were made between T1-T2, T2-T3, and T1-T3 (level of significance: $p<0.025$); T1-Fu3, T1-Fu6, T1-Fu9 (level of significance: $p<0.016$).

Measurement procedures

Head realignment test. This test, a modified version of that of Revel et al. (26), evaluated axial motor and postural control as well as perception of head-trunk alignment of patients with ICD. The apparatus consisted of a helmet, on which a laser pen was fixed, and a dartboard-like panel bearing 20 concentric circles. The radius of the outer circle was 20 cm. The radii of the other circles decreased progressively by 1 cm. Before the start of each test, the subjects, wearing the helmet, were seated at a distance of 90 cm from a wall onto which the laser beam was projected. They were required to align their head with their trunk while keeping their eyes open. Once alignment was achieved, the panel was attached to the wall, its center being made to correspond with the point where the laser beam fell. Each trial was carried out with eyes closed and the patient's head was passively rotated 20°, 40°, or 60° toward the right or the left. Then, the patient was requested to resume the starting position, i.e., their subjectively defined optimal head-trunk alignment. Once the patient had assumed the position and reported that his head and trunk were aligned, the examiner recorded the distance between the laser-beam projection and the center of the panel. This distance was used to assign a score, according to the following four-point scale of accuracy: four points were given when the distance between the beam and center of the panel was less than 5 cm, three points when the distance was between 5 and 10 cm, two points for distances between 10 and 15 cm and one point for distances between 15 and 20 cm. Zero points were given when distances were greater than 20 cm. Since blocks of 30 trials were carried out, the maximum score that could be reached in this test was 120 points. After each trial, patients opened their eyes and regained the starting position. The head was rotated passively leftward in 15 of the 30 trials (five trials for each angular displacement of 20°, 40° and 60° respectively) and rightward in the other 15 trials. The order of direction of rotation and angular displacement was randomized. The test lasted approximately one hour. In each evaluation phase (T1, T2 and T3), each of the patients underwent 4 blocks of trials (or complete tests) carried out on 4 different days. The HRT was always conducted by the same examiner, in the same room, and at the same time (10.00 a.m.). The reproducibility of the HRT was assessed by submitting two normal subjects to 5 blocks of trials, carried out on 5 different days. Consistency of results across sessions was verified by means of an ANOVA test for repeated measures. This analysis showed a good reproducibility of the HRT in both the normal subjects (Subject 1: $F<1$, $p=0.647$; Subject 2: $F<1$, $p=0.604$). The inter-observer reliability of the HRT was assessed by matching the data scored by four different observers for a single subject within a single session by means of a one-way ANOVA. Data scored by the different observers did not show any significant differences ($F<1$, $p=0.947$).

Disability questionnaire. Each patient was required to fill in a 16-item questionnaire (see Appendix) investigating impairment of activities of daily living due to dystonic head movements, and instructed to base his/her answers on the previous two-week period. Each item was scored on a five-point scale, in which four indicates normal performance and zero indicates maximum disability. Thus, the maximum possible score on the DQ was 64 points. This questionnaire is currently being validated in our rehabilitation unit.

Visual analogue scale. The VAS, a widely used instrument for assessing subjective pain (27), was used in order to assess cervical pain in our ICD patients. Higher scores (within a 0-10 range) indicate most intense cervical pain. The validity and reliability of the VAS is reported elsewhere (27).

Intervention

EMG biofeedback. EMG biofeedback is a widely used technique which trains patients to inhibit unwanted muscle contractions (13). The rehabilitative training was carried out following the procedure described by Korein et al. (16). The integrated EMG equipment used for providing feedback to the patient was the RSP Biofeedback (Modell TES-626, Treichler Electronic Systems, FL-9497 Triesenberg, imported by Sanitas, MI, Italy). This equipment utilizes digital integration, which rapidly reflects muscle activity. Patients obtained visual feedback regarding intensity of dystonic muscle contraction by looking at a 12-cm row of 16 light-emitting diodes (LEDs). The greater the muscle contraction the more LEDs were illuminated, thus longer lines indicated higher levels of contraction. Furthermore, changes in EMG activity were also signaled by means of auditory feedback consisting of a variation in the click rate or in the sound intensity of a pure tone. Faster clicks and louder noises thus indicated a higher level of muscle contraction.
In the first part of the treatment, patients were trained in volitional control of spasmodic activity, greater control corresponding to a reduction in the number of lighted LEDs and consequently, in noise levels. Thus, the patients used both auditory and visual feedback. According to the improvement shown by the patient, visual feedback provided by the LEDs was withdrawn. Patients then performed the task using only auditory feedback. Once patients had learned to control the activity of their spasmodic neck muscles while seated, more complex types of motor exercise were proposed with ongoing feedback. For example, patients were asked to perform limb movements or to change posture (e.g., from sitting to standing), simultaneously controlling the activity of their spasmodic neck muscles.

Physiotherapy program. Each physiotherapy session started with 20 minutes of passive myofascial elongation maneuvers according to the procedure proposed by Bienfait (23). Patients were supine on a physiotherapy bed with a therapist seated behind them. The therapist used a two-stage procedure aimed at reducing contraction of the target muscles. In the first stage, the therapist positioned his hands on the insertions of the target muscles and slowly induced their elongation for a few seconds. Care was taken to avoid causing pain. In the second stage, the therapist guided relaxation of the target muscles to their previous length. The target muscles were the sternocleidomastoid, scalene complex, levator scapulae, and upper trapezius (see Bienfait (23) for details).
After these maneuvers, the session continued for 40 minutes with exercises aimed at improving postural control while maintaining correct head-trunk alignment. These exercises were carried out following Souchard's principles of "global postural reeducation" (22).

Results

Head realignment test

In the pre-treatment baseline evaluation, no patient showed any significant fluctuation of performance on the HRT.
As shown in Figure 1, the PP induced a significant improvement of performance on the HRT in patients 3 and 4. Patient 2 showed a trend toward improvement. A significant improvement of performance after EMG biofeedback was seen in patients 1 and 3.
Table II summarizes the statistical comparisons.
All patients showed a significant improvement of performance in the T1-T3 comparisons (see PP+EMG and EMG+PP in Table II).

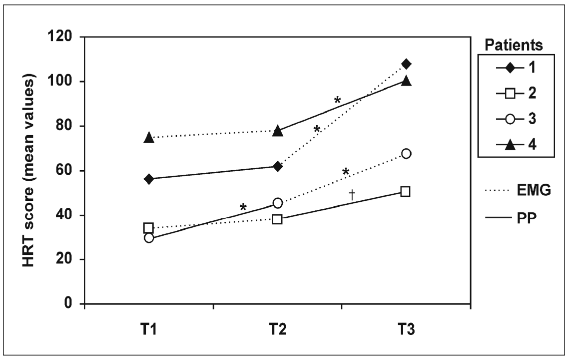

Figure 1 - Performance of ICD patients in the HRT.
High scores indicate accurate performance. Scores at T1, T2 and T3 are the average of four HRTs repeated on different consecutive days. *statistically significant; †trend toward significance.

Disability questionnaire

As shown in Figure 2, patients 1, 3, and 4 reported a significant reduction of their disability in activities of daily living as a result of the PP. EMG biofeedback, on the hand, led to a significant reduction of disability in patient 1, whereas patient 3 showed a marginal improvement of performance.
The T1-T3 comparisons showed that, with the exception of patient 2, all patients obtained significant improvements in performance (Table II). The shaded part of Figure 2 shows that follow-up assessments were carried out only in patients 1, 3, and 4. These patients maintained a significant reduction of daily life disability for six, nine and three months, respectively (Patient 1: T1-Fu6: χ^2=19.91, p<0.001; Patient 3: T1-Fu9: χ^2= 7.17, p=0.007; Patient 4: T1-Fu3: χ^2=5.92, p=0.014).

Visual analogue scale

Since patients 1 and 2 did not report any clinically significant cervical pain, no amelioration of VAS scores was expected (Fig. 3). On the other hand, patients 3 and 4 reported a progressive decrease in their cervical

pain. In patient 3, this decrease was statistically significant after the PP and approached significance after the EMG biofeedback.
The T1-T3 comparison showed that both patients achieved a significant reduction of pain (Table II). Therapeutic effects were maintained for six months in patient 3 (T1-Fu6: χ^2=13.33, p=0.002) and for three months in patient 4 (T1-Fu3: χ^2=5.00, p=0.025).

Discussion

The present study shows that a novel physiotherapy program based on postural reeducation exercises and on elongation maneuvers of myofascial cervical structures may have therapeutic benefits in patients with ICD. This beneficial effect may be at least as great as that of a standard program using EMG biofeedback. The outcome measures selected for the present study evaluated ability to align head with trunk, degree of disability in activities of daily living, and subjective pain induced by ICD. In the HRT, both the PP and the EMG biofeedback led to significant improvements in two patients. In the DQ, three patients reported a reduction of their disability following PP, whereas EMG biofeedback led to improvement in only one patient. The PP and the EMG biofeedback resulted in a similar reduction of subjective cervical pain, as indicated by VAS scores. The effects of treatments could not be ascribed to spontaneous fluctuations of performance given that all patients showed a stable performance in the pre-treatment baseline HRT.
During the two treatment phases (T1-T2 and T2-T3), there was an overall tendency towards progressive improvement in all the outcome measures. As a result, the level of improvement obtained in the T1-T3 comparisons was generally somewhat higher than that obtained in any single phase of treatment. On the one hand, this outcome could indicate that ICD patients need more than 15 sessions of treatment in order to obtain therapeutic effects. This suggestion is in agreement with previous studies on EMG biofeedback in which the therapeutic protocol involved more sessions than that of the present study (16,21). However, given the short interval between the two treatments (two weeks), a carry-over effect on the overall clinical improvement cannot be excluded in the present data. In this regard, patient 3 reported feeling that the reduction of muscular contracture induced by the PP seemed to prepare the neck muscles for the controlled activity car-

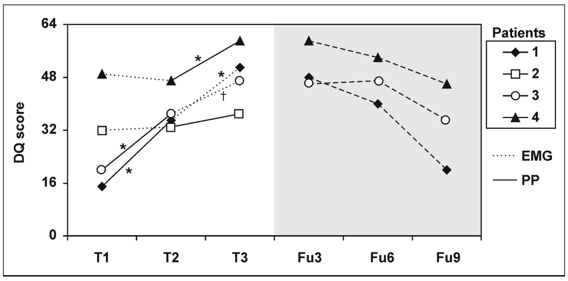

Figure 2 - DQ scores in all experimental evaluations.
High scores indicate low disability. Scores at T1, T2 and T3 are each an average of four DQ scores obtained on four consecutive days. The shaded portion refers to follow-up evaluations. *statistically significant; †trend toward significance.

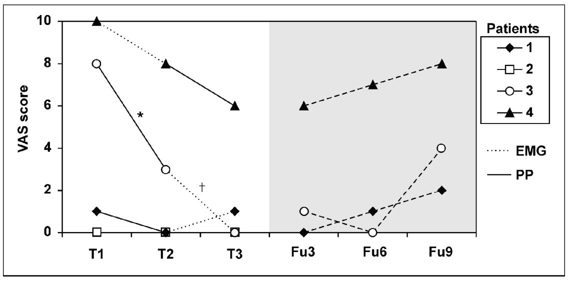

Figure 3 - VAS scores in all experimental evaluations.
High scores indicate intense pain. Scores at T1, T2 and T3 are each an average of four VAS scores obtained on four consecutive days. The shaded portion refers to follow-up evaluations. *statistically significant; †trend toward significance.

Table II - Results of statistical comparison.

Patients	Treatment	HRT	DQ	VAS
	PP	†	p<.001	n.p.
1	EMG	p<.001	p=.002	n.p.
	PP+EMG	p<.001	p<.001	n.p.
	PP	p=.094*	†	n.p.
2	EMG	†	†	n.p.
	EMG+PP	p=.023	†	n.p.
	PP	p=.025	p=.002	p=.024
3	EMG	p=.003	p=.062	p=.060*
	PP+EMG	p<.001	p<.001	p<.001
	PP	p=.008	p=.004	†
4	EMG	†	†	†
	EMG+PP	p<.001	p=.014	p=.015

* trend toward significance; †not significant; n.p.=no pain.

ried out in EMG biofeedback therapy. Unfortunately, the number of patients examined in the present study is insufficient to substantiate this suggestion. Future studies should be carried out with several focused objectives in mind. First, the question of whether each of these therapies is better administered alone or in combination should be addressed. Second, the optimal sequence of the two treatments (PP-EMG vs EMG-PP) needs to be determined. Lastly, it should be considered whether the promising results of the present study can be ascribed to non-specific factors such as an increase of attention. These studies should include larger groups of patients, with the possible addition of a placebo group.

An interesting issue in rehabilitation of ICD concerns the long-term duration of therapy. According to previous studies, the improvement on the DQ and the VAS as assessed at T3 evaluation was maintained for a period lasting from three to nine months following the end of training. This would suggest that amelioration of ICD might be maintained by twice-yearly administration of the therapeutic programs used in this study.

Cervical pain is a frequent complaint of patients with ICD. In some cases, the pain may be related to previous trauma around the head or neck (28). However, it is most often related to the prolonged anomalous posture maintained by patients with ICD. The very presence of pain can cause severe muscle spasms, which then exacerbate any movement disorder. On this basis, Foley-Nolan et al. (21) successfully treated a patient suffering from post-whiplash cervical dystonia with TENS. In the present study, the two patients reporting intense feelings of cervical pain before treatment experienced a progressive, significant reduction of pain symptoms after the end of the two phases of experimental treatment. Thus, in agreement with the study of Korein et al. (16) in patients submitted to a longer program of EMG biofeedback therapy, the correction of anomalous head posture of patients with ICD leads to a significant reduction of cervical pain.

Another interesting result of the present study emerges when comparing the effects of PP and EMG biofeedback. Indeed, EMG biofeedback has hitherto been considered the only sufficiently reliable rehabilitative procedure for ICD (16). The present study shows that PP produces performance improvements similar to those obtained with EMG biofeedback. These results, although preliminary, encourage future studies aimed at detailed evaluation of the usefulness of this novel rehabilitative approach to ICD.

In summary, the present report confirms the results of previous studies on the effect of EMG biofeedback and suggests that our novel PP may be useful for the rehabilitation of ICD.

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References

1. Nutt JG, Muenter MD, Aronson A, Kurland LT, Melton LJ 3rd. Epidemiology of focal and generalized dystonia in Rochester, Minnesota. Mov Disord 1988;3:188-194
2. Fahn S, Marsden CD, Calne DB. Classification and investigation of dystonia. In: Movement Disorders 2. London; Butterworths 1987
3. Meige H, Feingel EC. Tics and their treatment. London; Appleton 1907
4. Oppenheim H. Uber eine eigenertige Kampfrankheit des kindlichen und jugenlichen Aletrs (Dysbasia Lordotica Progressiva, Dystonia musculorum deformans). Neurol Zentbl 1911;30:1090-1107
5. Marsden CD, Harrison MJ, Bundey S. The natural history of idiopathic torsion dystonia. In: Dystonia. Advances in Neurology. Vol. 14. New York; Raven Press 1976
6. Berardelli A, Rothwell JC, Hallett M, Thompson PD, Manfredi M, Marsden CD. The pathophysiology of primary dystonia. Brain 1998;121:1195-1212
7. Dauer WT, Burke RE, Greene P, Fahn S. Current concepts on the clinical features, aetiology and management of idiopathic cervical dystonia. Brain 1998;121:547- 560
8. Rondot P, Marchand MP, Dellatolas G. Spasmodic torticollis - review of 220 patients. Can J Neurol Sci 1991;18: 143-151
9. Tsui JK, Eisen A, Stoessl AJ, Calne S, Calne DB. Double-blind study of botulinum toxin in spasmodic torticollis. Lancet 1986;2:245-247
10. Jahanshahi M, Marsden CD. Treatment for torticollis [letter]. J Neurol Neurosurg Psychiatry 1989;52:1212
11. Hurrel M. Electromyographic feedback in rehabilitation. Physiotherapy 1980;66:293-298
12. Brudny J, Grynbaum BB, Korein J. Spasmodic torticollis: treatment by feedback display of the EMG. Arch Phys Med Rehabil 1974;55:403-408
13. Health and Public Policy Committee, American College of Physicians. Biofeedback for neuromuscular disorders. Ann Intern Med 1985;102:854-858
14. Basmajian JV. Biofeedback in rehabilitation: a review of principles and practices. Arch Phys Med Rehabil 1981; 62:469-475
15. Orne MT. The efficacy of biofeedback therapy. Ann Rev Med 1979;30:489-503
16. Korein J, Brudny J, Grynbaum B, Sachs-Frankel G, Weisinger M, Levidow L. Sensory feedback therapy of spasmodic torticollis: results in treatment of 55 patients. In: Dystonia. Advances in Neurology. Vol. 14. New York; Raven Press 1976.
17. Keefe FJ, Surwit RS. Electromyographic biofeedback: behavioral treatment of neuromuscular disorders. J Behav Med 1978;1:13-24
18. Korein J, Brudny J. Integrated EMG feedback in the management of spasmodic torticollis and focal dystonia: a prospective study of 80 patients. Res Publ Assoc Res Nerv Ment Dis 1976;55:385-426
19. Jahanshahi M, Sartory G, Marsden CD. EMG biofeedback treatment of torticollis: a controlled outcome study. Biofeedback Self Regul 1991;16:413-448
20. Leplow B. Heterogeneity of biofeedback training effects in spasmodic torticollis: a single-case report. Behav Res Ther 1990;28:359-365
21. Foley-Nolan D, Kinirons M, Coughlan RJ, O'Connor P. Post whiplash dystonia well controlled by Transcutaneous Electrical Nervous Stimulation (TENS): case report. J Trauma 1990;30:909-910
22. Souchard PE. Le champ clos. Bases de la méthode de Rééducation Posturale Globale. 2ème edition. Saint-Mont; Le Pousoe Publ 1993
23. Bienfait M. Il trattamento delle fasce "Les Pompages". Milan; Quaderni A.I.T.R. 1987

24. Anastasopoulos D, Nasios G, Psilas K, Mergner T, Maurer C, Lucking CH. What is straight ahead to a patient with torticollis? Brain 1998;121:91-101
25. Kirk RE. Experimental design: procedures for the behavioral sciences. Belmont (CA); Brooks/Cole Publishing Company 1968
26. Revel M, Andre-Deshays C, Minguet M. Cervicocephalic kinesthetic sensibility in patients with cervical pain. Arch Phys Med Rehabil 1991;72:288-291
27. Carlsson AM. Assesment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. Pain 1983;16:87-101
28. Sheehy MP, Marsden CD. Trauma and pain in spasmodic torticollis. Lancet 1980;i:777-778

APPENDIX

DISABILITY QUESTIONNAIRE FOR PATIENTS WITH CERVICAL DYSTONIA

1. **Do you have tremor?**
   4 No
   3 Rarely
   2 Sometimes
   1 Often
   0 Always

2. **Are you able to write while standing up?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

3. **Can you drive a car?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

4. **Can you ride a bicycle?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

5. **Can you keep your head straight while walking?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

6. **Do you experience visual exploration difficulties while walking?**
   4 No
   3 Only slight difficulties
   2 Some difficulties easily overcome by compensatory movements
   1 Serious difficulties, but still surmountable
   0 Serious difficulties, often insurmountable

7. **Do you ever bump into things?**
   4 No
   3 Rarely
   2 Sometimes
   1 Often
   0 Always

8. **Can you see the shoulder opposite to your head deviation?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

9. **Can you see your navel?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No

10. **Do you have any difficulties eating?**
   4 No
   3 Only slight difficulties
   2 Some difficulties easily overcome by compensatory movements
   1 Serious difficulties, but still surmountable
   0 Serious difficulties, often insurmountable

11. **Do you use any particular maneuver to control your dystonic movements?**
   4 No
   3 Rarely
   2 Sometimes
   1 Often
   0 Always

12. **Do you have difficulties going down the stairs?**
   4 No
   3 Only slight difficulties
   2 Some difficulties easily overcome by compensatory movements
   1 Serious difficulties, but still surmountable
   0 Serious difficulties, often insurmountable

13. **Do you have difficulties when you dress yourself?**
   4 No
   3 Only slight difficulties
   2 Some difficulties easily overcome by compensatory movements
   1 Serious difficulties, but still surmountable
   0 Serious difficulties, often insurmountable

14. **Do you have difficulties at work?**
   4 No
   3 Only slight difficulties
   2 Some difficulties easily overcome by compensatory movements
   1 Serious difficulties, but still surmountable
   0 Serious difficulties, often insurmountable

15. **Do you feel awkward in social situations?**
   4 No
   3 A little awkward
   2 Considerable, but controllable, awkwardness
   1 I often escape from social situations
   0 I always escape from social situations

16. **Can you control your head when you take a photo?**
   4 Yes, normally
   3 Yes, with minimum effort
   2 Yes, but with difficulty
   1 Yes, but with great difficulty
   0 No