Effectiveness of dry needling for upper extremity spasticity, quality of life and function in subacute phase stroke patients

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ABSTRACT

Background: Stroke is the fourth leading cause of death in Europe, represents one of the most common causes of disability in adult patients, and involves considerable short- and long-term social and healthcare costs.

Objective: The effectiveness of deep dry needling (DDN) on affected arm functionality was assessed throughout 8 weeks of treatment in patients with stroke in the subacute phase.

Methods: Eighty patients were included in this two-group non-randomised study after a propensity score analysis was carried out. Both groups received standard physiotherapy treatment on the affected arm. The needling group also received 6 sessions of DDN during the 8-week period. Patients were evaluated before and after each session using the Fugl-Meyer upper extremity (FM UE) scale, the modified modified Ashworth scale (MMAS), the resistance to passive movement scale (REPAS) and a 10-point numeric pain rating scale (NPRS 10). The Brunnstrom recovery stage was recorded at the beginning and at the end of the study, and the EuroQoL quality of life survey was completed at the beginning of the study, after the first month of treatment and at the end of the study.

Results: Patients treated with DDN showed a reduction in spasticity measured using the REPAS ($p<0.001$) and the MMAS ($p<0.05$). There was also an improvement in the Brunnstrom recovery stages ($p<0.05$).

Conclusion: The addition of a specific DDN treatment to a standard physiotherapy treatment appeared to lead to a higher reduction in spasticity in the affected arm; however, it did not provide additional changes in functionality, pain and quality of life. Further studies with a randomised controlled trial design are required to confirm our findings.

Keywords

Stroke, upper extremity, functionality, muscle spasticity, dry needling

INTRODUCTION

Stroke is the fourth leading cause of death in Europe, represents one of the most common causes of disability in adult patients, and involves considerable short- and long-term social and healthcare costs.[1] Upper extremity impairments interfere with motor recovery and lead to a loss of patients' quality of life and independence in the activities of daily living (ADLs).[2] Twenty percent of patients develop medium- and long-term spasticity in the affected arm, in which the flexor muscles are most frequently affected.[3]

Different approaches have been proposed for spasticity treatment, with the infiltration of botulinum toxin (BTX) A being the most commonly used. However, BTX A infiltration may provoke adverse effects. Therefore, other treatment approaches, such as acupuncture or dry needling, have been proposed. According to a recent meta-analysis,[4] acupuncture has been shown to be effective at reducing spasticity at the elbow and wrist,[5,6] but only a few clinical trials[7–9] and case series[10] have shown that dry needling can be effective for spasticity management.[11]

One technique called Dry Needling for Hypertonia and Spasticity (DNHS®), which is a modality of deep dry needling (DDN) with specific diagnostic and application[12] criteria, developed for treating spasticity in patients with central nervous system impairments, merits special attention. To date, no studies have evaluated the effects of DDN on the spasticity and functionality of the affected upper extremity or on the perceived quality of life of patients with stroke in the subacute phase.

Based on previous studies showing the effectiveness of dry needling for stroke patients in the chronic phase, we hypothesised that stroke patients in the subacute phase receiving standard physiotherapy treatment plus dry needling would exhibit greater improvements in spasticity, upper extremity motor function and perceived quality of life than those patients receiving

standard physiotherapy treatment alone. The aim of this study was to compare the effect of an 8-week course of each therapy in patients in the subacute phase of stroke.

METHODS

Design

This was a single centre study with two non-randomised groups and a repeated measures mixed design (TREND guidelines).[13] Ten physiotherapists of the physiotherapy service of Guadarrama Hospital, experts in DDN and in the treatment of neurological patients, were involved. Since the present study was based on usual clinical practice, the allocation to the groups was not randomised; instead, patients received DDN plus standard physiotherapy treatment, or standard treatment only, depending on whether their usual physiotherapist had accredited training in DDN. The subsequent propensity score analysis allowed the extraction of a comparable subsample of both groups, simulating the conditions of a randomised clinical trial.

All the patients signed an informed consent document before participating. The study was approved by the Clinical Research Ethics Committee of Puerta de Hierro Majadahonda Hospital (act nº 14.17, dated 24 July 2017) and was registered at ClinicalTrials.org (ref. NCT03462693) on 12 March 2018. All procedures were applied in accordance with the Declaration of Helsinki.

Participants

The study was carried out in the rehabilitation service of Guadarrama Hospital between March and October 2018. In order to meet the criteria for inclusion in the study, participants needed to: (1) be aged ≥ 18 years; (2) understand and voluntarily sign the informed consent form before being included in the study; (3) have a medical diagnosis of ischaemic or haemorrhagic stroke in the subacute phase (1–3 months); and (4) have grade 1–3 spasticity in a muscular group of the affected upper extremity measured using the modified modified Ashworth scale (MMAS). The exclusion criteria were as follows: (1) flaccidity or rigidity in the muscles of the affected

arm (grades 0 or 4 measured using the MMAS); (2) receipt of a dose of BTX A in the previous two months; (3) cognitive or severe language impairment; (4) insurmountable needle phobia; or (5) any medical contraindication to the application of DDN.

Sample size

R Ver. 3.3.3 software was used. Due to the absence of data from patients with stroke in the subacute phase for a sample size calculation, a pilot study was conducted with 20 patients. Sample size was calculated with the results of the final score of the Fugl-Meyer upper extremity (FM UE) scale using an unpaired means model with an estimated effect size of 0.812. Using a two-tailed α value of 0.05 and 80% power, the sample size needed was calculated to be at least 28 subjects (14 per group).

Propensity score analysis

Given that there was no randomisation in the current study, a propensity score analysis (PSA) was used to pair the patients in each group according to baseline demographic and clinical variables and create a quasi-randomised design. The baseline variables used were age, sex, the affected side of the body, the Barthel index, the presence of pain in the affected shoulder, smoking history, hypertension and prior diagnosis of diabetes mellitus, cardiovascular risk factors and trunk control in a sitting position (evaluated by the trunk control test). A standardized difference of means higher than 0.2 was used to consider the existence of significant differences between groups for each of the assessed variables.[14,15]

Outcome measurements

Primary outcome measurement—Fugl-Meyer upper extremity scale: FM UE is a quantitative cumulative scale designed to evaluate motor development and balance in patients with stroke.[16] There is a maximum score of 66 points in the motor function block, 12 for sensation, 24 for passive joint motion and 24 for joint pain.

Resistance to passive movement scale: The resistance to passive movement scale (REPAS) is a quantitative scale that represents the summation of all scores obtained with the Ashworth scale in the upper extremity when assessing resistance to passive stretch during the following movements: shoulder abduction; elbow flexion and extension; forearm supination; and wrist and finger extension.[17]

Modified modified Ashworth scale*:* The MMAS is an ordinal scale used to evaluate spasticity in patients with stroke. This scale assesses the resistance to passive stretching of affected muscles, with a scoring system from 0 (= no increase in muscle tone) to 4 (= affected part(s) rigid in flexion or extension).[18,19]

Brunnstrom recovery stages: The Brunnstrom scale is an ordinal scale that classifies the motor recovery of the affected upper extremity in patients with stroke into six stages, from 1 (flaccid paralysis) to 6 (normal movement with normal speed).[20]

EuroQoL 5D-5L: The EuroQoL 5D-5L is a quality of life questionnaire composed of five domains (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) scored with a reverse 5-point Likert scale, from 1 (indicating no problem) to 5 (indicating extreme problems).[21]

10-point numeric pain rating scale: The 10-point numeric pain rating scale (NPRS 10) evaluates pain from 0 (no pain) to 10 (the most intense pain imaginable).[22,23]

Adverse events: Adverse effects during the study (e.g. bleeding, haematoma, post-dry needling pain) were recorded.

Local twitch response: The existence of local twitch responses (LTRs) and number of them were recorded during the dry needling application.

All outcome measurements were recorded at the beginning and at the end of the study (8 weeks). In addition, the EuroQoL 5D-5L was recorded at 4 weeks and the FM UE, MMAS, REPAS and NPRS 10 were recorded immediately before and after each session of DDN.

Intervention

Patients received standard physiotherapy treatment according to the standardised work plans used in daily clinical practice at Guadarrama Hospital. The treatment protocol consisted of a multimodal approach for the affected upper extremity (allowing the inclusion of DDN if the physiotherapist had the training and experience to apply it), focusing on the reduction of spasticity, passive positioning of the upper extremity and repetitive task training exercises,[24] and lasted 45 minutes, 5 days a week. Therefore, the eligible patients included in the study were treated by their usual physiotherapist and were classified into two groups depending on whether they were receiving DDN treatment in their session. A period of 7 days between DDN treatments was always respected to allow tissue repair.[25] An independent assessor blinded to the intervention recorded the outcomes.

In the case of the DDN group, DDN treatment was included in 6 of the standard treatment sessions (weeks 1, 2, 3, 4, 6 and 8) according to the normalized protocol used at Guadarrama Hospital for dry needling application. In each DDN session and according to the aforementioned inclusion criteria, the muscle groups that presented a score of 1 to 3 in the MMAS were treated and then evaluated (Figure 1).

The clinician followed the published DNHS® essential diagnostic criteria for patients with neurological impairments.[26] The DDN application was based on the DNHS®12 technique. The intensity of the application was adjusted according to the patients' tolerance. Repeated needle insertions were performed in the muscle at approximately 1 Hz. LTRs were intended to be achieved for every muscle treated.

The DNHS® technique was performed using solid filiform disposable needles for dry needling measuring 0.25x25 mm and 0.25x40 mm (Agupunt, Barcelona, Spain), based on the depth of the muscles to be treated, with the aid of guide tubes after cleaning the skin with antiseptic.

Statistical analysis

The statistical analysis was carried out using R Ver. 3.3.3 software. The analysis of missing values was performed by intention-to-treat. The level of significance was established at $p<0.05$. The non-parametric effect size between groups in the quantitative variables (r) was defined as <0.20 (not relevant), ≥ 0.20 and <0.50 (small), ≥ 0.50 and <0.80 (moderate), and ≥ 0.80 (large); the effect size in the categorical variables (Cohen's g) was defined as ≥ 0.05 and <0.15 (small), ≥ 0.15 and <0.25 (moderate), and ≥ 0.25 (large). A PSA was performed with the aim of extracting a comparable subsample of both groups on which the analysis was carried out. The Shapiro-Wilk test was performed to determine the normality of the distribution for all quantitative variables. The qualitative variables were described in absolute values and frequencies and with the median and interquartile range (IQR) for the global scores; the quantitative variables were described by the mean and standard deviation (SD). Given that the PSA creates samples that are considered related, the Wilcoxon signed-rank test was used on groups in each of the sessions to analyse the REPAS, FM UE, NPRS 10 and EuroQoL 5D-5L scores. To analyse the changes in the MMAS and Brunnstrom stages, McNemar's test was used between groups for each of the levels of each scale in each session. A generalized estimation equations (GEE) model, a regression model with the paired samples obtained with the PSA, and Spearman correlation test, were applied to the final scores of the REPAS, FM UE and EuroQoL 5D-5L as predictors of the intervention group (forward steps method). It was analysed with the Wilcoxon signed-rank test if the presence or absence of at least one LTR in any of the muscles treated in each session were associated with different therapeutic effects.

RESULTS

Patient flow through the study

The eligibility criteria were applied to a total of 218 patients. After carrying out a propensity analysis, a final sample of 40 patients from each group was obtained (Table 1), on which the statistical analysis was performed (Figure 2).

Table 1: Baseline characteristics of patients

		Dry needling (n=40)	Standard treatment (n=40)	SMD
Age		72.6±14	73.7±12.8	0.086
Sex	Male	20 (50%)	20 (50%)	<0.001
	Female	20 (50%)	20 (50%)	
Days since stroke		35.9±13.6	33.7±17.3	0.141
Type of stroke	Haemorrhagic	19 (48%)	17 (43%)	0.099
	Ischaemic	21 (52%)	23 (57%)	
Side of body	Right	17 (43%)	16 (40%)	0.050
	Left	23 (57%)	24 (60%)	
Body mass index		24.9±4.1	25.6±3.8	0.157
Smoker	No	30 (75%)	32 (80%)	0.118
	Yes	10 (25%)	8 (20%)	
Diabetes mellitus	No	30 (75%)	27 (68%)	0.164
	Yes	10 (25%)	13 (32%)	
Hypertension	No	13 (32%)	16 (40%)	0.155
	Yes	27 (68%)	24 (60%)	
Heart disease	No	24 (60%)	25 (62%)	0.051
	Yes	16 (40%)	15 (38%)	
Barthel index		18.6±18	16.7±14.8	0.114
Trunk control test		44.6±28.4	41.1±27	0.125
NPRS 10 at shoulder		6.9±1.7	7.4±1.2	0.043

NPRS 10: 10-point numeric pain rating scale; SMD: standardized mean difference (significant if SMD>0.2). Data are expressed as the mean and standard deviation and as absolute and relative values (%).

Affected arm function

No significant differences were found between the groups on the FM UE scale (primary outcome). With regard to the Brunnstrom stages, significant differences were found between the groups after treatment in patients at Brunnstrom stage 2 ($X^2(1)=4.558$, $p=0.032$) and 6 ($X^2(1)=36.026$, $p<0.001$), with a moderate to large effect size in favour of the DDN group (Table 2).

Table 2: Fugl-Meyer upper extremity scores and Brunnstrom stages

	Dry needling (n=40)	Standard treatment (n=40)	Cohen's g (95% CI)
Fugl-Meyer upper extremity scale			
Function motor block			
T1	23.5±15	27.5±16.1	
T12	33.2±17.4	32.4±17.6	
Sensation			
T1	9.2±4.4	11.2±1.5	
T12	10.1±3.7	10.9±2.1	
Passive joint motion			
T1	20.9±5.9	22.9±1.7	
T12	21.9±4.6	22.3±2.3	
Joint pain			
T1	19.6±7.1	22.7±2.2	
T12	73.3±27.2	81.7±21.3	
Total Fugl-Meyer score			

T1	73.3±27.2	81.7±21.3	
T12	85.9±27.1	87.8±21.6	
Brunnstrom recovery stage 1			
T1	1 (1%)	1 (3%)	
T12	0 (0%)	1 (3%)	
Brunnstrom recovery stage 2			
T1	24 (60%)	23 (58%)	
T12	11 (28%) [a]	14 (35%) [a]	0.174 (0.027, 0.203)
Brunnstrom recovery stage 3			
T1	6 (15%)	6 (15%)	
T12	10 (25%)	6 (15%)	
Brunnstrom recovery stage 4			
T1	7 (18%)	7 (18%)	
T12	11 (28%)	9 (23%)	
Brunnstrom recovery stage 5			
T1	2 (5%)	3 (8%)	
T12	6 (15%)	10 (25%)	
Brunnstrom recovery stage 6			
T1	0 (0%)	0 (0%)	
T12	2 (5%) [a]	0 (0%) [a]	0.5 (0.031, 0.5)
Total Brunnstrom score			
T1	2 [2, 3]	2 [2, 3]	
T12	3 [2, 4]	3 [2, 4]	

CI: confidence interval; T1: pre-treatment session 1; T12: post-treatment session 6; Cohen`s g = effect size for qualitative variables with dependent samples. Data are expressed as median [interquartile range] and as absolute and relative values (%).

[a] Statistically significant differences ($p<0.05$)

Spasticity of the affected arm

There was a decrease of 2.5 points on the REPAS scale in the DDN group compared to an increase of 2.6 points in the standard treatment group, with a significant difference of 6.15 (95% confidence interval (CI) 5-8) points between groups after the last session ($Z=6.135$, $p<0.001$) and with a moderate effect size in favour of the DDN group (Table 3).

There were significant differences in MMAS scores between the groups after the last session for the following movements: (a) MMAS of 0 in elbow extension ($X^2(1)=21.043$, $p<0.01$), forearm supination ($X^2(1)=9.09$, $p=0.003$), wrist extension ($X^2(1)=7.111$, $p=0.008$) and finger extension ($X^2(1)=8.1$, $p=0.004$), with a greater improvement in the number of patients without spasticity in the DDN group and large effect sizes in favour of the DDN group; (b) MMAS of 2 in shoulder abduction ($X^2(1)=5.785$, $p=0.016$), with fewer patients with a MMAS degree of 2 in the DDN group and a large effect size in favour of the DDN group. Regarding MMAS scores, there was a median improvement of 1 point at the end of treatment (8 weeks) in the DDN group for shoulder abduction (1 [1, 2]), forearm supination (1 [1, 2]), wrist extension (1 [0, 2]) and finger extension (1 [1, 2]) compared to the standard treatment group (Table 3).

Table 3: Spasticity scores measured with the modified modified Ashworth scale and the resistance to passive movement scale

	Dry needling (n=40)	Standard treatment (n=40)	Cohen's g (95% CI)

MMAS	T1	T12	T1	T12	
Shoulder abduction	2 [2, 2]	1 [1, 2]	2 [1, 2]	2 [2, 2]	
Grade 0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Grade 1	1 (3%)	2 (5%)	6 (15%)	5 (13%)	
Grade 2	3 (8%)	1 (3%) [a]	8 (20%)	12 (30%) [a]	0.357 (0.318, 0.423)
Grade 3	1 (3%)	0 (0%)	2 (5%)	4 (10%)	
Elbow extension	2 [1, 2]	2 [1, 2]	2 [1, 2]	2 [1, 2]	
Grade 0	0 (0%)	5 (13%) [a]	0 (0%)	0 (0%) [a]	0.5 (0.117, 0.5)
Grade 1	10 (25%)	7 (18%)	15 (38%)	13 (33%)	
Grade 2	14 (35%)	15 (38%)	15 (38%)	18 (45%)	
Grade 3	8 (20%)	1 (3%)	1 (3%)	6 (15%)	
Elbow flexion	2 [1, 2]	1 [0, 1]	1 [1, 2]	2 [1, 2]	
Grade 0	0 (0%)	3 (8%)	0 (0%)	0 (0%)	
Grade 1	5 (13%)	2 (5%)	9 (23%)	9 (23%)	
Grade 2	4 (10%)	1 (3%)	6 (15%)	6 (15%)	
Grade 3	2 (5%)	0 (0%)	1 (3%)	3 (8%)	
Forearm supination	2 [1, 3]	1 [1, 2]	1 [1, 2]	2 [1, 3]	
Grade 0	0 (0%)	3 (8%) [a]	0 (0%)	0 (0%) [a]	0.5 (0.284, 0.5)
Grade 1	7 (18%)	7 (18%)	24 (60%)	17 (43%)	
Grade 2	7 (18%)	3 (8%)	12 (30%)	12 (30%)	
Grade 3	5 (13%)	1 (3%)	1 (3%)	11 (28%)	
Wrist extension	2 [2, 2]	1 [0, 2]	1 [1, 2]	2 [1, 3]	
Grade 0	0 (0%)	4 (10%) [a]	0 (0%)	0 (0%) [a]	0.5 (0.309, 0.5)

Grade 1	3 (8%)	3 (8%)	18 (45%)	12 (30%)	
Grade 2	14 (35%)	5 (13%)	15 (38%)	12 (30%)	
Grade 3	4 (10%)	1 (3%)	2 (5%)	14 (35%)	
Finger extension	2 [2, 3]	1 [1, 2]	1.5 [1, 2]	2 [1, 3]	
Grade 0	0 (0%)	2 (5%) [a]	0 (0%)	0 (0%) [a]	0.5 (0.23, 0.5)
Grade 1	3 (8%)	5 (13%)	9 (23%)	11 (28%)	
Grade 2	5 (13%)	5 (13%)	7 (18%)	8 (20%)	
Grade 3	4 (10%)	0 (0%)	2 (5%)	8 (20%)	
REPAS					r (95% CI)
T1	4.9±3.2		5.9±2.5		
T12	2.4±1.8 [a]		8.5±4.1 [a]		0.685 (0.496, 0.781)

CI: confidence interval; T1: pre-treatment session 1; T12: post-treatment session 6; MMAS: modified modified Ashworth scale; REPAS: resistance to passive movement scale; Cohen`s g = effect size for qualitative variables with dependent samples (reported only when significant differences exist between groups); r = effect size for quantitative variables. Data are expressed as median [interquartile range], mean ± standard deviation, and in absolute and relative values (%).

[a] Statistically significant differences ($p<0.05$)

Quality of life and pain

In the EuroQoL 5D-5L survey, a significant difference of 0.57 (95% CI 0-1.5) points between groups was found after the fourth needling session in the self-care dimension ($Z=7.137$, $p<0.001$), with a reduction of over 0.95 points in the needling group and 0.21 points in the standard treatment group and a large effect size in favour of the DDN group. There were no

significant differences ($p>0.05$) found in the pain measured with the NPRS 10 between groups in any of the sessions.

Modelling the result variables

The final GEE model was significant and indicated that the final scores in the REPAS (coefficient= -1.638, $p<0.001$) and motor function block of the FM UE (coefficient=0.341, $p=0.048$) scales were associated with the group. The Spearman test showed a significant and negative correlation ($\rho=-0.27$, $p=0.015$) between the final scores in the REPAS and the motor function block of the FM UE scale.

Deep dry needling schedule

Out of a total of 545 needlings, only 10 (2.1%) presented an adverse event in the form of a small post-DDN haematoma. The muscles most frequently treated were the biceps brachii (33%), followed by the flexor carpi ulnaris (20%) and pronator teres (18%). Thirty entries with the needle were applied in 83.3% of the treatments: this number was lower in some instances, owing to the patient's tolerance or because LTRs ceased. In 41% of the patients, there were no LTRs, and when LTRs appeared, they ranged from one (24%) to two (21%) by needling muscle. LTRs were mainly found in biceps brachii (17%), flexor carpi ulnaris (14%) and pronator teres (12%). No significant differences between groups were found in the outcome measures from each session regarding the presence or absence of LTRs.

DISCUSSION

The results obtained in this study suggests that adding the application of dry needling in eight of the sessions of a multimodal standard physiotherapy programme for eight weeks leads to a higher reduction in spasticity in the affected arm. However, dry needling did not provide

additional changes in functionality, pain or quality of life when compared with the standard treatment group.

Notably, most of the previously published studies focus on the treatment of the lower extremities,[27] with few studies evaluating the efficacy of DDN on the upper extremities.[9] These have usually been case studies[11,28] or single group studies.[10,29] Although some randomised trials with a comparator[9,27] have been reported, the evidence is still scarce. However, all these studies have been carried out with stroke patients in the chronic phase. There are very few studies that have evaluated the efficacy of DDN during the subacute[30] phases (less than three months) and the outcomes have been restricted to pain.

The spasticity in the needling group, both in the global REPAS score as well as when measured by the MMAS scale, was significantly reduced when compared with the standard treatment group at the end of the study. The improvements observed in shoulder abduction, elbow extension, forearm supination and wrist and finger extension are similar to results found in previous studies.[9,31] Although the mechanisms involved in spasticity changes due to dry needling are not clear, they seem to be related to local changes in the muscle fibres[32] and improvements in H_{max}/M_{max}[10] activity.

Although no significant changes between groups were found in the scores of the FM UE scale, larger increases in the motor function block (9.6 points in the DDN group vs. 4.88 points in the standard treatment group) and total score (12.6 points in the DDN group vs. 6.08 points in the standard treatment group) were noted in the needling group. This improvement in motor skills is in line with previous studies that have described an increase in activity range[9,31,33] and in the analytic motor skills of the hand.[10] This fact can be linked to the significant increase in the number of patients treated with DDN that reached Brunnstrom stage 6 (not achieved in the standard treatment group) and who stopped presenting a stage 2 as described by Ansari et al.[33] The GEE model and the Spearman test also indicated that patients treated with DDN tended to

obtain the greatest reductions in spasticity and the greatest improvements in motor function, consistent with the findings of DiLorenzo et al.[30]

No differences were found in the results of the DDN group depending on the presence of an LTR. These data are in apparent disagreement with previous studies that linked the appearance of LTRs with greater effectiveness,[34] although, in the case of neurological patients, there are currently no studies with conclusive results that can correlate this response with the effectiveness of the technique.[30,35]

Limitations

The main limitation of the present study is the non-randomised design: despite balancing both groups using PSA, it is not possible to avoid the presence of potentially confounding non-included variables that make comparison between the groups difficult. Accordingly, we cannot prove a causal relationship between the interventions and outcomes. In addition, both patients and physiotherapists were not blinded, therefore specific effects of the needling could not be distinguished from non-specific (including contextual) effects, placebo effects and regression to the mean.

Conclusions

The results of the present study indicate that DDN is a safe technique and may be effective at reducing the spasticity of the treated muscles in the affected arm. It is not clear that the appearance or absence of LTRs is necessary to achieve significant improvements in patients with stroke. Studies with a randomised controlled trial design and post-treatment follow-up are required to evaluate the actual impact of DDN to draw conclusions that can guide clinical practice.

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Conflict of interest statement

The DNHS® technique was registered by Pablo Herrero. The other authors of this work declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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FIGURE LEGENDS

Figure 1

Deep dry needling of pectoralis major (A), biceps brachii (B), triceps brachii (C), pronator teres (D), flexor carpi ulnaris (E) and flexor digitorum superficialis and profundus (F).

Figure 2

Flow diagram of patients through the course of the study. BTA, botulinum toxin. MMAS, modified modified Ashworth scale.