

Clinical Effects of Capacitive Electric Transfer Hyperthermia Therapy for Cervico-Omo-Brachial Pain

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Abstract. We conducted physical therapy for patients suffering from cervico-omo-brachial pain (n=22) with high frequency hyperthermia equipment by a capacitive electric transfer method, MD-303 (0.65 ± 0.05 MHz), which is employed in Europe and America. The 22 patients comprised 6 with cervical spondylosis deformans, 6 with cervico-omo-brachial pain syndrome, 4 with periartthritis scapulohumeralis, 3 with cervical sprain, 2 with tennis elbow, and 1 with RA hand. The electrotherapy was performed 10 times in total, for 20 min per time. A rise in skin temperature was observed even 15 min after treatment, with no occurrence of adverse reactions, and this therapy was highly effective in relieving pain, with an efficacy rate of 81.8%. This paper reports the results of the use of this therapy.

Key words: Cervico-omo-brachial pain, Physical therapy, Capacitive electric transfer.

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INTRODUCTION

Various types of physiotherapeutic equipment are used in Japan. However, little use is made of high-frequency-range hyperthermia equipment. We used hyperthermia equipment with a radio frequency, particularly the middle frequency range, for the treatment of various cervico-omo-brachial pain symptoms. This paper mainly describes the results of the use of this therapy, with an overview of relevant publications.

METHODS

1. Subjects

Twenty-two volunteer patients with various cervico-omo-brachial pain symptoms for whom electrotherapy was not contraindicated were en-

rolled in this study. The 22 patients consisted of 17 females and 5 males, with a mean age of 46.3 years (range, 21 to 71 years old).

The patients suffered from the following diseases: cervical spondylosis deformans (6), cervico-omo-brachial pain syndrome (6), periartthritis scapulohumeralis (4), cervical sprain (3), tennis elbow (2) and RA hand (1) (Table 1).

2. Equipment used and manner of electricity usage

The appearance of and specifications for high frequency hyperthermia equipment, MD-303, are shown in Fig. 1. Hyperthermia therapy was conducted for 20 min once daily, 10 times in total. Therapeutic efficacy was evaluated in terms of improvement in post-treatment symptoms from pretreatment symptoms. No other therapies that might affect the therapeutic efficacy judgment were conducted. It was decided not to change the medi-

cation the patients had been receiving before the study. Therapies and medication conducted for diseases other than the target symptoms of the study were continued, unless they affected the present assessment.

A 40 mm or 50 mm movable electrode was used for the affected site, and a rod electrode was gripped as the return electrode for the affected side hand.

The electrotherapy was performed in the following manner: paste was applied to the site with the severest pain and its adjacent area, and electric output was raised by moving the movable electrode within the patient's tolerance level, while a skin temperature tolerable to the patient was maintained.

3. Evaluation methods

Evaluation of symptoms, finally including the presence or absence of adverse reactions, was carried out before the start of treatment and after the

end of the 10th treatment.

Symptom evaluation items included spontaneous pain, projected pain, motor pain, feeling of shoulder stiffness, numbness, limited motion and tenderness. These symptoms were evaluated according to severity classification standards (Table 2) set with reference to the Pain and QOL Scale⁷⁾.

How symptoms, following the 10th treatment, changed from pretreatment symptoms was evaluated in terms of their severity (changes in grades).

A seven-grade ranking scale was used to evaluate the above-mentioned improvement of each symptom in accordance with the improvement evaluation standards (Table 3). For reference, skin temperature changes were observed before, immediately after, and 15 min after the third, fifth, and 10th treatment using thermography.

The therapeutic effectiveness of the hyperthermia equipment was judged in accordance with the effectiveness evaluation and judgment standards (Table 4), with reference to the symptom improvement evaluation standards.

The safety of the equipment was judged based on the overall evaluation of the presence or absence of adverse reactions, the operation state of the equipment during usage, etc.

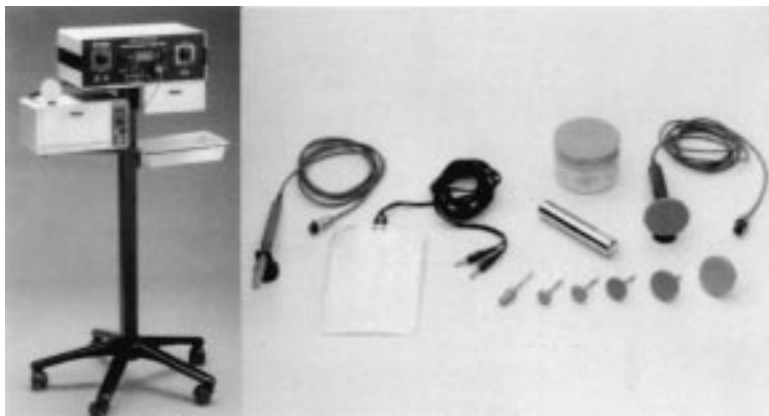
RESULTS

1. Therapeutic efficacy

The mean therapeutic effectiveness of all of the patients improved from grades before treatment of 9.5 ± 4.75 (from 2 to 18 grades), to grades after the

Table 1. Patients

	N.O
Cervical spondylosis deformans	6
Cervico-omo-brachial pain syndrome	6
Periarthritis scapulohumeralis	4
Cervical sprain	3
Tennis elbow	2
RA hand	1
Total	22



MD-303 Return electrode Movable electrode

General Characteristics

Frequency	0.65±0.05MHz
Output Power	140W
Maximum Capacity of Electrode	400pF
Required Voltage	100V
Required Frequency	50/60Hz
Required Input Power	320W
Dimensions	602×430×170 mm
Weight	13.5 kg

Fig. 1. Hyperthermia equipment MD-303

10th treatment of 6.32 ± 3.36 (from 1 to 13 grades) (Table 5). A statistically significant difference in this symptom improvement was observed between before and after treatment (Student's t-test, $p=0.05$).

Table 2. Symptom severity classification standards

Grade	Severity of symptoms
4	Daily life is extremely limited, with findings of intolerable symptoms (pain, numbness, limited movement, etc.)
3	Daily life is very limited, with findings of severe symptoms (pain, numbness, limited movement, etc.)
2	Daily life is moderately limited, with findings of moderate symptoms (pain, numbness, limited movement, etc.)
1	Daily life is slightly limited, with findings of slight symptoms (pain, numbness, limited movement, etc.)
0	No limit to daily life is observed, with no findings of symptoms (pain, numbness, limited movement, etc.)

The results of improvement evaluation of the seven symptom items in accordance with the improvement evaluation standards (Table 4) are shown in Table 6. Two patients exhibited slight exacerbations, including projected pain, feeling of shoulder stiffness, and numbness, and another two patients, symptoms were unchanged (Tables 5 and 6).

2. Changes in skin temperature

The skin temperature of the affected site changed from $29.3\text{--}29.8^\circ\text{C}$ before treatment to $29.7\text{--}29.8^\circ\text{C}$ immediately after treatment, and further to $30.6\text{--}31.3^\circ\text{C}$ 15 min after treatment. The skin temperature rose statistically significantly following every treatment, i.e. immediately and 15 min after treatment, compared with the pretreatment temperature (Student's t-test, $p=0.05$). It was particularly noted that the skin temperature was elevated even at 15 min after treatment (Fig. 2). Fig. 3 shows an effective case. The patient was a 57-year-old female suffering from right periartthritis scapulohumeralis. Seventeen grades for

Table 3. Symptom improvement evaluation standards

Improved	Details			
Marked improvement	Three-level or more improvement in symptoms and findings	4-0	4-1	3-0
Improvement	Two-level or more improvement in symptoms and findings, or post-treatment disappearance of pretreatment symptoms, despite their grade being 1	4-2	3-1	2-0
Slight improvement	One level or more improvement in symptoms and findings	4-3	3-2	2-1 1-0
Unchanged	No change in symptoms or findings	4-4	3-3	2-2 1-1
Slight exacerbation	One-level exacerbation of symptoms and findings			
Exacerbation	Two-level or more exacerbation of symptoms and findings			
Marked exacerbation	Two-level or more exacerbation of symptoms and findings			

Table 4. Effectiveness evaluation judgment standards

Effectiveness judgment standards		
Very effective	Marked improvement in four or more items	However, if slight or more exacerbation of even one item is observed, the case was judged as not applicable and treated as applicable to the following evaluation. However, if slight or more exacerbation of even one item is observed, the case was judged as not applicable and treated as applicable to the following evaluation.
Effective	Marked improvement, improvement, or slight improvement in three or more items	
Slightly effective	Marked improvement, improvement, or slight improvement in one or more items	
Ineffective	No change in four or more items, with no item showing slight or better improvement	
Slightly exacerbated	Slight exacerbation of even one item	
Exacerbated	Exacerbation or marked exacerbation of even one item	
Markedly exacerbated	Marked exacerbation of two or more items	

Table 5. Therapeutic effectiveness

N.O.	Age (yr)	Gender	Clinical diagnosis	Spontaneous pain	Projected pain	Motor pain	Feeling of shoulder stiffness	Numbness	Limited motion	Tenderness	Total score before treatment	Total score after 10th treatment	Effectiveness
1	55	M	CSD	2-2	3-2	3-1	3-1	3-1	2-1	2-2	18	10	E
2	57	F	PSH	2-1	2-1	3-2	3-2	3-0	2-1	2-0	17	7	E
3	71	M	CSD	3-2	3-2	2-2	3-3	3-1	1-1	2-2	17	13	E
4	25	F	CS	2-2	0-0	2-2	3-2	0-0	1-1	2-1	10	8	SEF
5	48	F	PSH	3-2	2-2	2-2	3-3	0-0	0-0	3-2	13	11	SEF
6	68	F	CSD	3-2	3-0	3-2	3-2	1-0	2-1	2-2	17	9	E
7	34	M	CS	3-2	2-0	3-3	2-2	2-1	2-1	2-1	16	10	E
8	32	F	COB	1-1	0-0	1-1	2-1	1-0	1-1	1-0	7	4	E
9	26	F	COB	2-1	0-0	2-2	1-1	0-0	0-0	1-1	6	5	SEF
10	65	F	CSD	2-0	2-0	2-1	2-0	0-0	1-1	0-0	9	2	E
11	53	M	CSD	2-1	0-0	2-2	2-2	2-2	2-2	2-2	12	11	SEF
12	54	F	COB	2-2	0-0	2-2	2-1	0-0	1-1	0-0	7	6	SEF
13	36	F	COB	0-0	0-0	3-3	1-1	0-0	3-3	0-0	7	7	IE
14	52	F	PSH	0-0	0-1	3-2	2-1	0-0	1-1	2-1	8	6	SEX
15	52	F	CSD	2-0	0-0	0-0	1-2	1-2	0-0	0-0	4	4	SEX
16	24	F	COB	2-1	0-0	2-1	2-1	0-0	0-0	0-0	6	3	E
17	70	F	PSH	0-0	0-0	2-1	2-1	0-0	1-1	2-1	7	4	E
18	39	M	COB	0-0	0-0	2-0	2-1	0-0	0-0	0-0	4	1	SEF
19	23	F	CS	2-0	0-0	2-1	2-1	0-0	1-1	1-1	8	4	E
20	68	F	RA	1-1	0-0	2-2	0-0	0-0	2-2	2-2	7	7	IE
21	45	F	TE	2-1	0-0	2-2	2-1	1-1	0-0	2-1	9	6	E
22	21	F	TE	0-0	0-0	1-1	0-0	0-0	0-0	1-0	2	1	SEF

Clinical diagnosis: Cervical spondylosis deformans (CSD), Cervico-omo-brachial pain syndrome (COB), Periarthritis scapulohumeralis (PSH), Cervical sprain (CS), Tennis elbow (TE), RA hand (RA). Effectiveness: Very effective (VE), Effective (E), Slightly effective (SEF), Ineffective (IE), Slightly exacerbated (SEX), Exacerbated (EX), Markedly exacerbated (MEX).

pretreatment symptoms improved to 7 grades for symptoms after the 10th treatment. At the third treatment, the skin temperature of the affected site was 29.0°C before treatment, 29.8°C immediately after treatment, and 32.6°C at 15 min after treatment. A marked rise of the skin temperature even after the end of treatment was observed.

3. Effectiveness rate

The effectiveness of the hyperthermia equipment was judged in accordance with the effectiveness evaluation judgment standards (Table 4). The rates of “very effective” patients, “effective” patients, and “slightly effective” patients were 0.0%, 50.0%, and 31.8%, respectively. The total of “slightly effective” and effective patients accounted for 81.8% (18/22 patients) (Table 6).

4. Safety

One patient exhibited increased pain of the affected site a few hr after the electricity was used. However, no adverse reactions due to the hyper-

Table 6. Effectiveness rate

	N.O	%
Very effective	0	0.0
Effective	11	50.0
Slightly effective	7	31.8
Ineffective	2	9.1
Slightly exacerbated	2	9.1
Exacerbated	0	0.0
Markedly exacerbated	0	0.0
Total	22	100.0

“Slightly effective” and better patients were treated as effective cases.

thermia equipment were observed, and there were no safety problems.

DISCUSSION

1. High-frequency hyperthermia equipment

The frequency used for high-frequency therapy

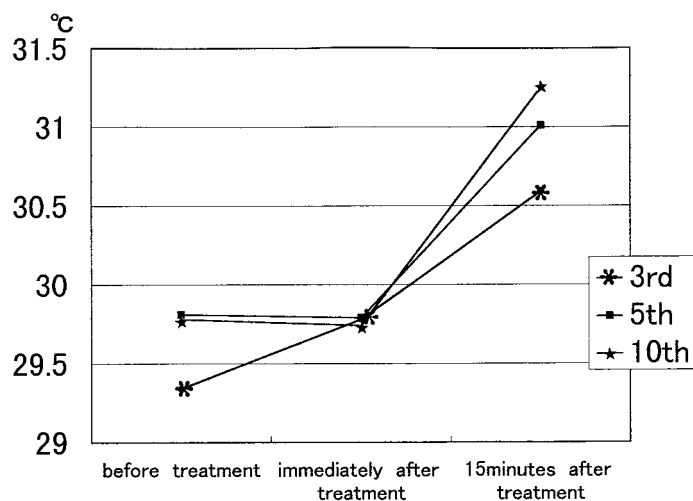


Fig. 2. Changes in skin temperature

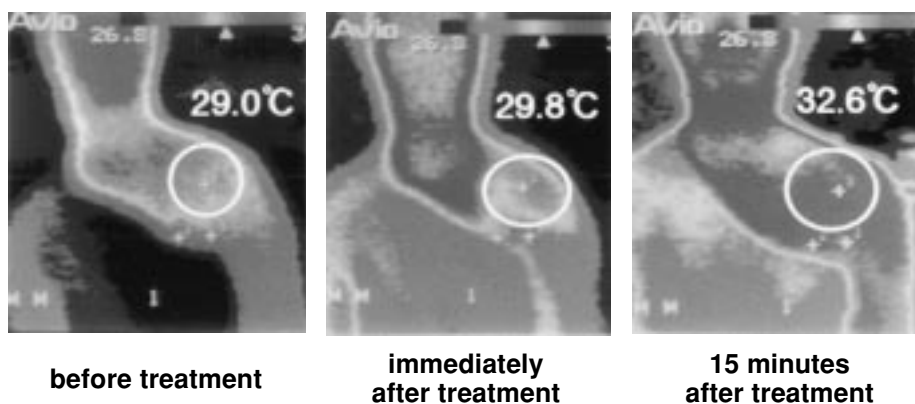


Fig. 3. Thermography

in Japan is mainly ultra-short waves of 2,450 MHz, while little use is currently made of other frequencies^{4, 5}). The use of a small movable electrode (for the affected site) and a return electrode (for the affected side hand) makes high-frequency current less likely to disperse. As a consequence, high-frequency current has been reported to heat the affected site efficiently by producing joule heat due to the resistance of the affected site tissue⁸). Because of the high electric resistance of the tissue immediately below the electrode, ordinary ultra-short wave therapeutic equipment has been reported to be liable to cause hot spots in this site.

However, the hyperthermia equipment used in this study uses medium waves (0.65 ± 0.05 MHz), which induce few adverse reactions due to electro-

magnetic waves, with few contraindications, based on the capacitive electric transfer theory. Because of the characteristics of the frequency used and the double electrode system, however, the hyperthermia equipment used in this study has little likelihood of causing hot spots^{5, 8}). Heating deep in the body was reported to produce a rise of 3 to 5°C at a depth of 5–10 cm after the electricity was used for 15 min. The temperature did not fall quickly, even after the end of the current application, rather it was maintained for 3 to 4 hr. This has been reported to alleviate pain owing to various biological effects⁸).

It is noted that this hyperthermia equipment has characteristics different from those that have been used in Japan.

2. Evaluation of effectiveness

Since no control group was included in the present study, we compared the therapeutic efficacy of the present hyperthermia equipment and other similar equipment. Fisher's exact test ($p=0.05$) was used to compare the results with those of a semiconductor laser irradiation group²⁾, a group of patients who underwent treatment using a high-frequency pulse electromagnetic field¹⁾, and a group of patients for whom high-frequency therapy was effective³⁾, each of which served as a control group.

The effectiveness rate of the present hyperthermia equipment was 81.8%, and no statistically significant difference was observed from the laser therapy group (effectiveness rate, 73.5%)²⁾ or the high-frequency therapeutic equipment group (effectiveness rate, 78.0%)¹⁾. However, the effectiveness rate (90.0%)³⁾ of the high-frequency pulse group was significantly higher than that of the present equipment group.

The above results demonstrated that the effectiveness of the hyperthermia equipment was nearly equivalent to that of the conventional physiotherapeutic equipment⁶⁾.

3. Assessment of patients exhibiting symptom exacerbation

Two patients (Nos. 14 and 15) exhibited slightly exacerbations, mainly of symptoms at sites other than the electrification site, but not of cervico-omo-brachial symptoms due to the use of the electricity. No patient exhibited any exacerbation of spontaneous pain (Table 5).

4. Clinical application

It is not thought that there will be many patients with various types of cervico-omo-brachial pain in the orthopaedic surgery field for which treatment with hyperthermia equipment will be mainly used. However, therapy using this equipment was considered to be simple and effective enough as a supportive therapy to relieve pain in patients with various diseases involving the cervico-omo-brachial region.

CONCLUSION

Hyperthermia equipment MD-303 was used for patients suffering from various diseases involving the cervico-omo-brachial region in the orthopaedic surgery field, and its effectiveness in relieving pain was evaluated. Post-treatment symptoms were improved, with statistical significance from pretreatment symptoms, demonstrating the effectiveness of this hyperthermia therapy, and no occurrence of adverse reactions was observed.

From these findings, it is concluded that hyperthermia therapy using this equipment is useful for the treatment of various painful orthopaedic symptoms.

REFERENCES

- 1) Ashida K: Clinical evaluation of high-frequency pulsed electromagnetic field on alleviating lumbar pain. *Research of New Medical Devices* 1992, 1 (1): 115–122 (in Japanese).
- 2) Harada T, Tsuruoka H, Endo G, et al.: A clinical application of the 1W Ga-Al-As diode laser—double blind study—. *J. Physical Medicine* 1998, 9 (2): 99–103 (in Japanese).
- 3) Hashida T, Kato S, et al.: Clinical evaluation of lumbar pain treatment with a rechargeable high-frequency therapeutic device. *Research of New Medical Devices* 1992, 1 (1): 123–131 (in Japanese).
- 4) Kikuchi M: RF-ha-no-ohyo (application of radio frequency waves): The institute of Electrical Engineers of Japan (IEEJ), *CBiological Effects of Electromagnetic Fields and Measurement*, 1st ed. CORONA PUBLISHING CO., LTD. Tokyo, 1995, 200–203 (in Japanese).
- 5) Kotsuka Y: Hyperthermia: The institute of Electrical Engineers of Japan (IEEJ), *Biological Effects of Electromagnetic Fields and Measurement*, 1st ed. CORONA PUBLISHING CO., LTD. Tokyo, 1995, 215–239 (in Japanese).
- 6) Takahashi K, Suyama T, Onodera M, et al.: Clinical Effects of Capacitive Electric Transfer Hyperthermia Therapy for Lumbago. *The Journal of Physical Medicine* 1999, 11: 45–51.
- 7) Totoki T, Takahashi M, Yonekura M, et al.: Evaluation of the pain and QOL. *Clinic All-round*, 1992, 41 (1): 74–78 (in Japanese).
- 8) Zauner Gutmann A: *Recientes avances en fisioterapia*. 1st ed., Editorial JIMS, Barcelona, 1993, 143–160 (in Spanish).