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CORONA DISCHARGE THERAPY
FOR THE PAIN OF KNEE OSTEOARTHRISIS

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INTRODUCTION

Physiotherapy utilizes various types of physical stimulation including thermal, electrical, photic and mechanical stimulation. The diathermatic therapy utilizing electromagnetic waves is one of such physiotherapy methods. Even though their functional mechanism is unknown, some of these physiotherapy methods have been used as additional treatment for relieving the pain of chronic painful diseases such as osteoarthritis. In our hospital, in November, 1991, we started to use an instrument emitting corona-discharged electromagnetic waves. We applied the corona discharge to the surface of the region or section of the body under treatment. Recently, we investigated the pain relief effects of corona discharge therapy for knee osteoarthritis. The following is the report of our study.

I. CORONA DISCHARGE THERAPY INSTRUMENT

We used an instrument (trade name *Sonotron*) which treats a diseased part with 430KHz electromagnetic waves modulated at 3 to 5KHz. The instrument is composed of a device to generate electromagnetic waves and an applicator to discharge them. The waves are balance-modulated (via the coil in the applicator) to be in tune

with the body. The output is 10 W. Resonance sound, which is generated when the corona discharge is applied to the diseased part, is used as a barometer for application (Fig.1). During treatment, the end of the applicator is not in contact with, but at a distance of about 2 cm from the skin, and the applicator is moved in a clockwise fashion over the diseased part. Output stops automatically after every 15 seconds of emission, and is restarted by pushing the start button. Each diseased part is treated eight times. The treatment takes only a few minutes a day.

Contraindications for this treatment are, similar to those for ultra short wave therapy; pregnancy, the presence of tumors or any implanted metal device including pacemakers.

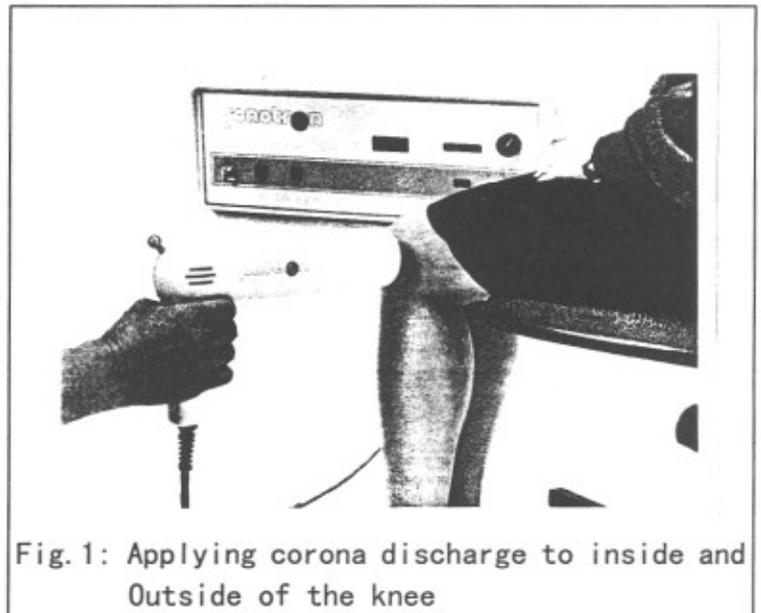


Fig.1: Applying corona discharge to inside and Outside of the knee

In 1891, Nikola Tesla reported that high frequency current would not over stimulate the human organism and could be used for medical purposes. In 1892, D'Arsonval observed that the human organism developed fever and perspired in the 300 to 700KHz electric field and he utilized such for treatment of skin diseases. Later, Alfonso DiMino who was taught by D'Arsonval adapted this principle to develop the instrument for corona discharge therapy. The instrument is now commercially manufactured by ADM Tronics in the USA, and distributed in Japan by Nitto Kagaku in Nagoya.

II . SUBJECTS AND METHODOLOGY

The subjects of our study were 141 knee osteoarthritis cases who received our corona discharge therapy from February 1992 on. In each treatment, corona discharge was applied twice to each of the front, back, inside and outside parts of the knee. This treatment was done twice a week for two weeks. During these two weeks, the subjects were treated with corona discharge therapy only and did not receive any other additional treatment or therapy.

In order to judge short term treatment effects, 79 cases and 116 knees were studied by evaluating the pain level before the treatment and on the seventh day and the fourteenth day after commencing the series of treatment, respectively. The 79 cases were from 39 to 84 years old (66.9 years old on the average) and consisted of 20 males and 59 females. The pain was evaluated subjectively by using a visual analog scale which was designed to classify the pain levels into 10 grades. The pain was also evaluated objectively by using the evaluation table of the Criteria for Judging Treatment Results for Knee Osteoarthritis set by Japan Orthopedic Surgery Association (See Table 1). For testing differences, Macintosh software, STATVIEW 4.0 was used and corresponding two-group t-test was performed.

In order to judge the long term treatment effects, we conducted surveys on the 116 cases and asked the subjects if the treatment was effective and how they felt about the treatment as of December 1993. At the time of questioning, 294 days on the average had passed after the treatment, and we obtained answers for 77 cases, 66% of the total.

Table 1: Evaluation Table

Date: _____

Name: _____

Tester: _____

1. Subjective Evaluation of Pain

	No pain	Slightly painful			Painful		Badly painful			Unbearably painful		
		0	1	2	3	4	5	6	7	8	9	10
Before treatment												
After treatment												

2. Table of Evaluation of Joint Functions

Criteria for Judgement		R	L	Special Note		
Pain	No pain: No pain in ordinary motions in spite of occasional fatigue and dull feeling	30	30	Description by the patient		
	Slight: Slightly painful at the beginning of various motions	25	25			
	Moderate: Always painful during various motions; the pain vanishes after short rest	15	15			
	Strong: Very painful when loaded or during various motions; alleviated during rest	5	5			
	Severe: Always very painful during rest and various motions	0	0			
Excursion (The sum of movable ranges)	Over 120° (able to use Japanese ADL)	20	20	Measured angles Right: ° - ° Left : ° - °		
	90° -119° (able to go up and down the stairs and stand up from a chair)	15	15			
	60° -89° (able to walk normally on the flat ground)	10	10			
	30° -59° (able to pick up things from the floor)	5	5			
	0° -30° (able to go up down a 5cm high step)	0	0			
Automatic extension failure (including bending contracture)	Null: (0° -10°)	10	10	Measured angle		
	Slight: (11° -30°)	5	5		Contracture	Failure
	Heavy: (Over 31°)	0	0	R	°	°
Genu varum & valgum (including lateral flailing) Judged in the standing position if possible	Null:	10	10	Measured angle		
	Slight: (below 15°)	5	5			
	Heavy: (Over 16°)	0	0	L	°	°
				Back & forth flailing	°	°

Walking ability (Judged without using appliances, sticks, or assisting devices)	Normal: Able to walk without difficulty in daily activities. Also able to walk fast	20	Appliance		R L
	Slightly difficult: Able to walk a certain distance (500m to 1km) if necessary	15		Some-times	
	Moderately difficult: Unable to walk more than 500m even if necessary. Limited range of activity.	10		Always	
			1 stick	2 sticks	
	Very difficult: Barely able to walk. Range of activity is limited to inside the house.	5	Some-times		
			Always		
Unable to walk: Unable to walk even in the house	0	Wheel-chair	Some-times		
			Always		
		0	10m walking speed: seconds		
Ordinary motions in daily life	Standing up from a chair (To be judged difficult if hands must be used to support)	210	Description by the patient		
	Going up the stairs (To be judged difficult if a handrail is required.)	210			
	Going down the stairs (To be judged difficult if a handrail is required.)	210			
	Standing on one leg (To be judged difficult if support is required)	210			
	Running (To be judged difficult if able to walk fast only)	210			
		Total	Thigh periphery		
Hydrarthrosis	Right: ++ . + . ± . -		Right	cm	
	Left : ++ . + . ± . -		Left	cm	

In order to compare the results of the corona discharge therapy with those of other types of thermotherapy, we treated 10 cases, 15 knees with far-infrared radiation thermotherapy. The results were evaluated on the same basis as done for the corona discharge therapy. The improvement was calculated based on the scores evaluated before the treatment and on the fourteenth day after the treatment. Results were statistically processed. The difference was tested by a non-corresponding two-group t-test.

For this investigation, far-infrared radiation was applied to the right knee and corona discharge was applied to the left knee of one healthy person for 5 minutes. The increase in skin temperature at the knees was measured with stereo thermography (INFRAEYE 1200).

III. RESULTS

As for the short-term treatment effects, the average mark in the subjective pain evaluation was 5.8 points before the treatment, which became 4.1 points on the seventh day and 3.4 points on the fourteenth day after commencing the series of treatments. Thus, p was less than 0.01 and significant improvement was observed on both of the seventh and fourteenth days. In evaluation according to the Criteria for Judging Treatment Results for Knee Osteoarthrosis as well, the average mark was 13.6 points before the treatment, which became 20.4 points on the seventh day and 23.3 points on the fourteenth day after starting the series of treatments, both showing a significant improvement. (Fig. 2)

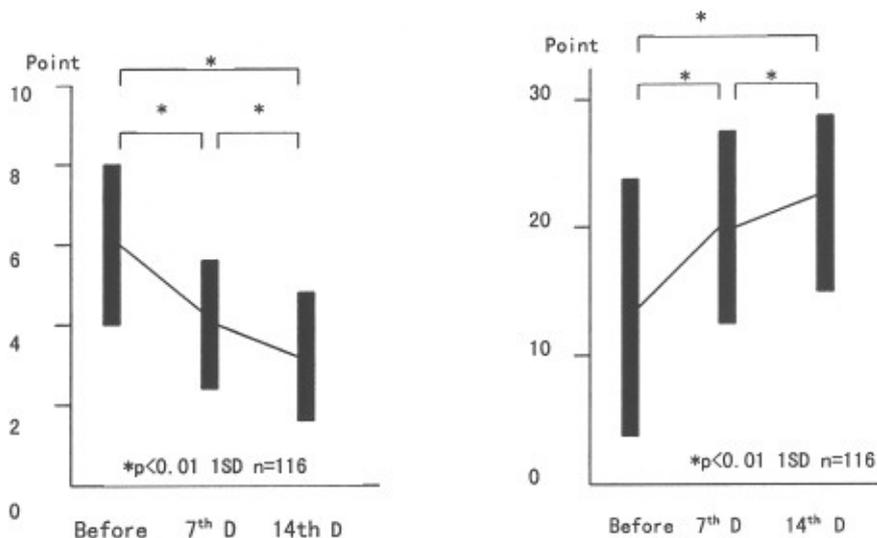


Fig. 2

As for the objective judgement, improvement was found in the score in the movable range to evaluate the joint functions. This was 14.5 points before the treatment, and became 15.6 points in the first week and 16.9 points in the second week after commencing the treatment. In automatic extension failure and in genu varum and genu valgum, no significant improvement was found after the treatment (Fig. 3).

Significant improvement was found in walking ability and in making movement in daily life. The total point score for the joint function evaluation was 61.0 points on average before the treatment. It then became 72.6 points for the first week and 80.0 points for the second week, both of which showed a significant difference of $p < 0.01$ (Fig. 4).

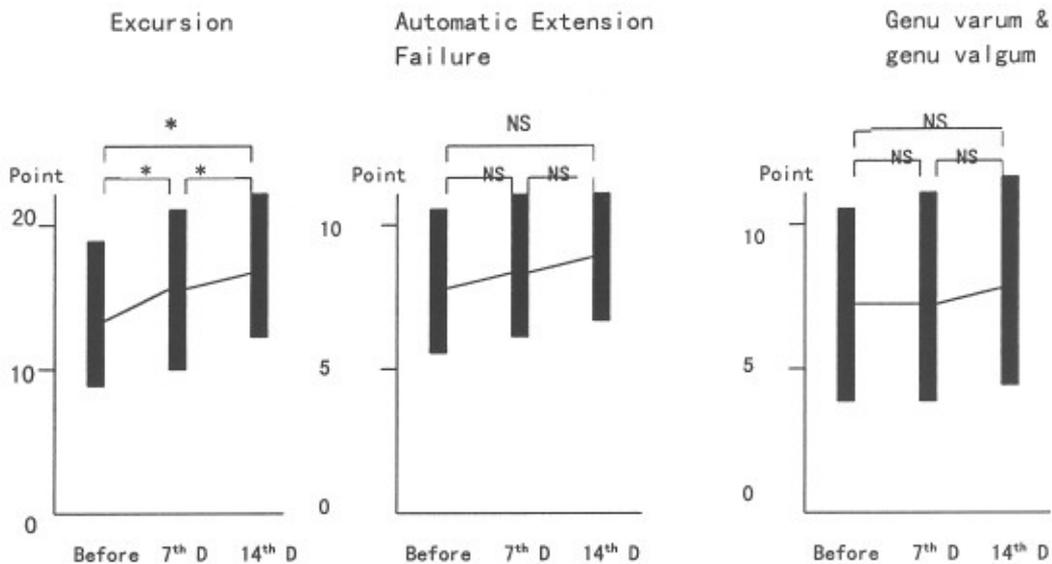


Fig.3 Evaluation of Joint Functions

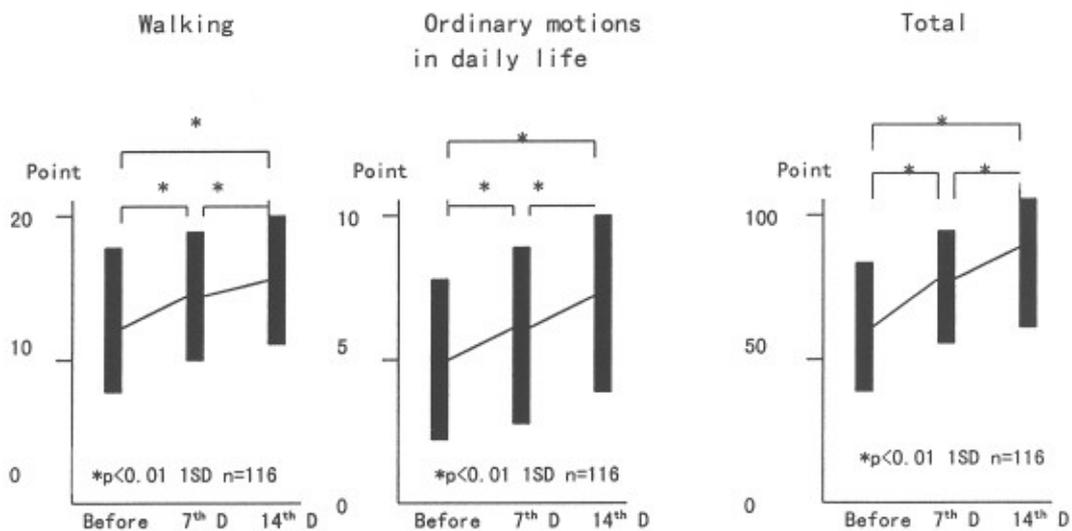


Fig.4: Evaluation of Knee Functions

There were 8 cases in the subjective pain evaluation and 7 cases in the joint function evaluation that manifested no change. These figures correspond to about 6.9% of the total.

Table 2 (on page 13) shows the average values, standard errors, and standard deviations for all the items.

According to the questionnaires about the corona discharge therapy, 68.8% answered that the pain was alleviated and 61.0% said they were not receiving treatment at the time of answering. With respect to the impression of the treatment, 81.8% answered favorably and 18.2% answered that it was not different from other instrument treatment or that it was not effective. (Fig. 5)

When the corona discharge therapy is compared with the far-infrared radiation thermotherapy, the corona discharge therapy showed 3.3 points of improvement in the subjective pain evaluation while the far-infrared radiation therapy showed 2.1 points. Thus, the corona discharge therapy showed more significant improvement ($p < 0.01$). In the score of joint function evaluation, the corona discharge therapy improved by 19.0 points while the far-infrared radiation therapy improved by 12.1 points, and again the corona discharge therapy showed more significant improvement ($p < 0.05$). (Fig. 6)

In a thermography test conducted to compare the thermal effects of these two types of therapy, the far-infrared radiation therapy showed a greater increase in skin temperature in a wider range.

OBSERVATION

In recent years, remarkable progress has been made in the improvement of medical equipment; this, thanks to the advance in the general sciences. Various instruments have been developed utilizing electro-magnetic and ultrasonic waves and rays of light, including lasers. Information has come to light about their

functioning mechanism. Though thermotherapy cannot cure disease itself, it surely can relieve the pain of certain diseases. The corona discharge therapy device (Sonotron) is patented for its thermal effects. In our study, even though the corona discharge therapy showed a smaller heating effect than the far-infrared radiation therapy, it provided sufficient pain relief. The questionnaires also proved that the corona discharge therapy gave a relatively long pain relief effect for knee osteoarthritis. Its pain relief effect was also recognized for lumbago and shoulder joint periphery infection.

Generally it is known that the higher the frequency of electromagnetic waves, the more effectively the temperature of the (human) organism will be increased. However, ultrashort waves may cause injury. The corona discharge therapy instrument does not use such dangerous ultrashort waves. It operates on a frequency of as low as 430KHz which provides deep penetration into the skin. Moreover, an application of low frequency waves has a neurostimulating effect. In our research, some of the subjects felt a sensation of peripheral heat when the corona discharge was applied to the cervical vertebrae or the lumbar vertebra. This implies that the corona discharge therapy has not only a thermal effect but also some other neurostimulating effect. It is known that the pressure points noted in Chinese medicine have a lower impedance than the regions around them. An electric needle is used to give an electric current in these pressure points as a form of anesthesia and for various other treatments. We found that the emission of the *tuned sound* changed at some points during the corona discharge therapy. Based on this fact, we suppose that the corona discharge generates an electromagnetic field at points including the pressure points, and has some effect on these points.

The corona discharge therapy instrument has an advantage in that it can be used without touching the skin, therefore avoiding the risk of patient-to-patient contagion. However, this therapy requires one therapist to treat each patient. The treatment method could be improved, for example, by developing an automatically rotating applicator.

As for any side effects, some subjects felt a sensation of heat when the corona discharge was applied to a certain part continuously, but in no cases did burns develop. No case became worse while no positive effect was found in about 7% of the total.

We carried out a blood test before and after each corona discharge application, and found a significant decrease ($p < 0.01$) in the Na concentration. We are still studying about the significance and mechanism of this phenomenon.

SUMMARY

- 1) The pain relief effect of the corona discharge therapy was found in 68.8% of the cases of knee osteoarthritis.
- 2) We assumed based on the research that the therapy had some neurostimulating effect in addition to the thermal effect.
- 3) The therapy was not efficacious for about 7% of the total cases. However, no case became worse or had any significant side effect. Accordingly, it can be concluded that the corona discharge therapy is a safe physiotherapy method.

Table 2 Statistics

Items	Before treatment	Standard error	Standard deviation	7 th day	Standard error	Standard deviation	14 th day	Standard error	Standard deviation
Subjective pain evaluation	5.78	0.16	1.77	4.14	0.15	1.66	3.41	0.15	1.65
Pain	13.58	0.80	8.57	20.39	0.68	7.38	23.28	0.56	6.01
Excursion	14.53	0.45	4.84	15.56	0.44	4.74	16.94	0.39	4.21
Automatic extension failure	7.80	0.24	2.58	8.53	0.22	2.38	8.99	0.19	2.09
Genu Varum and genu valgum	7.03	0.33	3.55	7.20	0.33	3.51	7.50	0.32	3.46
Walking ability	13.15	0.42	4.50	15.00	0.38	4.12	16.64	0.37	4.00
ADL chair	1.36	0.06	0.68	1.70	0.05	0.53	1.78	0.04	0.43
ADL going up	1.18	0.05	0.55	1.29	0.06	0.60	1.54	0.05	0.57
ADL going down	0.97	0.04	0.47	1.16	0.05	0.54	1.35	0.06	0.59
ADL one leg	0.91	0.06	0.68	1.11	0.06	0.68	1.24	0.06	0.69
ADL running	0.46	0.05	0.58	0.62	0.06	0.63	0.84	0.07	0.75
Total score of joint function	60.96	1.82	19.57	72.56	1.72	18.52	80.00	1.52	16.41

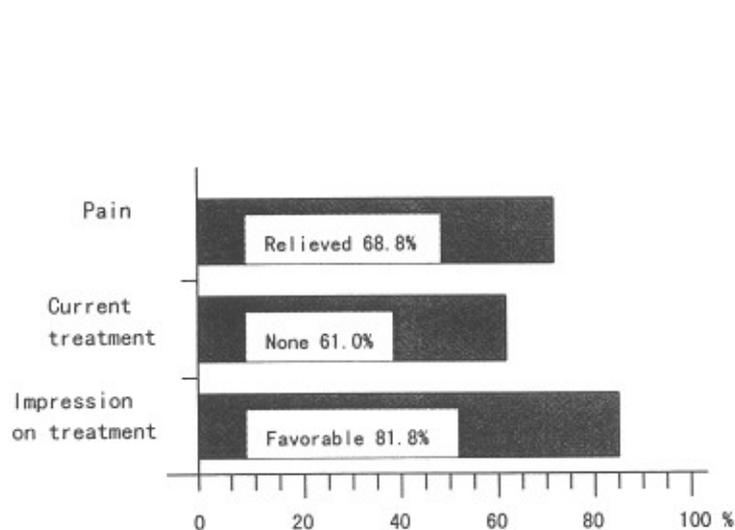


Fig. 5: Questionnaires

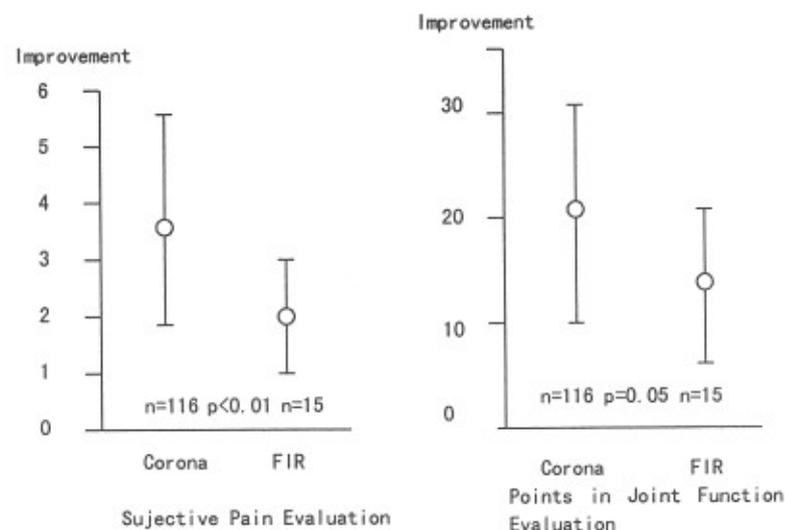


Fig. 6: Comparison with Far Infrared Radiation Therapy