

## Iontophoresis with alternating current and direct current offset (AC/DC iontophoresis): a new approach for the treatment of hyperhidrosis

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### Summary

Tap-water iontophoresis (TWI) using direct current (DC) is the most effective therapy in palmoplantar hyperhidrosis. Side-effects of this method are discomfort, with burning and tingling, and skin irritation, including erythema and vesicles. Incorrect use may induce iontophoretic burns at sites of minor skin injury. Elaborate safety measures are required to prevent electric shock.

The aim of this study was to minimize side-effects and to increase technical and safety standards of TWI, without loss of efficacy. In a controlled blind study, treatment of palmar hyperhidrosis by alternating current (AC) or by AC with DC-offset (AC/DC) was compared with the conventional DC method.

Palmar hyperhidrosis was completely controlled after an average of 11 treatments by either AC/DC iontophoresis or the conventional DC method. Virtually no effect was seen when AC without DC-offset was used for TWI. There were no signs of cutaneous irritation, or subjective sensations of discomfort when AC with or without DC-offset was employed. AC/DC iontophoresis should become the treatment of choice for palmoplantar hyperhidrosis.

The mechanism of action is unknown. It is hypothesized that an interrupted stimulus-secretion-coupling leads to a functional disturbance of sweat secretion.

Localized idiopathic hyperhidrosis is a common disorder of unknown origin, and principally involves the axillae, palms and soles. Affected individuals suffer from social embarrassment and occupational problems.

Axillary hyperhidrosis is often relieved by topical application of aluminium chloride hexahydrate in aqueous solutions,<sup>1-3</sup> but this therapeutic approach has proved of little value in hyperhidrosis of the palms or soles.<sup>4</sup> Many other treatments have been proposed for palmoplantar hyperhidrosis, including surgical sympathectomy,<sup>5</sup> systemic anticholinergic agents,<sup>6</sup> clonidine,<sup>7</sup> clonazepam,<sup>8</sup> and amitriptyline,<sup>9</sup> but these methods are often ineffective, and may be associated with serious side-effects.

The principle of tap-water iontophoresis (TWI) has been known for decades,<sup>10</sup> and TWI is now widely recognized as the treatment of choice for palmoplantar hyperhidrosis.<sup>11,12</sup> Shortcomings of TWI using direct current (DC) are discomfort, with burning and tingling,

skin irritation, including erythema and vesicles, and the necessity for elaborate safety measures to prevent electric shock in case of incorrect use.<sup>13</sup> Minor skin injuries, or skin contact with metal items may lead to iontophoretic burns (Fig. 1).

To minimize side-effects, and to increase technical and safety standards of TWI without loss of efficacy, alternating current (AC) with and without offset of direct current, were investigated for their therapeutic value. In a controlled blind study AC and AC/DC iontophoresis were compared with the conventional DC method.

### Methods

#### Patients

Twenty-five patients, who were referred to the department of dermatology, participated in the study. Their ages ranged from 8 to 35 years. They had been suffering from palmoplantar hyperhidrosis since early childhood. Fifty per cent of the patients gave a family history of

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Figure 1. Electrical burn at the site of contact with a metal ring, worn during iontophoresis.

hyperhidrosis, with at least one affected first-degree relative.

Results of laboratory studies, including full blood count, thyroid hormones, and blood sugar, were within the normal range.

#### *Iontophoresis appliances*

Two new methods employing AC were used for the treatment of palmo-plantar hyperhidrosis. The experimental TWI appliances were operated by a rechargeable energy source, and were disconnected from the mains supply during treatment. They generated: (i)  $\pm 8$  V sawtooth waveform (AC) at a frequency of 5.1 kHz, which produced a patient current of 8–12 mA r.m.s. (Fig. 2a), or (ii) 0–16 V sawtooth waveform (AC with DC-offset) at a frequency of 4.3 kHz, which produced a patient current of 8 mA DC with an AC current of 8–12 mA r.m.s. superimposed (Fig. 2c). The conventional DC method of TWI (Hidrex GmbH, Wuppertal, Germany) employed an average direct current of 15 mA (range 8–25 mA) and 30 V (range 20–40 V) (Fig. 2b), and was used as a control. The voltage set was dependent on the sensitivity threshold for skin discomfort, as previously described.<sup>13</sup>

In each of the three regimens amperages varied according to the individual electrical skin resistance of the patients. Using AC or AC/DC, voltages were fixed,

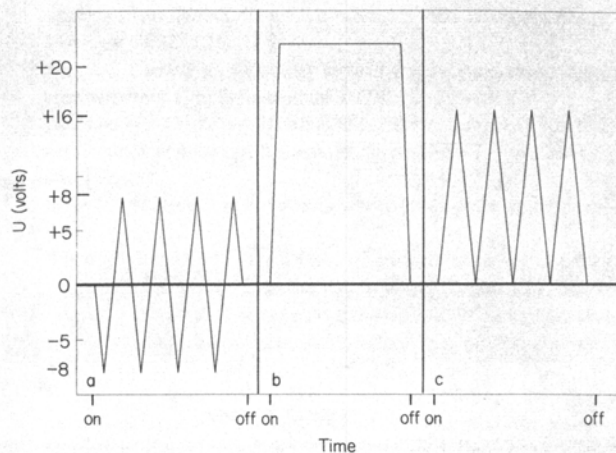


Figure 2. Output currents of TWI appliances. (a) Alternating current (AC); (b) Direct current (DC); (c) AC with DC-offset.

and the resulting amperages showed small variations in the range of 8–12 mA r.m.s. The different frequencies of 4.3 and 5.1 kHz were chosen because they were produced by the generating equipment available.

In the DC method, different voltages were selected according to the sensitivity threshold for discomfort. On these variations, differences in electrical skin resistance are superimposed, resulting in a wide amperage range (8–25 mA).

#### *Measurements of electrical parameters*

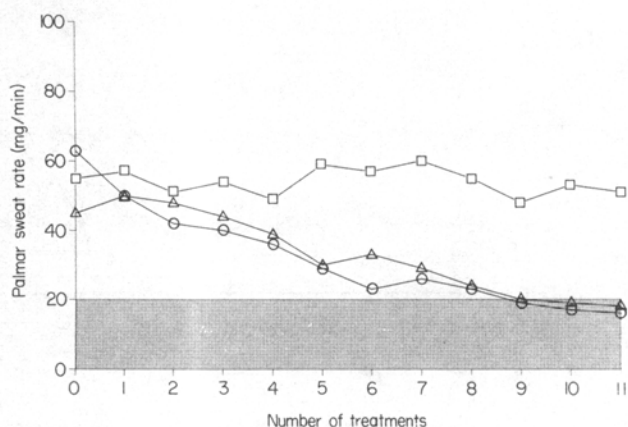
Voltages were measured with the Fluke 73 Multimeter (Fluke, Washington, U.S.A.), and amperages were measured with the Unigor A43 Multimeter (Metrawatt GmbH, Nürnberg, Germany) at the beginning of each treatment session.

#### *Assessment of sweat secretion rates*

Sweat secretion rates/min of the palms were determined gravimetrically before each treatment. Palms were blotted dry and then brought into contact with a sheet of Xerox copypaper for 1 min. The amount of sweat secreted during this collection period was determined as weight increase, using laboratory scales. Normhidrosis was defined as a gravimetrically measured constant palmar sweat rate of less than 20 mg/min. In addition to gravimetric measurements, the patients were asked to judge subjective improvement of their hyperhidrosis.

#### *Treatment*

In a controlled blind study, the patients' palms were treated for 30 min four times weekly according to the



**Figure 3.** Gravimetric measurements of palmar sweat rates during TWI. —□—, Alternating current (AC); —△—, Direct current (DC); —○—, AC with DC-offset. ■, normhidrosis.

established method of TWI.<sup>13</sup> The patients were unaware of which treatment method was being used. DC ( $n=10$ ), AC ( $n=5$ ) or AC with DC-offset ( $n=10$ ) was used either until sweating was reduced to normal, or they had received a maximum of 25 treatments. If there was no benefit, patients were changed to the DC method after a treatment-free interval of 6 weeks.

When sweating was sufficiently reduced, maintenance therapy was carried out once weekly.

## Results

Using the conventional DC method (Figs 2b, 3) of iontophoresis, normal sweating was achieved after an average of 11 palmar treatments. In addition to resolution of the hyperhidrosis, palmar livedo, and oedema of the fingers also resolved.

Side-effects were minimal, and restricted to slight discomfort during treatments and mild skin irritation. High DC amperages caused subjective sensations of burning and tingling on the submerged skin, and transient erythema. Defects of the horny layer such as fissures or erosions resulted in stinging and itching, even at low electric currents. In these cases, lesions were covered with petrolatum before TWI. When DC was employed, mild electric shocks occurred when incorrect technique was used, e.g. rapidly submerging the hands in, or rapidly removing them from, the water baths.

Using AC (Fig. 2a), the hyperhidrosis remained unchanged, as shown by gravimetric measurements (Fig. 3) and clinical assessment. No side-effects were seen during the whole period of 25 treatments. After this ineffective therapeutic approach, the patients were treated by DC iontophoresis, and responded well.

Using AC with DC-offset (Fig. 2c), palmar hyperhidrosis was completely controlled after an average of 11 treatments. The reduction of palmar sweating was monitored by quantitative gravimetric measurements (Fig. 3) and clinical assessment. As with DC iontophoresis, acrocyanosis and oedema of the fingers subsided. There were no signs of cutaneous irritation or subjective sensations of discomfort when the AC/DC method was employed.

## Discussion

The principle of TWI for treatment of palmoplantar hyperhidrosis is well established and represents the most effective therapy. A number of studies<sup>10-13</sup> using TWI with DC have proved its efficacy.

We have demonstrated that palmar hyperhidrosis can be completely controlled by a method combining AC with DC. The efficacy of AC/DC iontophoresis is equal to that of conventional DC treatment. Virtually no effect was seen when pure AC was used.

Localized side-effects are believed to be related to greater current.<sup>13</sup> The conventional DC-method as used by our group<sup>13</sup> employs an amperage of 8-25 mA at a voltage of 20-40 V. In our experience (unpublished data) energy levels below 8 mA DC are insufficient to reduce hyperhidrosis. The AC-method, with or without DC-offset, uses a fixed voltage (16 V), resulting in a current of 8-12 mA (r.m.s.). This reduction to a lower energy level may explain the lack of side-effects. In addition, the mild electric shock which usually occurs when the hands are rapidly submerged in, or removed from, the water baths is prevented. Hence, elaborate safety measures are not necessary using the AC/DC method. The goals of minimizing side-effects, and increasing technical and safety standards of TWI, without loss of efficacy, were achieved in this study. AC/DC iontophoresis should become the treatment of choice for palmoplantar hyperhidrosis.

The mechanism of action of TWI remains unknown. In Shelley's study, using a different type of iontophoresis apparatus, there was histological evidence of keratinous plugging of the distal eccrine ducts.<sup>14</sup> However, with TWI the current densities are much lower, and are well below the threshold of damage to the acrosyringium. As a consequence, mechanical obstruction is absent.<sup>13,15,16</sup> In an experimental study we confirmed that anhidrosis following TWI involves a functional disturbance of the secretory mechanism by interrupting the stimulus-secretion-coupling; morphological alteration of sweat glands was absent.<sup>16</sup>

## References

- 1 Hölzle E. Die Therapie der Hyperhidrosis. *Hautarzt* 1984; **35**: 7-15.
- 2 Hölzle E, Braun-Falco O. Structural changes in axillary eccrine glands following long-term treatment with aluminium chloride hexahydrate solution. *Br J Dermatol* 1984; **110**: 399-403.
- 3 Scholes KT, Crow KD, Ellis JP *et al.* Axillary hyperhidrosis treated with alcoholic solution of aluminium chloride hexahydrate. *Br Med J* 1978; **ii**: 84-5.
- 4 Jensen O, Karlsmark T. Palmoplantar hyperhidrosis. Treatment with alcohol solution of aluminium chloride hexahydrate: a simple method of transpiration measurement. *Dermatologica* 1980; **161**: 133-5.
- 5 Adler OA, Engel A, Rosenberger A, Dondelinger R. Palmar hyperhidrosis: CT guided chemical percutaneous thoracic sympathectomy. *Fortschr Geb Röntgenstr Nuklearmed Ergänzungsband* 1990; **153**: 400-3.
- 6 Shelley WB, Horvath PN. Comparative study on the effect of anticholinergic compounds on sweating. *J Invest Dermatol* 1951; **16**: 267-74.
- 7 Kuritzky A, Hering R, Goldhammer G, Bechar M. Clonidine treatment in paroxysmal localized hyperhidrosis. *Arch Neurol* 1984; **41**: 1210-11.
- 8 Takase J, Tsushimi K, Yamamoto K *et al.* Unilateral localized hyperhidrosis responding to treatment with clonazepam. *Br J Dermatol* 1992; **126**: 416.
- 9 Eedy DJ, Corbett JR. Olfactory facial hyperhidrosis responding to amitriptyline. *Clin Exp Dermatol* 1978; **12**: 298-9.
- 10 Bouman HD, Grunewald Lentzer EM. The treatment of hyperhidrosis of hands and feet with constant current. *Am J Phys Med* 1952; **31**: 158-69.
- 11 Levit F. Treatment of hyperhidrosis by tap water iontophoresis. *Cutis* 1980; **26**: 192-4.
- 12 Hölzle E, Ruzicka T. Treatment of hyperhidrosis by a battery-operated iontophoretic device. *Dermatologica* 1986; **172**: 41-7.
- 13 Hölzle E, Alberti N. Long-term efficacy and side effects of tap water iontophoresis of palmoplantar hyperhidrosis—the usefulness of home therapy. *Dermatologica* 1987; **175**: 126-35.
- 14 Shelley WB, Horvath PN, Weidmann FD, Pillsbury DM. Experimental miliaria in man. I. Production of sweat retention anidrosis and vesicles by means of iontophoresis. *J Invest Dermatol* 1948; **11**: 275-91.
- 15 Hill AC, Baker GF, Jansen GT. Mechanism of action of iontophoresis in the treatment of palmar hyperhidrosis. *Cutis* 1981; **28**: 69-72.
- 16 Reinauer S, Schauf G, Hubert M, Hölzle E. Wirkungsmechanismus der Leitungswasser-Iontophorese: Funktionelle Störung des sekretorischen Epithels. *Z Hautkr* 1992; **67**: 622-6.