ABSTRACT

Background. Patient demand for non-invasive, no-downtime aesthetic and medical procedures is growing steadily. Radiofrequency (RF) has become an adjunct non-invasive modality for improvement in the appearance of cellulite, reduction in excess fat deposits and skin tightening and is typically applied for deep skin heating without ablation of the epidermis and dermis. Since RF can cause skin hyperthermia (temperature >45°C) even in deep skin structures, non-invasive RF technology may be an attractive modality for sweat gland thermolysis in the case of primary axillary hyperhidrosis.

Material & Methods. Twenty patients (17 women, 3 men) diagnosed with primary axillary hyperhidrosis assessed by hyperhidrosis disease severity scale (HDSS) and positive iodine-starch test [8 patients (40%) HDSS = 4; 12 patients (60%) HDSS =3] underwent 4 axillary (bilateral) treatments with high power, guided radiofrequency device (SweatXTM, Alma Lasers Ltd, Caesarea Israel).

Results. All 20 patients demonstrated sweat reduction at 1, 3 and 6 months after the last treatment as indicated by iodine-starch test and HDSS questionnaire. One month after the last treatment all patients shifted from HDSS 3 or 4 to HDSS 1 or 2. At 6-month follow-up, 11 patients (55%) reported HDSS=2 and 9 patients (45%) reported HDSS =1. In the control group, 80% of patients (8 patients) showed HDSS=2 and 2 patients HDSS=1(no change from baseline).

Conclusion. The use of non-invasive bimodal RF technology is safe and effective for long-term (up to 6 months) sweat reduction in patients with primary axillary hyperhidrosis.

Recommendations. Since axillary hyperhidrosis is known to coexist with malodor originating from the apocrine sweat glands, the SweatX technology could potentially be effective for reduction in axillary osmidrosis.
The apocrine gland is relatively bigger than the eccrine. It is situated in the deep dermis or sub-cutaneous tissue at 6-8 mm depth (Fig 1). The apocrine gland secretion is a thick, milky, odorless fluid rich in proteins, ammonia, lipids and carbohydrates. Their secretion which fluoresces is a turbid fluid (pH 5.0-6.5) containing proteins, sugars, ferric iron, and ammonia. A characteristic smell is produced when bacteria residing on the skin decompose the produced fluid.

TECHNOLOGY

The SweatX system (Alma Lasers Ltd., Caesarea, Israel) is a high power, short-wave electromagnetic energy device operating at 40.68 MHz. The SweatX system employs two types of RF-induced heating of biological tissue: (1) Unipolar Pro handpiece – single electrode characterized by high RF-energy penetration depth and (2) Coaxipolar Pro handpiece – coaxial electrodes optimized for shallow treatment. The dominant heating mechanism in both cases is rotational movement of water molecules in the alternating electromagnetic fields (dielectric heating). The handpieces are operated by dynamic phase control of the RF electromagnetic field intensity and depth of penetration to accommodate the different depths and physical size of the eccrine and apocrine sweat glands, and impedance matching network which provides compensation of the reactance of the attached piece of the skin. Figure 2 depicts thermographs of the Unipolar Pro and Coaxipolar Pro handpieces with multi-level depths of tissue penetration: Unipolar-Pro: Shallow (5-8mm), medium (10-12mm) and deep (15-18mm), and Coaxipolar Pro: Shallow (1-2mm), medium (3-5mm) and deep (6-8mm), respectively.

MECHANISM OF ACTION

Water is a polar compound and is abundant in the human body. When radiant RF electromagnetic energy is absorbed in tissue, it provokes oscillation of the dipole water molecules, which leads to frictional heating. The amount of heating is proportional to the amount of radiation. Sweat gland water content is 99-99.5% whereas that of surrounding skin appendages (hair follicle, sebaceous gland) is significantly less.

CLINICAL STUDY

Between December 2012 and March 2013 twenty patients (17 women and 3 men; age range 16-51 year-old) diagnosed with primary axillary hyperhidrosis were randomly recruited to the SweatX study conducted at a major dermatology clinic in Moscow. Study objectives, protocol (number of treatments and intervals) benefits and possible risks were delegated to the patient by the clinic medical staff. Patients screening for the study was done on the population routinely seeking dermatology services at the clinic. Each patient signed an informed consent. The following Inclusion/ Exclusion criteria were applied to each prospective patient prior to the study enrollment. Inclusion criteria were: hyperhidrosis disease severity scale (HDSS) questionnaire between 3 and 4 (Fig. 3).

<table>
<thead>
<tr>
<th>HDSS Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>My underarm sweating is never noticeable and never interferes with my daily activities</td>
</tr>
<tr>
<td>2</td>
<td>My underarm sweating is tolerable but sometimes interferes with my daily activities</td>
</tr>
<tr>
<td>3</td>
<td>My underarm sweating is barely tolerable and frequently interferes with my daily activities</td>
</tr>
<tr>
<td>4</td>
<td>My underarm sweating is intolerable and always interferes with my daily activities</td>
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Figure 3. Hyperhidrosis Disease Severity Scale (HDSS).
In the iodine-starch test, a 10% povidone iodine antiseptic solution was applied to both axillae and allowed to dry for five minutes. Cornstarch powder was then spread on the area and any excess starch brushed away. After 15 minutes, the regions were photographed (Fig 4A). Exclusion criteria: iodine allergic reaction, active infection, pregnancy planning, pregnancy or lactation, prior surgery for axillary hyperhidrosis in the past 12 months, axillary injections of botulinum toxin A in the last 12 months, history of cancer, pacemaker or other electronic implant. At baseline 8 patients had HDSS level 4, and 12 patients had HDSS level 3. Forty eight hours prior to the iodine-starch test male patients were asked to shave both axillae and all patients to avoid any use of deodorants.

All qualified patients exhibited positive iodine-starch test (Minor’s test) on both axillae. Each patient underwent consecutive 4 treatments spaced one week apart. Baseline photography of each patient’s axilla iodine – starch test was captured at baseline, 1, 3 and 6 months after the last treatment. Similarly, HDSS was recorded at baseline, 1, 3 and 6 months after the last treatment.

During each treatment, room ambient conditions – temperature and relative humidity were monitored and recorded. Prior to the application of the RF handpieces, each axilla was coated with water-free aromatic oil for lubrication to ease handpiece engagement with the axilla area. Both handpieces were applied in overlapping strokes across the treatment area. Axillary skin temperature was monitored by laser thermometer (Fig 4B) to keep the epidermis below 45°C.

Each SweatX treatment comprised 2 treatment steps: Initially, the Unipolar-Pro was employed over the entire axilla area to increase the axilla temperature under 45 degrees Celsius to the therapeutic level by depositing 25kJ of dielectric RF energy at 70-80 Watts. The Unipolar Pro enables efficient, safe volumetric deposition of RF energy to creating heat load on both eccrine and apocrine sweat glands, despite their differing anatomical structures and depths. Immediately upon conclusion of the first step, the Coaxial Pro handpiece is applied to the same, now heated, axilla area. The purpose of the second step is to maintain the axilla deep tissue temperature at a therapeutic level of 48-50 degrees Celsius by depositing and maintaining thermal load primarily at the eccrine gland level (4-6 mm in depth) by depositing 10kJ of dielectric RF energy at 50-60 Watts.

Treatment time for each axilla was 8-10 minutes (~20 minutes for both axillae). Clinical endpoints were transient tissue erythema and skin tenderness which last up to 1 hour. No pre-treatment local anesthesia or pain medications were needed and downtime is minimal. Post treatment care was cleaning and drying both axillae. Each patient underwent consecutive 4 treatments spaced one week apart. Baseline photography of each patient’s axilla iodine-starch test was captured at baseline, 1, 3 and 6 months after the last treatment. Adverse side effect log was recorded for each patient and after each treatment and during each follow-up visit.

RESULTS

All 20 patients completed the study protocol. Expectedly, during the treatment the axillae become erythemous and tender which resolved up to 3-4 hours after the treatment. No adverse side effects were noted or recorded during the course of the study (between the study treatments and the follow-up visits). Before starting the SweatX treatment protocol, 8 patients (40%) reported sweating severity (HDSS) equal to HDSS 3, and 12 patients (60%) HDSS level 4. At 3 month follow-up visit, patient improvement (by iodine-starch and HDSS) was almost unchanged (with one patient exception) in comparison with 1 month follow-up visit. At the conclusion of the 6 month follow-up, 11 patients (55%) were evaluated for sweat intensity of HDSS level 2, and 9 patients (45%) reported sweat intensity of HDSS level 1 (Fig 5). At 6 month follow-up visit, the control group patients showed no changes from baseline in their HDSS questionnaires.

**Figure 4.** Positive axillary iodine-starch test (A); laser beam axillary skin temperature monitoring during SweatX treatment (B).

**Figure 5.** Patients HDSS (1-4) at baseline (BL), 1, 3 and 6 months (M) follow-up (FU)
Figure 6 below depicts the number of patients shifted from baseline HDSS (4 and 3) one month after the last treatment. From patient HDSS 4 group (n=8), 5 patients (63%) converted to HDSS 2 and 3 patients (37%) to HDSS 1. From patient HDSS 3 group (n=12), 9 patients (75%) converted to HDSS 2 and 3 patients (25%) to HDSS 1.

**DISCUSSION**

This is the first study demonstrating the safety and long term efficacy (up to 6 months) of non-invasive short-wave guided dielectric radiofrequency technology for sweat reduction in patients with primary axillary hyperhidrosis. Interestingly, one month after the last treatment, all patients with HDSS 3 or 4 shifted to HDSS 1 or 2. This observation was in correspondence with improved in iodine-starch test results.

Although significant and similar improvement pattern was established 1 month after the last treatment in patients with HDSS 4 & 3 (Fig. 6), patients reported significant improvement in their daily sweat sensation already after their 3rd and 4th treatment. The clinical results were maintained unchanged in most patients up to 6 months where patients demonstrated significant sweat reduction (Fig. 7). In the absence of histological evidence, it is speculated that the sustained high power RF dielectric heating of the highly saturated eccrine glands at different levels in the dermis and hypodermis may deactivate the gland electrophysiology function (i.e., thermal shock) or damage the hyperactive water-targeted secretory ducts of the eccrine glands by shut down the electro-conductivity pathway of the glands and presumably deactivation or decay of pre-synaptic and post-synaptic excitation/activation of the gland cholinergic receptors. The current concept about axillary sweat glands differentiates between eccrine sweat glands producing abundant clear, non-odorous sweat and acrine sweat glands excreting small amounts of turbid, odorous milky sweat. Since axillary hyperhidrosis is known to coexist with malodor, the SweatX technology may potentially be effective for the reduction in axillary osmidrosis (malodor).

In summary, the SweatX RF device provides safe and effective long term solution for patients with primary axillary hyperhidrosis.

**REFERENCES**