Clinical and histopathological study of the TriPollar home-use device for body treatments

Professional non invasive treatments for body contouring based on radiofrequency (RF) became popular in aesthetic clinics due to proven efficacy and safety. A new home-use RF device for body treatments has been developed based on TriPollar™ technology. Our objective was to evaluate the TriPollar home-use device for circumference reduction, cellulite improvement and skin tightening using objective and subjective methods. An ex-vivo human skin model was used for histological and biochemical evaluations of the TriPollar clinical effect. Additionally, twenty four subjects used the new device on the abdomen and thigh areas and the circumference reduction was measured. Ex-vivo models indicated a significant increase of 82% in hypodermal glycerol release. Histology revealed a 34% alteration in adipocyte appearance. Collagen synthesis increased by 31% following TriPollar treatment. A significant average reduction of 2.4 cm was measured on the treated thighs. On the control thighs a lesser, non-significant reduction was found. Average abdominal laxity was reduced from 1.4 at baseline to 0.8 following treatments. A certain reduction was measured in the abdomen circumferences, although it was not significant. The reported results demonstrate the safety and efficacy of the new TriPollar home-use device for body contouring and skin tightening. Treatment may lead to discrete circumference reduction and moderate laxity improvement.

Key words: fat, home-use, lipolysis, radiofrequency, skin tightening, TriPollar

Radiofrequency devices for aesthetic applications such as body and face skin tightening, cellulite reduction, rhytids and body contouring treatments are becoming increasingly popular in clinics worldwide due to their demonstrated efficacy and safety combined with a relative lack of complications and down-time. Patients can immediately return to their normal routines. The only limitation of these aesthetic procedures is the need for multiple treatments requiring frequent visits to the clinic over a period of several months. To overcome this limitation a novel home-use TriPollar RF device was developed and studied, using both an experimental human skin model and at-home clinical treatments on the thighs and abdomen. The home-use device is designed to treat areas of the body in need of firming or fat reduction, including the abdomen, buttocks, waist, thighs and arms.

The new home-use device for body treatments is based on TriPollar™ RF technology, previously proven in clinic systems (re GN™ and apollo™ by Pollogen™) as well as in a home-use facial device (STOP™, Ultragen™). The device focuses low RF power from four electrodes deep into the dermal and hypodermal layers to stimulate dermal activity, tighten collagen fibers and increase new collagen production as well as to stimulate fat metabolism. The device incorporates an automatic temperature monitoring mechanism. When the skin temperature reaches a pre-programmed threshold, the power will turn off and on alternately to maintain the desired skin temperature and prevent overheating. Based on prior clinical and histopathological experience with the TriPollar™ technology [1-3] this new device is expected to be safe and effective in reducing the appearance of cellulite, circumference reduction and treatment of localized fat deposits, as well as accelerating the production of collagen fibers to improve lax, sagging skin, when self-applied at home.

The anti-cellulite and skin tightening effect of the device is the result of three separate mechanisms induced by the TriPollar™ treatment- lipolysis, drainage and collagenesis. This study was designed to investigate these clinical effects on ex-vivo human skin samples harvested from abdominoplasty and maintained in survival conditions, as well as on twenty four female subjects who consented to treat themselves at home on thighs and abdomens.

Materials and methods

Ex-vivo study

Human skin samples were obtained from eight donors during abdominoplasty surgery. For each donor, part of the skin sample first underwent a single treatment with the POSET™ (Ultragen™, Israel) for 10-20 minutes, using
the regular clinical protocol, while another part served as a control. Each skin sample was placed on a porous membrane and positioned in a culture well which was kept in a sterilizer at 37 °C. The culture medium, provided by GREDECO research, was placed at the bottom of the well. The medium was renewed three times per week.

At day 4, skin samples were collected for lipolysis evaluation by glycerol dosage and for histological analysis of the hypodermis. The hypodermis of each skin fragment was separated from the dermis and placed in Krebs-Ringer bicarbonate buffer, pH 7.4, glucose 5.5 mM and bovine serum albumine 40 mg/mL. Preparations were shaken and the released glycerol was dosed by the Vaughan enzymatic method (glycerokinase/glycerophosphate dehydrogenase). Results were expressed in mmoles/g of hypodermal tissue. Histological analysis for modifications of adipocytes was performed based on shape (inhomogeneity, elongation, and irregularity) and changes in the membrane (withered appearance, partial rupture of the cell wall). A quantitative score was attributed to determine the percentage of modified adipocytes in the hypodermis.

To study the effects of collagenesis, skin fragments were maintained in survival medium for 12 days. Samples were then enzymatically digested overnight at 4°C in an acetic acid 0.5 M solution containing pepsin. Fibroblast activity for collagen synthesis was evaluated by a spectrophotometric method at 540 nm, measuring the acid-soluble new collagen synthesized after fixation by Sirius red staining (Sirel Collagen Assay, Interchim, France). Results were expressed in μg of collagen/mg of skin. Finally, histological quantification of dermal collagen by computerized image analysis was performed. Skin fragments were fixed in Bouin's solution and embedded in paraffin. Serial sections of 4 μm thickness were obtained and specifically stained with picric acid solution containing 0.1% Sirius red. Stained slides were examined by a Leitz microscope (160X) connected to a camera (XC-75 CE) and a microprocessor (Q520). The surface area of collagen bundles was measured (μm²) and the relative collagen content of the dermis was calculated (%).

Clinical study
Twenty four (24) female subjects were enrolled in the study. Subjects were divided into two equal groups. One group, ages 25-60 (mean 45.7) was assigned for treatment of a single thigh while the other group, ages 20-49 (mean 33.8) was assigned for treatment of the abdomen. Subjects were screened for any contraindications to radiofrequency treatments and signed an informed consent form. Treatment areas were photographed at baseline, subjects were weighed and treatment area circumferences were measured using a standardized method. During the measurement procedure the distance between the subject's feet was constant – about the width of the pelvis and her arms were crossed and raised in front of the chest. A height measuring device was used to measure at the same height from the floor or another fixed reference point. The measurement height for each subject was recorded in the patient file. Measurement was performed at the abdomen slightly under the navel and 5 cm below. On the thigh area, measurement was made on the upper third of the thigh. At least three marks of the same height were taken at the front, back and sides of the measured area, and a measuring tape (with tension control) was placed across all marks which were made, parallel to the floor and under the reference points. This created a straight, horizontal and continuous line between the marks. In order to minimize measurement inaccuracies, the same person re-measured the patients.

Abdominal treatment areas were scored for skin laxity level (figure 1). Subjects were then instructed on the use of the POSET™ device (Ultragen™, Israel) and commenced home treatments two to three times a week for two to three months. Subjects returned to the clinic for follow up visits at 6 and 12 weeks following initiation of the study. At each follow up visit treatment areas were photographed, subjects were weighed, circumferences measured and abdominal laxity was scored. Additionally, subjective patient evaluations of the treatment and clinical results were collected, using 5-point scales (no result to excellent result, very uncomfortable to very comfortable, and not satisfied to extremely satisfied). Finally, any side effects such as excessive erythema or edema, crusting, blistering, dyspigmentation, and pain observed or reported by the subjects were recorded.

Statistics
Mean values and standard errors were calculated from raw data. Differences between treated and untreated measurements were analyzed using the paired Student's t-test at a significance level of p < 0.05.

Results
Ex vivo study
A statistically significant (p = 0.04) increase in lipolysis following a single treatment with the new home-use device was found on the human skin samples. Glycerol levels
increased to 4180.8 nM/g for the treated skin samples compared to 2301.8 nM/g for the untreated skin samples, reflecting an increase of 81.6% (figure 2). Histological analysis of adipocytes in the hypodermis following treatment revealed modifications in the shape such as inhomogeneity, elongation, irregularity, and changes in the membrane, such as withered aspect and partial rupture of the cell wall (figure 3). The average percentage of modified adipocytes in the different skin samples was 34% (range 16.1% to 51.5%). Although no significant modification of the fibrous tracts located between fat cells was found, an occasional visible thinning of the collagen fibers was noticed.

In all treated human skin samples a significant increase of collagen synthesis by dermal fibroblast activity was detected. In treated skin, a level of 30.5 μg/mg of newly synthesized collagen was found, as compared to untreated skin, where the level was only 23.3 μg/mg (figure 4). This represents an increase of 31% (p = 0.006).

Finally, histological quantification of dermal collagen by computerized image analysis did not reveal a statistically significant increase in dermal collagen. In the superficial dermis the relative percentage of collagen cross section in treated skin samples was calculated to be 81.7% as compared to 79.5% in the untreated control samples, while in the mid dermis relative collagen cross sections were calculated to be 82.3% for treated samples compared to 82.1% for the controls.

Clinical study
Of the 24 subjects enrolled in the study 22 attended the 6 weeks follow-up visit and 20 attended the 12 weeks follow-up visit. No significant change in subjects' weight was detected. A statistically significant average reduction of 2.4 cm (p = 0.021) was measured on the treated thighs but not on the control thighs where some reduction (1.9 cm), which was not statistically significant (p = 0.06), was found.

Improvement in abdominal skin laxity was scored in seven out of twelve subjects. Overall average laxity was reduced from 1.4 at baseline to 0.8 following treatments. A subtle average reduction was also measured in the abdominal circumstances, but it was statistically insignificant.

Photographs demonstrated significant visible improvement in some of the treatment areas. Sample thigh and abdominal photographic results are shown in figures 3-6. Figure 6 demonstrates noticeable improvement in the abdominal stretch marks of this 32 year old patient.

Based on the subjective patient evaluations, 57.9% of the subjects reported moderate to excellent visible clinical results, 26.3% reported slight visible results and only 15.8% reported no clinical results. Average score was 2.9 on the 1-5 scale. 68.4% of the subjects were satisfied to extremely satisfied with the treatment while all the rest (31.6%) were slightly satisfied. Average satisfaction score was 2.9. 84.2% of the subjects felt comfortable to extremely comfortable with the treatment while the rest (15.8%) felt somewhat uncomfortable. Average comfort score was 3.4. No adverse events were reported throughout the treatment period.

Discussion
In recent years, various cosmetic/aesthetic dermatology procedures and technologies have become an accepted
modality, in dermatological and aesthetic clinics, for the nonablative treatment of skin ageing and other skin or subcutaneous fat-related aesthetic problems [4].

The first RF device aimed at skin tightening (Thermage Inc.) was initially studied using a standard guinea pig model [5]. Dermal heating as shallow as the papillary dermis or as deep as the subcutaneous fat was achieved. The results showed that heating the dermal layer of the skin is associated with collagen denaturation and subsequent thickening and shortening of collagen fibrils. This is followed by a period of increased fibroblast activity and neo-collagen formation over a period of several months. Histological changes associated with new collagen formation in the dermis were noted in the treatment areas, where significant skin contraction was observed. FDA clearance of this device for periorbital wrinkles and rhytids was based on a multicenter, blinded, clinical trial performed on 86 patients who underwent a single treatment using high fluence, since it was initially believed that the highest fluences would yield the best results [6]. This original treatment protocol was consequently found to cause significant side effects, such as scars and skin indentation, since many patients were treated under regional blocks or general anesthesia and could not provide feedback on excessive pain and heat. Consequently Thermage provided a revised protocol [7] advising that multiple passes at low fluences should be administered, and showed via ultrastructural analysis of collagen fibril architecture that this revised protocol provided much more collagen deposition deeper in the dermis than the high-fluence protocol [8], leading to more consistent results with higher patient comfort and safety.

RF tissue tightening devices operating under this revised protocol began to offer patients a non-surgical option to tighten and contour skin on any body area. The first reported study on cellulite treatments and body contouring employed an RF device combined with infrared heat and pulsed vacuum massage [9]. All patients showed some level of improvement in skin texture and cellulite, with mean decrease in thigh circumference of 2 cm, while in another study with the same device [10] 90% of patients noticed overall clinical improvement and average circumference thigh measurements were reduced by 0.8 cm on the treatment side.

Emilia del Pino et al. [11] reported on the effect of an RF-only device on cellulite and subcutaneous tissue of the buttocks and thighs. They administered two RF treatments spaced 15 days apart on 26 healthy female patients with visible bilateral cellulite on either the buttocks or the thighs. RF volumetric tissue heating was delivered in 3 passes of 30 seconds each. Results were analyzed using real-time ultrasound imaging. From the measurements of the distance between the stratum corneum to the Camper’s fascia and from the stratum corneum to the muscle they were able to demonstrate that 68% of the patients presented a contraction of the volume of approximately 20%. They concluded that high-energy RF is a useful modality for cellulite, especially when flaccidity is the main problem. Adverse effects included small blisters in 2 patients and ecchymosis in 3 patients. These resolved spontaneously without complications.

Goldberg [12], using the same RF system, evaluated whether deep RF-induced heating could tighten skin irregularities of cellulite when administered in six treatment sessions every two weeks. A secondary objective was to determine if such a deeply penetrating device produced undesired effects on lipid metabolism. Thirty subjects with Nurnberger-Muller Scale III-IV upper thigh cellulite were treated every other week, 27 showed evidence of clinical improvement in their cellulite as measured by an independent evaluator. The mean decrease in leg circumference was 2.45 cm and the graded improvement on a 1 to 4 scale was noted to be 2.9. Histologic changes showed dermal fibrosis of the upper dermis. Blood tests as well as magnetic resonance imaging of the areas treated showed no abnormalities.

Clinical and histological study results with yet another RF device have recently been reported [13]. Twelve weekly sessions were given for 12 minutes on the buttocks of 50 patients, with a treatment end point of 42 degrees C external skin temperature. Cellulite changes and tissue condition were assessed before and immediately after the first session, before the final 12th session, and 2 months thereafter. A patient Satisfaction Index was recorded. Objective
evaluation involved clinical photography, three-dimensional optical skin surface measurements, and histological findings. Almost all patients noted an improvement of cellulite and body silhouette at the final session, which slightly decreased at the 2-month assessment. Improved skin appearance was objectively detected. Histological tissue samples following the first session were stained with either haematoxylin and eosin (H&E), to study the morphological findings, or with oil red O, to identify lipid deposits [14]. Histological findings showed changes in shape, size, and lipid content, as well as in cytoplasmic and nuclear morphology. After RF treatment adipocytes were more polyhedral, with irregular, degenerated membranes, with less or no lipid content and apoptotic changes. The authors postulate that RF treatment on cellulite produces a decrease in the lipid content of cells as well as changes in the adipocyte membrane which lead to cell rupture and the death and extirpation of lipid content out of the cell.

Kaplan [1] has reported on the use of a clinic TriPollar RF technology device in reducing fat and collagen regeneration. Twelve healthy patients underwent weekly treatments on different body sites. Treatment areas were photographed and measured and patient satisfaction was monitored. One abdominal patient consented to a series of TriPollar RF treatments prior to a scheduled abdominoplasty. A controlled histopathology analysis was performed on skin samples taken during the abdominoplasty procedure. Histopathological examination revealed marked differences between treated and non-treated abdominal skin areas. An increase of 49% in dermal thickness, focal thickening of collagen fibers and focal shrinkage of fat cells was shown following TriPollar treatments. Average patient satisfaction indicated clear satisfaction with the clinical results achieved.

Another clinical study evaluating the TriPollar technology in circumference reduction and cellulite treatment was published recently [2]. Thirty-nine females with cellulite received eight weekly TriPollar treatments. Treatment areas included the abdomen, thighs, buttocks and arms. Subjects were evaluated using standardized photographs and measurements of body weight, circumference, subcutaneous thickness, and skin elasticity of the treatment sites at baseline, immediately after and 4 weeks after the final treatment. Results showed significant circumference reduction of 3.5 and 1.7 cm on the abdomen (P = 0.002) and thigh (P = 0.002) regions, respectively. At 4 weeks after the last treatment, the average circumferential reductions of the abdomen and thighs were sustained. Ultrasound measurements of the distance between the epidermis and the superficial fascia showed an average distance reduction of 10.5% in the thickness of adipose tissue with a maximum reduction of 39% in the thigh region.

Finally, the home-use facial device (STOP™, Ultragen™), was evaluated using the ex-vivo model (Accepted for publication, J Dermatol Treat) and a clinical study involving twenty three subjects (Submitted for publication). Results demonstrated the safety and efficacy of the STOP™ home-use device for facial skin tightening. Treatment can maintain a tighter, supplier skin with improvement of fine lines and wrinkles.

This ex-vivo study of the TriPollar RF home-use device, using an experimental human skin model taken from eight different abdominoplasty surgeries, clearly demonstrated lipolytic activity and moderate modifications in adipocytes following TriPollar treatment. Skin tightening was observed, with statistically significant stimulation of dermal fibroblast activity, resulting in increased collagen synthesis. Histological quantification of dermal collagen did not, however, reveal an increase in dermal collagen.

Results found in the ex-vivo part of the study were confirmed in the clinical part of the study in which a clear trend of improvement was found. Although based on a small sample size, both objective and subjective skin analysis techniques demonstrated the safety and efficacy of the TriPollar home-use device in improving skin texture and moderately reducing skin laxity on various body areas, such as the abdomen and thighs. A larger scale study should be done to further confirm the current preliminary data found in this clinical study. Results found following 2-3 weekly, self-administered, at-home treatments over a period of 12 weeks compare favorably with those reported with much larger, clinic based devices. The relatively slow RF heating combined with the built-in automatic temperature monitoring assure complete safety even without any clinical supervision, as evidenced by the lack of any adverse events in the clinical study.

As with clinic devices, the effects of treatment can be prolonged and enhanced with regular maintenance treatments, now particularly convenient due to the availability of the new TriPollar device at home.

Conclusion

The objective and subjective skin tightening results obtained in this study with the new home-use device used at home indicate efficacy and safety similar to those reported with the larger, clinic-based devices. The relatively slow RF heating combined with the built-in automatic temperature monitoring assure complete safety even without any clinical supervision, as evidenced by the lack of any adverse events in the clinical study.

Continued weekly application of the home-use device, on any body area and on patients with any skin type, can maintain tighter skin with a discrete reduction in circumference and moderate improvement in the laxity and the appearance of cellulite.

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Conflict of interest: none.

References


