In-vitro and In-Vivo Clinical Outcomes Using Viora's New Multi-CORE Technology with V-FORM Handpiece

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Key words: *RF, vacuum, body contouring, circumferential reduction, multi-polar, cellulite*

ABSTRACT: *Non-invasive procedures based on different technologies such as RF are mainly aimed at reducing fat volume. Recently, in the aesthetic market, new terms such as multi-polar, tri-polar, octi-polar, etc. have appeared. The main advantages of a multi-polar handpiece are the ability to create faster heating of the skin and to deliver homogenous distribution of heat. The aim of this study was to evaluate the safety and efficacy of Viora's new multi-polar RF handpiece (V-FORM).* ***Materials and Methods:*** *In-vitro study conducted on the skin of domestic porcine using a thermal video camera. In the case study group, 10 volunteers were treated with the V-FORM handpiece for a treatment series consisting of 3-8 sessions. The clinical assessment of the treatment outcomes included skin moisture level, skin impedance, body temperature, circumferential measurements, clinical photographic assessment and BMI measurements.* ***Results:*** *The in-vitro experiments revealed that heating depth obtained from the different RF frequencies validates the theory that RF penetration depth in tissue is an inverse function of frequency. In the case study group, the initial body temperature increased to an average of 34.0°C from 31.9°C, the initial skin moisture level increased to an average of 40.98% from 38.9% and the initial skin impedance decreased by an average of 18% by the end of the treatment course. All patients responded to the treatment and showed some degree of circumferential reduction (up to 15 cm), on at least one of two-three measured points. No side effects were recorded during the study.* ***Discussion and Conclusions:*** *According to clinical data collected in this study, the new V-FORM handpiece, without any doubt, represents an effective treatment with 100% response rate along with the safest treatment profile.*

INTRODUCTION

Local fat accumulation and cellulite formulation are two of the main symptoms related to the reduced metabolic rate in the tissue and rigid connective tissue. Non-invasive procedures based on various technologies such as radiofrequency (RF) energy, infrared light, high intensity focused ultrasound energy (HIFU), cryolipolysis, pulsed focused ultrasound energy, low-level laser therapy (LLLT), etc.[1-9] are mainly aimed to reduce fat volume. Technologies that aim to heat the adipose tissue focus mainly on improving the blood microcirculation to improve the metabolic rate in the impacted tissue. In several RF-based systems, the thermal energy is combined with vacuum to produce mechanical pressure [3-7; 10]. The addition of mechanical pressure enhances the improvement of blood microcirculation and stimulates lymphatic drainage.

RF's electrical current distribution mainly depends on the geometry of the device's electrodes. In the aesthetic market, two typical configurations are used: monopolar and bipolar. The major difference between these two configurations is in the way the RF current is controlled and directed at the target tissue [11]. The main advantage of a bipolar configuration is the controlled distribution of RF current inside the tissue, which is limited by distance between the two electrodes. Recently in the aesthetic market, new terms have sprouted up, such as multi-polar, tri-polar, octi-polar, etc. In this concept, the multi-polar RF is an engineering modification of a bi-polar configuration, where more than one pair of bi-polar electrodes exists in the handpiece [10]. One of the main advantages of a multi-polar handpiece is the ability to cover a much larger treatment area in one pulse, which in most cases leads to faster heating of the target tissue and homogenous distribution of heat.

The aim of this clinical study was to evaluate the safety and efficacy of Viora's new multi-polar RF handpiece (V-FORM) based on CORE, Viora's proprietary technology [10].

MATERIAL AND METHODS

Handpiece Description

Viora's new multi-polar RF handpiece (V-FORM) utilizes Viora's well established, proprietary CORE technology with vacuum [10]. The V-FORM handpiece has 4 levels of RF power, up to 50W, 4 levels of vacuum pressure intensity (up to 500 mbar) and 4 operational modes (I-IV) with three RF frequencies: 0.8, 1.7 and 2.45 MHz, with the fourth mode including all three RF frequencies. The V-FORM handpiece incorporates an integrated IR thermometer, *Dynamic RF System* and interchangeable applicators in different sizes. The Dynamic RF system constantly monitoring the skin impedance and actively adjusts according to changing environment and skin properties.

1. *In-vitro* Measurements of Penetration Depths of Different RF Frequencies

An *In-vitro* study was conducted on the skin of domestic porcine using a thermal imaging camera (T-Cam 160P, USA) to determine the heating depth of tissue when different RF frequencies are applied. The thermal video camera has a temperature measurement range of -20º-150ºC with a sensitivity of 0.07ºC and an accuracy of ±2°C. To investigate the effect of frequency on tissue heating depth, treatments were performed at fixed RF (level 4, 50 W), at three RF frequencies (0.8, 1.7 and 2.45 MHz) and 4 vacuum intensities. For comparison purposes, heating depth was arbitrarily defined as the depth at which skin tissue temperature reached 42ºC.

2. Case Study Group

A group of twelve volunteers (11 females and 1 male) participated in the current study, ranging in age from 23-70 years (average 43.7, SD 14.1) with Fitzpatrick skin type II-V. The inclusion criteria for the enrollment were no contraindications for RF treatment, BMI <35 and local fat accumulation or cellulite formation. A total of 19 treatment areas were treated in the study: 9 abdomen, 2 abdomen plus flanks, 2 arms and 6 thighs (Table I).

Table I: Case Study Patient Details

Patient ID	Treatment area	Age	BMI	Number of treatments
VF-001	Thighs, abdomen plus flanks	28	23	6
VF-002	Abdomen	33	22	7
VF-003	Abdomen	44	26	6
VF-004	Abdomen	56	26	8
VF-005	Abdomen	31	26	Dropped from the study
VF-006	Abdomen	40	26	3
VF-007	Abdomen and thighs	23	25	Dropped from the study
VF-008	Arms and abdomen	70	31	8
VF-009	Thighs	34	25	3
VF-010	Abdomen plus flanks	61	27	5
VF-011	Abdomen	47	24	2
VF-012	Thighs	57	23	3
Average		**43.7**	**25.4**	**5.1**
SD		**14.1**	**2.2**	**2.1**

The initial body weight range of the patients was 57.3 - 78.7 kg (average 67.64 kg, SD 7.56) with a height range between 150 – 180 cm (average 163.8 cm, SD 7.88) and a calculated BMI (Body Mass Index) of 22-31 kg/m^2 (average 25.4, SD 2.2). Six patients were in the range of normal "healthy weight" (BMI 18.5 -25 kg/m^2), five patients were in the "overweight" category (BMI 25 -30 kg/m^2) and one patient was in the "obese class I" (moderately obese) category (BMI 30 -35 kg/m^2) (**Table I**).

Treatment Regimen

Circumferential reduction and cellulite reduction treatments were performed once a week (7±1 day) for a treatment series consisting of 3-8 sessions. Each treatment area was treated for 15-20 minutes, according to the treatment area's size. The treatments were performed according to Viora's standard protocol.

Clinical Assessment

The clinical assessment of the treatment outcomes included several measurements and tools:

- The **skin moisture level** was measured with a digital moisture monitor (Skin Testing Checker, Hautpflege-Konzepte aus Erfahrung) before the treatment and immediately post treatment. The measurement was performed on the same spot of the body, after the glycerin was applied. According to the digital moisture monitor indicator, values <30% indicate extremely dehydrated skin, values between 31-36% indicate dehydrated skin, values of 34-47% indicated normal skin and values >48% indicated excellent hydration.
- A **skin impedance** measurement was conducted according to Ohm's law, in which the impedance was derived from the peak voltage detected during the "test pulse" of the V-FORM handpiece once applied to the skin. This measurement was performed in a separate test, on 10 randomly chosen treatment areas before the treatment and immediately post treatment on the same spot of the body, after the glycerin is applied.
- Body temperature was measured via an integrated IR thermometer, at three time points: before, during and immediately post treatment.
- Circumferential measurements were performed with the same tape measure at the same spots on the treated area. Two to three measurement points with 5 cm distance in between were taken for each treatment area at three times during the treatment course: before, middle of course and four weeks after the last treatment. The circumferential change (in cm) was calculated as follows: circumference (cm) recorded in the baseline meeting minus circumference (cm) recorded four weeks after the last session.
- Clinical photographic assessments were recorded at two phases: (1) at baseline - prior to the first treatment and (2) four weeks after the final treatment of the treatment course.
- BMI (Body Mass Index) was calculated by dividing weight (in kilograms) by height (in square meter). Body height and weight were measured according to a standardized protocol with participants standing without shoes and heavy outer garments [12]. The BMI change was calculated as follows: BMI at baseline and the BMI at four weeks post the final treatment.

Additionally, the treating practitioners were asked to record and immediately report any adverse or unexpected side-effects.

Statistical Analysis

All statistical tests were performed using Microsoft Excel 2010. In total, ten patients were included in the statistical analysis since two patients didn't complete the treatment course. Descriptive analysis was performed on the cohort, recording the number of valid cases for each test, minimum and maximum values measured, mean and standard deviation (SD), correlations between two values (CORREL) and percentage calculations.

RESULTS

1. *In-vitro* Measurement of Penetration Depths of Different RF Frequencies

The *in-vitro* experiments showed that heating depth obtained for the different RF frequencies available with multi-CORE technology, confirm the theory that RF penetration depth in tissue is an inverse function of frequency. In all experiments, the heating depth observed was greatest for the lowest RF frequency applied (0.8 MHz) and shallowest for the highest frequency applied (2.45 MHz) (**Figure 1**).

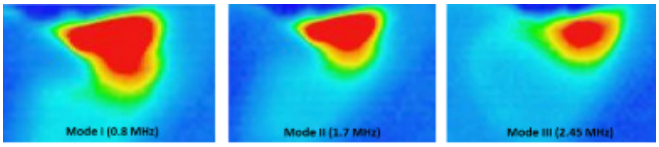

Figure 1: Thermal images of tissue heating effects (skin cross-section), at 50 W, vacuum level 4 and different RF frequencies.

In addition, this study showed that the incorporation of the vacuum mechanism also has a critical impact on the RF penetration depth (**Table II**).

Table II: Heating depths measured with V-FORM large applicator at the highest and lowest vacuum intensities, 50 W and 0.8 and 2.45 MHz RF frequencies.

Frequency [MHz]	Vacuum	Depth [mm]
0.8	1	13.3 ± 1.3
0.8	4	24.6 ± 2.5
2.45	1	8.4 ± 0.9
2.45	4	12.2 ± 1.1

2. Case Study Group

Ten (10) of twelve (12) patients completed the treatment course. No side effects were recorded during the study. The skin responded with slight erythema and sometimes edema, which is considered a positive end-point.

All patients maintained a stable weight (weight fluctuations were limited to -0.4 and + 0.6 Kg) during the entire period of the study. No patient underwent any treatments or took medications for fat volume reduction during the study.

A moderate positive correlation was found between the patient's age and BMI (correlation coefficient 0.54).

The pre-heating time for all body areas ranged between 1-6 minutes (average 2.26 min) with a low negative correlation to the body's end-point temperature (correlation coefficient -0.31).

The initial body temperature (temperature before the treatment) ranged between 31-35°C as the baseline (average 31.9°C) and increased to 32-36°C (average 34.0°C) by the end of the treatment course.

The initial skin moisture level (detected before the treatment) ranged between 28.5-49.0% as the baseline (average 38.9%) and increased to 31-50% (average 40.98%) by the end of the treatment course (these values are not related to the skin impedance test described in Table III below). The skin moisture level measured at the end of each treatment ranged between 28.6-65.0% (average 47.2%) which represents a 0.4-31.4% change in the moisture level post-treatment (average 9.23% change).

A test that aimed to evaluate the change in skin impedance was performed separately on ten randomly chosen treatment areas (Table III). The initial skin impedance (detected before treatment) ranged between 104.8 - 216.5 Ω in the baseline (average 151.3 Ω, SD 32.7) and decreased by 3.8%-35.9 % (average 18%) by the end of the treatment (Table III), which represents a 4.4-53.1 Ω change in the impedance post-treatment.

A moderate negative correlation was found between the changes in the skin's moisture level and skin impedance (correlation coefficient -0.5) with similar coefficient between initial values of impedance and

skin moisture level (Table III). This finding was expected, since blood and parts of the body with high water concentration have lower electrical resistance [10].

Table III: Skin impedance change post treatment (correlated to skin moisture level)

Patient ID	Treatment area	Skin moisture level (%)			Impedance (Ω)		
		Initial	End	Change (%)	Initial	End	Change (%)
VF-001	Abdomen	38.9	48.4	20	156.4	123.5	21.0
VF-002	Abdomen	32.0	54.2	41	201.9	188.0	6.9
VF-003	Abdomen	39.6	46.1	14	139.1	114.6	17.6
VF-004	Abdomen	38.5	46.7	18	147.7	94.6	35.9
VF-005	Abdomen	38.9	48.4	20	143.9	97.0	32.6
VF-006	Abdomen	41.6	48.3	14	144.0	132.0	8.3
VF-007	Abdomen	38.9	48.4	20	144.2	104.2	27.7
VF-008	Abdomen	36.3	47.0	23	104.8	95.7	8.6
VF-009	Thigh	37.2	46.6	20	216.5	179.3	17.2
VF-010	Abdomen	40.0	56.3	29	114.3	110.0	3.8
Average		**38.2**	**49.0**	**21.7**	**151.3**	**123.9**	**18.0**
SD		**2.5**	**3.2**	**7.6**	**32.7**	**32.1**	**10.7**

All patients (10 of 10) responded to the treatment and showed some degree of circumferential reduction, on at least one of two-three measured points. The measured circumferential reduction of all 36 measurement points ranged from -2 cm (gained circumference) to 15 cm, with an average reduction of 2.78 cm (SD 3.38) (Table IV). From a total 36 measurement points, only three measurement points did not show any change in the circumference, (0 cm) and three showed an increase in circumference (negative values in Table IV). Thighs showed the lowest percentage of circumferential reduction (1.68%), followed by the abdomen (4.28%) and arms (4.74%). A negligible positive correlation was found between the percentage of circumferential reduction and number of treatments (correlation coefficient 0.21). However, a low positive correlation was found between a percentage of circumferential reduction and BMI (correlation coefficient 0.44).

Table IV: All measurement points of circumferential reduction per treatment area, number of treatments and BMI (each line represents a separate measurement point)

Area	Circumference measurement		Circumferential Reduction		Number of treatments	BMI (Kg/m²)
	Baseline (cm)	4 weeks post last treatment (cm)	(cm)	(%)		
Thighs	63.0	62.5	0.5	0.8	6	23
	58.0	58.0	0	0		
	64.0	63.5	0.5	0.8		
	56.0	56.0	0	0		
	56.7	54.2	2.5	4.6	3	25
	52.5	51.4	1.1	2.1		
	40.4	39.0	1.4	3.6	3	23
	40.0	39.4	0.6	1.5		
Abdomen	94.0	90.0	4.0	4.4	6	23
	71.5	71.0	0.5	0.7		
	92.0	90.0	2.0	2.2	4	27
	96.0	94.0	2.0	2.1		
	87.0	85.0	2.0	2.4		
	92.0	90.5	1.5	1.7	6	26
	93.0	95.0	-2.0	-2.1		
	87.0	86.5	0.5	0.6		
	83.0	82.0	1.0	1.2	8	26
	91.0	87.0	4.0	4.6		
	101.0	95.0	6.0	6.3		
	112.0	100.0	12.0	12.0	5	31
	104.0	104.0	0	0		
	112.0	97.0	15.0	15.5	8	31
	104.0	96.0	8.0	8.3		
	92.0	89.0	3.0	3.4	5	27
	96.0	92.5	3.5	3.8		
	87.0	84.0	3.0	3.6		
Arms	38.0	37.0	1.0	2.7	4	31
	36.0	34.0	2.0	5.9		
	38.0	35.0	3.0	8.6	8	31
	36.0	38.0	-2.0	-5.3		
	35.0	34.0	1.0	2.9	4	31
	35.0	36.0	-1.0	-2.8		
	35.0	33.2	1.8	5.4	8	31
	35.0	34.0	1.0	2.9		

DISCUSSION & CONCLUSIONS

The *in-vitro* experiments showed that the heating depth obtained for the three RF frequencies used by Viora's multi-CORE technology confirms the theory that RF penetration depth in tissue is an inverse function of frequency. This theory was formerly confirmed with CORE technology in 2012 [10]. However, the thermal images in this study present greater RF penetration (Table II) with more homogenous heat distribution than previously demonstrated (**Figure 2**), which highlights the additional benefit of multiple-RF configuration with the CORE technology.

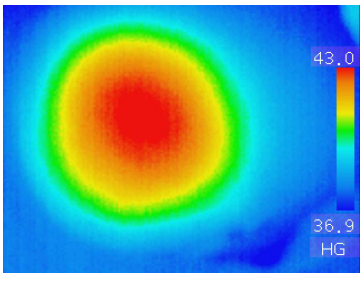

Figure 2: Thermal image of tissue heating effect (skin transverse or axial plane), at 50 W, vacuum level 4 and 0.8 MHz RF frequency.

Of the group in this case study, 100 percent of patients responded to the V-FORM treatment with at least a 0.6% circumferential reduction on one of the measurement points, indicating that RF treatment has influence on all types of patients. No correlation between the circumferential reduction and the number of treatments (correlation coefficient 0.21) may indicate that treatment response is based on individual characteristics of the patient such as metabolic rate, age

and BMI. The positive correlation between circumferential reduction and BMI (correlation coefficient 0.44) supports this conclusion. Interestingly, the high BMI values (above 30 kg/m^2) were mostly considered as exclusion criteria for RF-based treatments. In this study, the positive value of correlation between circumferential reduction and BMI indicates that the higher the patient's initial BMI, the higher percentage of circumference reduction we can achieve. Moreover, the patient with the highest BMI in this study (BMI 31 kg/m^2) was also the most responsive to the treatment, with the highest circumferential measurement values and percentages (15.5 and 8.3%, **Figure 3**). These findings may suggest the multi-polar RF together with CORE technology may represent a non-invasive solution for high BMI patients. However, in order to establish a more accurate recommendation, an additional study with a bigger cohort size with BMI 30-35 should be conducted. The moderate positive correlation between the patient's age and BMI was also expected due to the fact that the metabolic rate of the body reduces with age, which leads to higher values of BMI. The positive correlation between age and BMI was also showed in several unrelated studies [13-14].

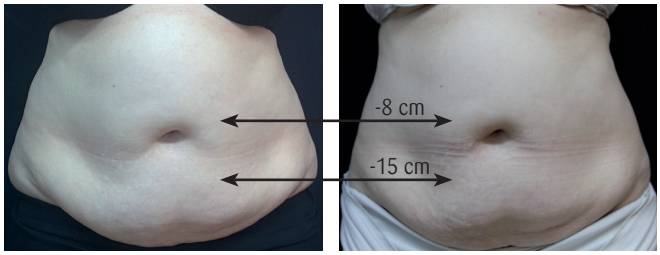

Figure 3: A 70 year old female (BMI 31) before (***left***) and 4 weeks after 8 treatment sessions (***right***), with 15 and 8 cm circumferential reduction (according to 2 measurement abdomen points).

Since in this study, all patients had maintained a stable weight, the circumferential reduction can be directly related to the treatment itself. Contrary to fat destruction techniques, such as laser lipolysis, liposuction, cavitation ultrasound, etc., the RF-based treatment is aimed to increase the metabolic rate and enhance natural lipolysis of the fat cells without hypodermal distraction [10]. The assessment of improvement in blood circulation can be evaluated via the changes in initial body temperature, skin moisture level and skin's impedance. In this study, the increase in initial body temperature from an average of 31.9°C to an average of 34.0°C by the end of the treatment course indicates improvement in local blood microcirculation. This data is further supported by an increase in the initial skin moisture level (from an average of 38.9% to 40.98%) and even more so by an 18% change in the skin's impedance. The negative correlation between skin moisture level and skin impedance (correlation coefficient -0.5) indicates that low water concentration contributes to the skin resistance as shown by high impedance values. This finding is expected, since blood, and parts of the body with high blood content, have the highest electrical conductivity [15]. The 0.4-31.4% change (average 9.23%) in the moisture level post-treatment is additional support for improved blood circulation. The change in the skin's moisture level at the end of the treatment course compared to the initial level recorded in the first treatment (average change of 40.98%) indicates a long term influence on the extracellular matrix achieved via fibroblast stimulation. This finding stands together with previously published data on the influence of RF and, in particular, CORE technology, on the dermal tissue [10].

In addition, the significant change in circumferential measurements post-V-FORM treatments can be contributed not only to volume reduction due to improved metabolic rate and enhanced natural lipolysis, but also to edema reduction due to vacuum pressure integrated in the handpiece. Moreover, the CORE technology enables the control of RF depth penetration which allows the final stages of the treatment with a additional skin tightening effect using higher RF frequencies (1.7 and 2.45 MHz).

Thighs showed the lowest percentage of circumferential reduction with only 1.68% reduction compared to abdomen and arms with 4.28% and 4.74%, respectively. This can be explained by the fact that patients who participated in the study for thigh treatments exhibited cellulite appearance and not local fat accumulation (**Figure 4**).

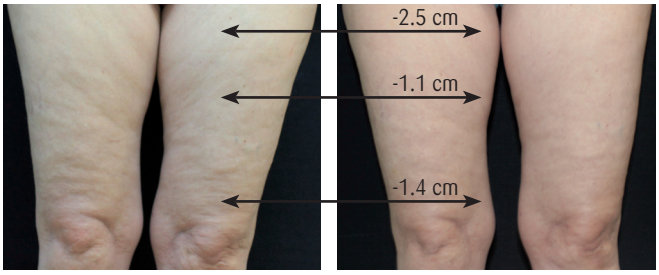

Figure 4: A 57 year old female (BMI 23) before (***left***) and 4 weeks after 3 treatment sessions (***right***) with 2.5, 1.1 and 1.4 cm circumferential reduction (according to 3 measurement points). Reduction of cellulite from grade 3 to grade 2.

The design of the V-FORM handpiece, which includes multiple electrodes (multi-polar RF), enables coverage of large treatment zones in a very short time (the time needed to increase the body temperature to 39-42°C measured an average 2.26 minutes pre-heating time). The negative correlation between pre-heating time and the body's end-point temperature is related to the fact that patients with higher skin conductivity can be heated much faster and to higher end-point temperatures.

During the entire study no adverse effects were recorded. This can be attributed to the fact that the V-FORM handpiece employs a Dynamic RF System that monitors the skin impedance during the entire pulse and controls the RF current release accordingly. The design of the applicator itself contributes to an even vacuum spread over the tissue which dramatically reduces the occurrence of hematomas. Multiple electrodes contribute to the homogenous heat spread over the tissue without hot-spots, which increases patients' tolerance to the treatments and also reduces the appearance of side effects. In addition, as expected, all skin types (I-V) that were included in the study reacted to the treatment regardless of the skin phototypes, as RF energy has similar behavior in all Fitzpatrick skin types.

In conclusion, according to clinical data collected in this study, the new V-FORM handpiece unequivocally demonstrates an effective treatment with 100% response rate along with the safest treatment profile.

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