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Histological Evaluation of Human" in Vivo" Cutaneus Surgical Incisions Created by the Standard Scalpel, Conventional and Colorado Needle Electrosurgery, Radiofrequency, PEAK Plasma blade and Ultracision Harmonic Scalpel

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Abstract:* We hypothesize that thermal damage to the subcutaneous microvasculature of skin incision may have contributed to the incision site complication rate. The purpose of this study was to histologically compare the zone of thermal necrosis for human cutaneus surgical incision made by different surgical cutting devices on vital tissue. Furthermore, for each specimen, the presence and character of micro bleeding was noted. Material And Methods: Human skin incisions were made "in vivo" on the lower abdomen prior to abdominoplasty by the standard scalpel, conventional and Colorado needle eletrosurgery, radiogrequency Ellman, PEAK PlasmaBlade and Ultracision Harmonic Scalpel. After formaldehyde fixation, the specimen was transported to pathology for histological evaluation and measurement of the thermal necrosis zone and micro bleeding zone. Results: As statistically significant ($P < 0.05$) we have three groups considering thermal necrosis zone: first group is only Standard Scalpel, second group PlasmaBlade and Conventional Electrosurgery and third group Colorado Needle Electrosurgery, Radiofrequency and Ultracision Harmonic Scalpel. With microbleeding zone, results are more dispersed, but also with statistically significances ($P < 0.05$) in between two groups of instruments: first group is Standard Scalpel, Conventional Electrosurgery, PlasmaBlade and Ultracision; and the second group consists of Colorado Needle Electrosurgery and Radiofregquency.

Index Terms— cutting devices, histology, incisions

I. INTRODUCTION

In conjunction with the scalpel, the use of electrosurgical devices is fundamental to the practice of surgery. While prized for hemostatic control and dissection capability the electrosurgical devices are associated with significant thermal damage to incised tissue with the potential for injury to adjacent structures and delayed would healing [1]. Accordingly, these limitations have led to improvements in electrosurgical device design including the Colorado Needle as a monopolar electrode with an ultra-sharp heat-resistant tungsten tip for precise soft-tissue dissection and hypothesized less thermal damage to the surrounding tissue. The list continues with ultrasonic blade which cuts through tissue by high frequency vibration generating stress and friction in tissue which coagulates as it cuts. This technique causes minimal energy transfer to surrounding tissue, potentially limiting collateral damage. The next one is radiofrequency (RF) electrosurgical systems with the high frequency and low temperature technology (Ellman) optimized for applications where minimal collateral tissue damage is desired. The newest are the PlasmaBlade devices which offer the precision of a scalpel with the pulsed plasma RF energy to the peak of devices and the bleeding control of traditional electrosurgery without the extensive collateral tissue damage.

The purpose of this study was to histologically compare the zone of thermal necrosis for cutaneus surgical incision made by different surgical cutting devices on vital human tissue. Furthermore, for each specimen, the presence and character of micro bleeding was noted.

II. MATERIAL AND METHODS

The 60 years old female patient, BMI 25.2, underwent abdominoplasty at our Department with signed precise mentioned informed consent for extra procedure. This study was approved by the institutional review board of Dubrava University Hospital (Zagreb, Croatia, EU) and is being conducted in accordance with all ethical standards for human clinical research. Human skin incisions were made "in vivo" on the lower abdomen prior to abdominoplasty. We used precise scheme for eleven groups of six incisions (Fig. 1). In every group we have used all six surgical cutting instruments. That way, every device was used at the same depth and quality of the skin. The group was defined as 10x14 cm quadrant of skin. The length of incisions was 5 cm and distance in between every incision 2 cm. We have decided to use single pass, the standard clinical surgical speed of incision and power level.

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In every group we have used the same consequence of devices:

1. Surgical scalpel blade No.15 as a control incision,
2. Electrosurgery device Ultrascision, Ethicon, Endo Surgery with standard tip and power level 50,
3. The Colorado Micro-Dissection Needle, Stryker, with the same electrosurgery device and the same power level 50,
4. Ellman radiofrequency unit, Surgitron 4.0 Dual RF, power level 10,
5. Medtronic PlasmaBlade device PS210-030S, power level 7,
6. The Ultrascision harmonic scalpel KLS Martin Me 402 Maxium, power level 5.

Only for Ultrasonic scalpel we used standard surgical scalpel for the light superficial epidermal incision and then the ultrasonic hand piece for cutting the dermis. After completion of all incisions the entire lower abdomen specimen with all 11 groups was excised, fixed in formaldehyde and transported to pathology. The standard abdominoplasty procedure was succeeded. At pathology, four specimens were cut of every incision. It means 24 specimens in every group and for 11 groups' equal 264 specimens.

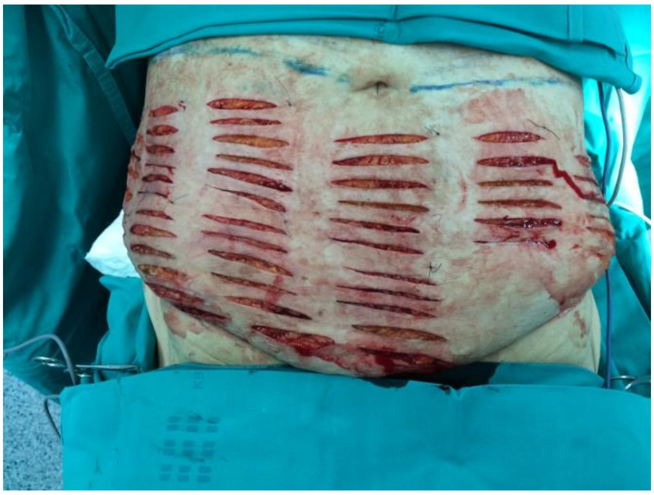

Fig.1 In vivo lower abdominal skin, eleven groups of six incisions, in every group we have used all six instruments.

The histological measurement was made exactly for the thermal necrosis zone in mm. For evaluation of micro bleeding zone (in vivo incisions) we have used semi quantitative method of assessment as follows:

1. No erythrocytes on the cutting edges – grade 0
2. Focal separated clusters of erythrocytes on the cutting edges – grade 1
3. Diffuse zone of erythrocytes on the cutting edges – grade 2

Each sample was graded four times and expresses as sum of four grades. With results of measurements and assessment we did statistical analysis; data were presented with median and range values and compared using Kruskal-Wallis test and pairwise adjusted comparisons of subgroups as post-hoc test. Only P < 0.05 was considered significant. Statistic was done using MedCalc Statistical Software version 15.11.3 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2015).

III. RESULTS

As statistically significant (P < 0.05) we have three groups considering thermal necrosis zone: first group is only Standard Scalpel, second group PlasmaBlade and Conventional Electroscurgery and third group Colorado Needle Electrosurgery, Radiofrequency and Ultracision Harmonic Scalpel (table 1).

Table 1. Thermal Necrosis

Incision Instrument	Thermal necrosis (mm)		
	Median (min – max)	**P (Kruskal-Wallis test)**	**Groups***
Standard Scalpel	0 (0 – 0.042)	<0.001	G1
Conventional Electrosurgery	0.218 (0.17 – 0.33)		G2
Colorado Needle Electrosurgery	0.458 (0.35 – 0.585)		G3
Radiofrequency (Ellman)	0.435 (0.323 – 0.57)		G3
PlasmaBlade (Medtronic)	0.173 (0.127 – 0.37)		G2
Ultracision Harmonic Scalpel	0.52 (0.23 – 0.702)		G3

Table 2. Micro bleeding

Incision Instrument	Micro bleeding (grade)		
	Median (min – max)	**P (Kruskal-Wallis test)**	**Groups***
Standard Scalpel	5 (3 – 7)	0.011	G1
Conventional Electro surgery	4 (2 – 7)		G1
Colorado Needle Electro surgery	3 (0 – 6)		G2
Radiofrequency (Ellman)	2 (0 – 5)		G2
PlasmaBlade (Medtronic)	4 (1 – 8)		G1
Ultracision Harmonic Scalpel	4 (2 – 7)		G1

With microbleeding zone (table 2.), results are more dispersed, but also with statistically significances (P < 0.05) in between two groups of instruments: first group is Standard Scalpel, Conventional Electrosurgery, PlasmaBlade and Ultracision; and the second group consists of Colorado Needle Electrosurgery and Radiofregquency.

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IV. DISCUSION

The most of the studies about this problem we could divide in three categories of comparasion: Measuring thermal collateral injury-necrosis and healing of surgical incisions; human and animal models; comparing CO2 laser or radiofrequency with electrosurgery in older studies and PlasmaBlade and electrosurgery in more recent studies, both with Scalpel incisions as a control. In human studies, because of the adequacy of material, results about the thermal necrosis and other paramethars should be more reliable. In one study authors contributed the PlasmaBlade may be advantageous in selected patients undergoing skin and nipple sparing mastectomy to traditional electrosurgery due to thermal damage [2]. They have used PasmaBlade to create a standard elliptical skin incision and to develop the subcutaneous dissection down to the muscle fascia. Reduced thermal injury depth, inflammatory response, and scar width in healing skin for PlasmaBlade incisions compared with electrosurgery are reported in the similar study but with three instruments on human abdominoplasty model [3]. The reduced thermal injury depth for PlasmaBlade in both studies is comparable with our results. Surprising result is published concerning meta-analysis witch compared scalpel versus electrosurgery for abdominal incisions with no statistically significant difference in overall wound complications rate not in rates of wound dehiscence. It was noticeable unclear outcomes of blood loss, pain, and incision time[4]. It means that conclusions are based on relatively few events and more research is needed.

In animal model, which is not fully comparable with human, the results are pretty much the same. The older animal studies compare CO2 laser and electrosurgery with scalpel as a control. The scalpel incisions produced more defined borders, healed more rapidly, and result in less collateral tissue damage than produced by CO2 laser or electrosurgery [5]. Another study compared histological parameters of wound healing on animal model in incisional wounds using the CO2 laser, scalpel, hot scalpel and electrosection. It found the most extensive tissue damage in CO2 laser wounds with delayed dermal healing and reepithelization. But final histology of both incisional and ablative wound at 6 weeks was similar [6]. The study about healing of rat fascia showed for the pulsed radiofrequency energy (PRE) device comparable results by all measures to those made with the standard scalpel [7]. The more recent studies on animal model compared PEAK plasmablade with electrosurgery and again scalpel as a control with the similar results as human studies. It means the acute thermal demage from the plasmablade was significanly less than both cut and coagulation mode electrosurgical incision [8]. Having in mind plasmablade-electrosurgery and scalpel relation, this is again compatible with our results. Considering all mentioned, our study is the only one with 6 instruments on abdominal in vivo human model, measuring the most important parameter of all – the zone of collateral necrosis! The additional value of the study is the grade of microbleeding (in vivo study) and specific pattern on the skin, using all six surgical cutting instruments in every group. That way, every device was used at the same depth and quality of the skin (uniform material).
Studying the zone of collateral necrosis of in vivo incisions on uniform human material, after scalpel in first statistically significant group, the less depth of necrosis showed the PlasmaBlade, then Conventional Electrosurgery, both statistically significant in the second group. In the third statistically significant group the less depth of necrosis resulted for Radiofrequency (Ellman), then Colorado Needle Electrosurgery and finally Ultracision Harmonic Scalpel. With microbleeding zone, results are more dispersed, but also with statistically significances in between two groups of instruments.

V. CONCLUSION

Studying the zone of collateral necrosis on uniform human material, after scalpel, successively decrease of the zone of collateral necrosis has been noticed for Plasma Blade, then Conventional Electro surgery, Colorado Needle Electro surgery, Radiofrequency and finally Ultracision Harmonic Scalpel. With microbleeding zone, results are more dispersed, but also with statistically significances in between two groups of instruments.

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