HOW IMAGE PROCESSING IN FUE HARVESTING CAN BE USED IN CALCULATING THE REDUCTION OF SKIN TRAUMA BY INJECTING NORMAL SALINE

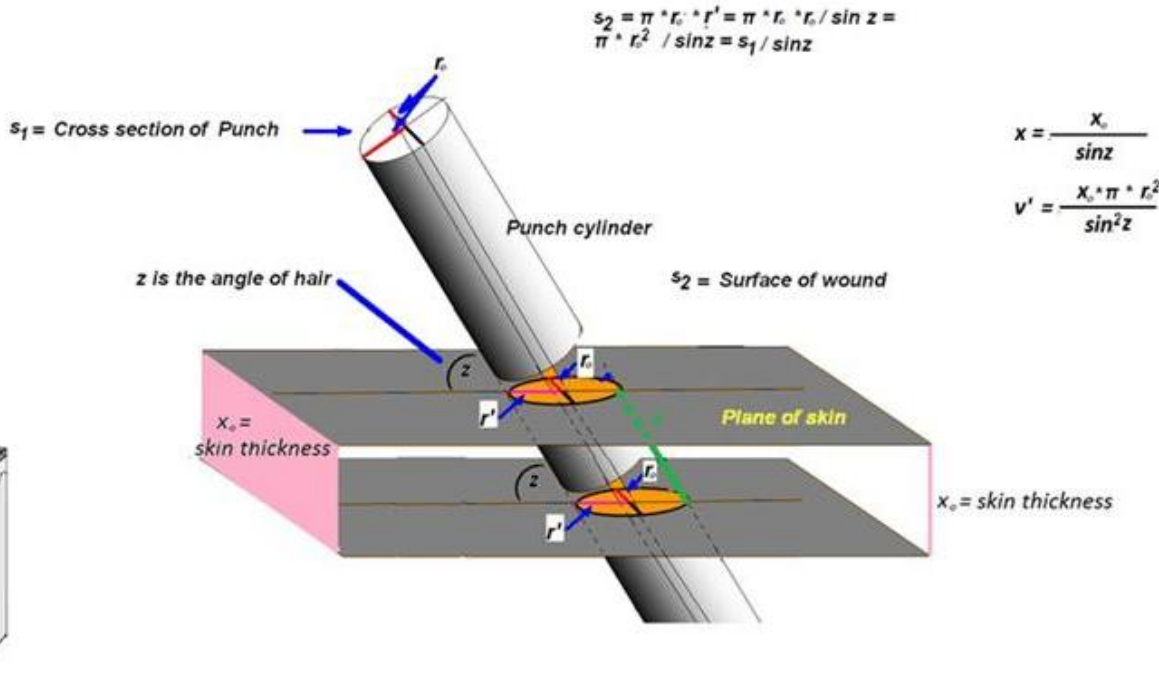*Georgios Zontos[1] MD, PhD , Georgios Nikiforidis[2] PhD*

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DISCLOSURES:

The Speaker has no relevant financial relationships or conflicts of interest to declare.

BACKGROUND

$s_2 = \pi \cdot r_o \cdot r' = \pi \cdot r_o \cdot r_o / \sin z = \pi \cdot r_o^2 / \sin z = s_1 / \sin z$

s_1 = Cross section of Punch

Punch cylinder

z is the angle of hair

s_2 = Surface of wound

$x = \dfrac{x_o}{\sin z}$

$v' = \dfrac{x_o \cdot \pi \cdot r_o^2}{\sin^2 z}$

x_o = skin thickness
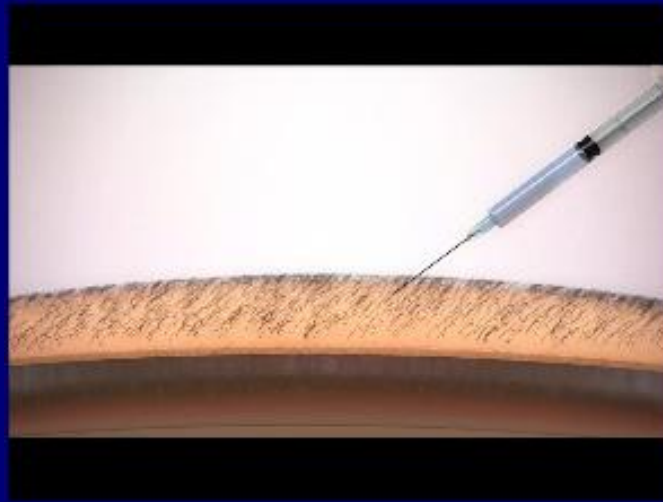
Plane of skin

x_o = skin thickness

Although the punch cross section is circular, the shape of the wound is elliptic, which is calculated by the formula $S_2 = S_1 / \sin z$ 1

Same punch size: the surface of wound depends on the value of outgrowth angle

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Definition
Acute Extraction (AE) & Vertical Extraction (VE)

Objective

1) To compare the exact percentage of skin mass removed by the same size punch in both
(Acute Extraction- AE) & (Vertical Extraction - VE).

2) How the injection of normal saline minimizes the injury to the donor area and therefore accelerates the healing process.

3) How image processing is a invaluable tool in validating the aforementioned aims.

A theoretical approach to the problem

All the calculation of this study are based on the principle that injection of normal saline increases the volume of the skin, while decreasing the density of the mass which is contained in the same area.

$$P = \left(\frac{S_x}{S_0} \right) \cdot \% \qquad 2$$

P : the percentage of skin mass which is removed in Vertical Extraction (VE)

S_0*: initial surface of wound in Vertical Extraction (VE)*

S_x *: final surface of wound , when normal saline has drained away in VE*

$$\frac{m}{m_x} = \frac{1}{\sin^2 z} \cdot \frac{S_x}{S} \qquad 3$$

Acute extraction causes tissue damage inversely proportional to sin²z

m: mass removed in Acute Extraction (AE)

m_x*: mass removed in Vertical Extraction (VE)*

S: final surface of wound in Acute Extraction (AE)

$$f(x) = \frac{1}{\sin^2 x}, x \in [0, \frac{\pi}{2}]$$
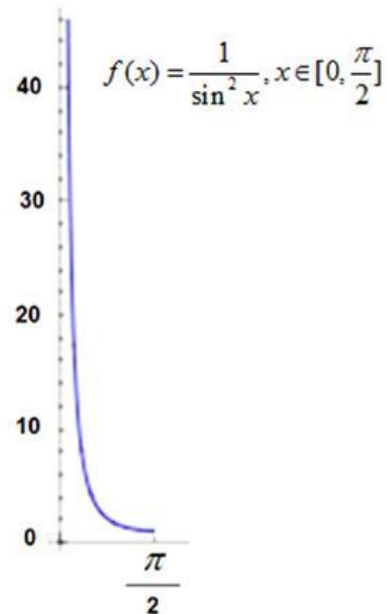
Method

1. *Pictures of wounds were taken with high resolution USB camera immediately after the extraction and 4 hours later in both Vertical Extraction (VE) and Acute Extraction (AE) .*

2. *The surfaces were measured accurately by using an advance image processing system and the results of all 13 cases were interpreted statistically.*

3. *The extraction was performed by using 1.00 mm punch*

The marked rectangles demonstrate the stretching of the skin before and after the injection of normal saline

Before
8.49 mm²
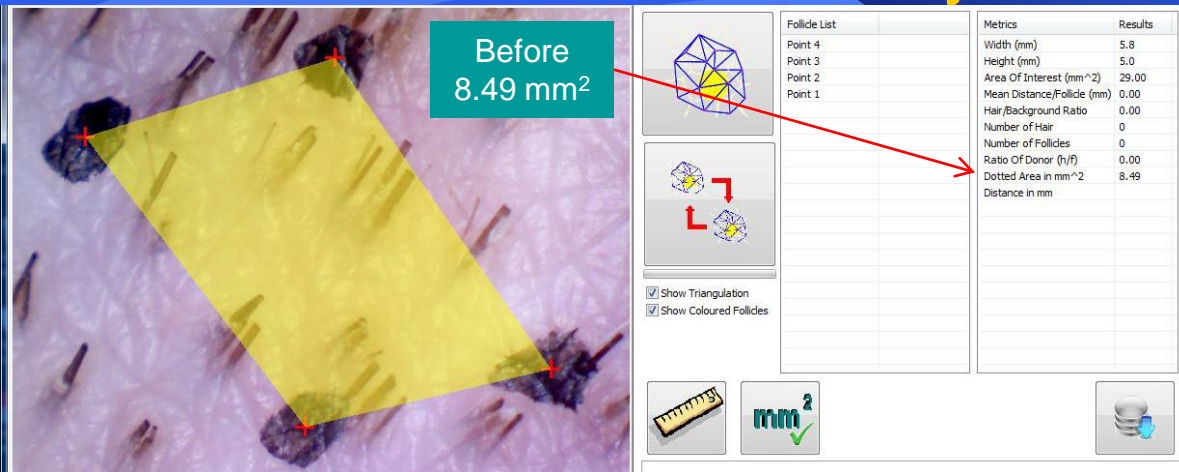
After
10.92 mm²

After the digital images are analyzed the surface of the skin is recorded automatically.

The percentage of the increase in the surface due to the stretching of the skin is (10.92-8.49) / 8.49 % =28.62%

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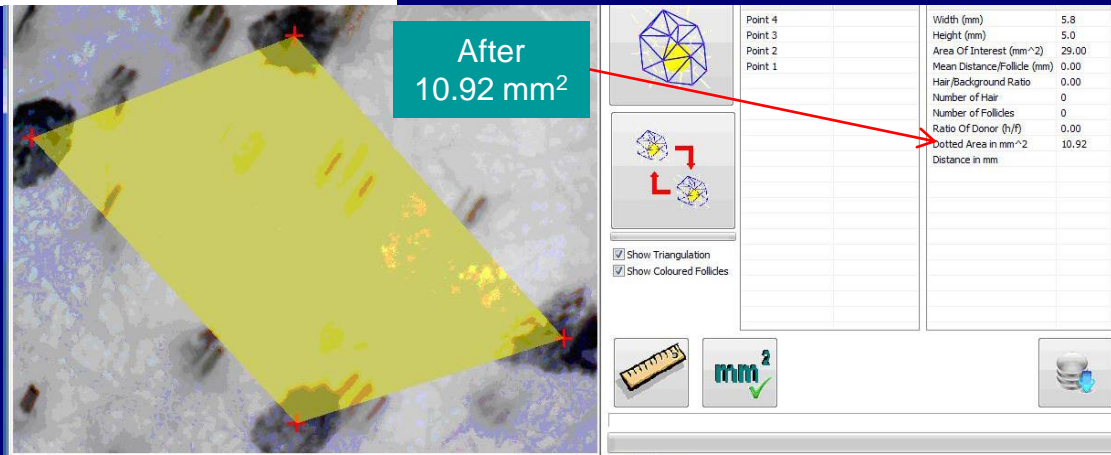
Advanced image processing system

Immediately after extraction: 0.97 mm²

Vertical Extraction:

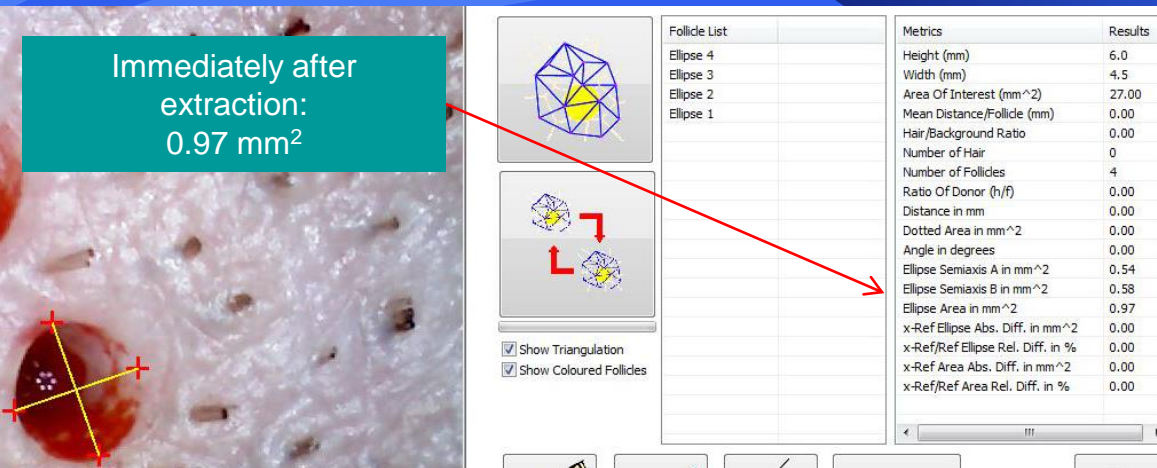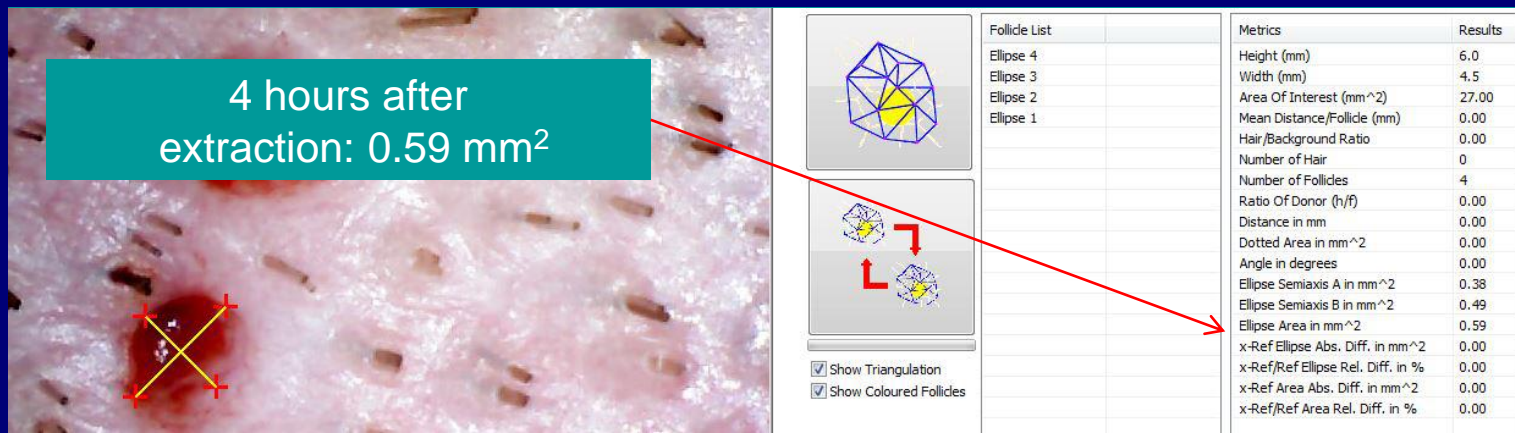| Follicle List		Metrics	Results
Ellipse 4		Height (mm)	6.0
Ellipse 3		Width (mm)	4.5
Ellipse 2		Area Of Interest (mm^2)	27.00
Ellipse 1		Mean Distance/Follicle (mm)	0.00
		Hair/Background Ratio	0.00
		Number of Hair	0
		Number of Follicles	4
		Ratio Of Donor (h/f)	0.00
		Distance in mm	0.00
		Dotted Area in mm^2	0.00
		Angle in degrees	0.00
		Ellipse Semiaxis A in mm^2	0.54
		Ellipse Semiaxis B in mm^2	0.58
		Ellipse Area in mm^2	0.97
		x-Ref Ellipse Abs. Diff. in mm^2	0.00
		x-Ref/Ref Ellipse Rel. Diff. in %	0.00
		x-Ref Area Abs. Diff. in mm^2	0.00
		x-Ref/Ref Area Rel. Diff. in %	0.00

☑ Show Triangulation
☑ Show Coloured Follicles

By using normal saline and placing the punch perpendicularly to the surface of the skin, the elliptic shape of the wound decreases by 39.18% and this number represents the rescued mass.

4 hours after extraction: 0.59 mm²

Follicle List		Metrics	Results
Ellipse 4		Height (mm)	6.0
Ellipse 3		Width (mm)	4.5
Ellipse 2		Area Of Interest (mm^2)	27.00
Ellipse 1		Mean Distance/Follicle (mm)	0.00
		Hair/Background Ratio	0.00
		Number of Hair	0
		Number of Follicles	4
		Ratio Of Donor (h/f)	0.00
		Distance in mm	0.00
		Dotted Area in mm^2	0.00
		Angle in degrees	0.00
		Ellipse Semiaxis A in mm^2	0.38
		Ellipse Semiaxis B in mm^2	0.49
		Ellipse Area in mm^2	0.59
		x-Ref Ellipse Abs. Diff. in mm^2	0.00
		x-Ref/Ref Ellipse Rel. Diff. in %	0.00
		x-Ref Area Abs. Diff. in mm^2	0.00
		x-Ref/Ref Area Rel. Diff. in %	0.00

☑ Show Triangulation
☑ Show Coloured Follicles
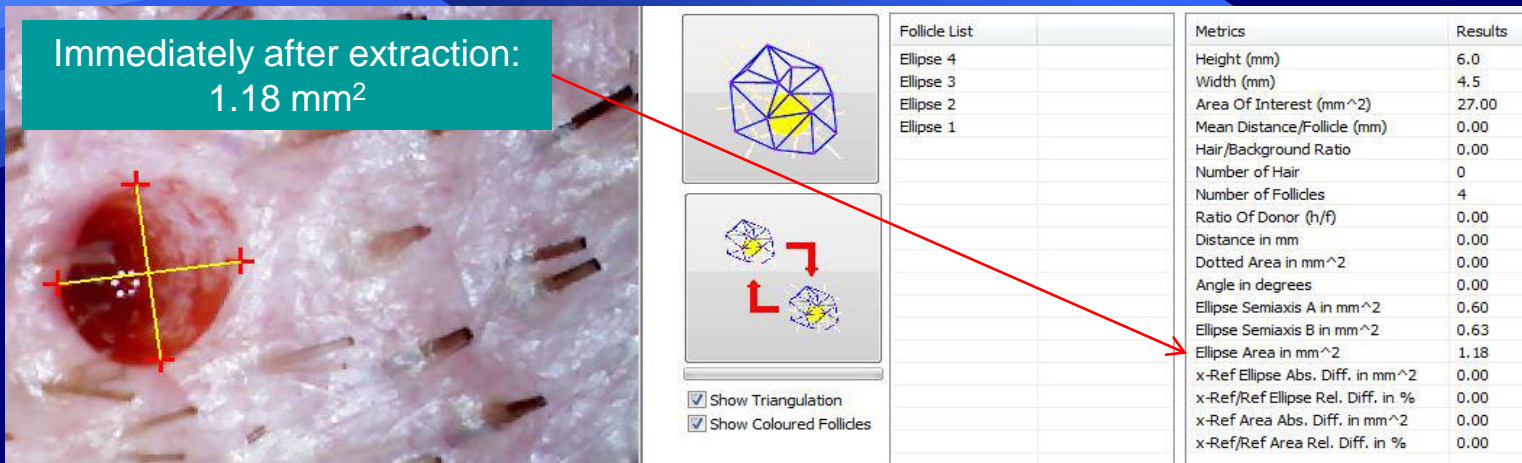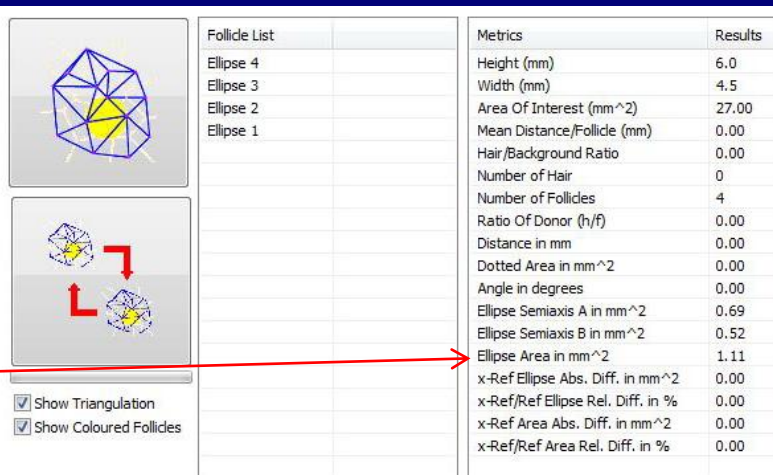
Advanced image processing system

Acute Extraction:

Without normal saline and placing the punch at a certain angle z, the elliptic shape wound decreases by a mere 5.93% caused by edema.

Immediately after extraction: 1.18 mm²

Follicle List
Ellipse 4
Ellipse 3
Ellipse 2
Ellipse 1

☑ Show Triangulation
☑ Show Coloured Follicles

Metrics	Results
Height (mm)	6.0
Width (mm)	4.5
Area Of Interest (mm^2)	27.00
Mean Distance/Follicle (mm)	0.00
Hair/Background Ratio	0.00
Number of Hair	0
Number of Follicles	4
Ratio Of Donor (h/f)	0.00
Distance in mm	0.00
Dotted Area in mm^2	0.00
Angle in degrees	0.00
Ellipse Semiaxis A in mm^2	0.60
Ellipse Semiaxis B in mm^2	0.63
Ellipse Area in mm^2	1.18
x-Ref Ellipse Abs. Diff. in mm^2	0.00
x-Ref/Ref Ellipse Rel. Diff. in %	0.00
x-Ref Area Abs. Diff. in mm^2	0.00
x-Ref/Ref Area Rel. Diff. in %	0.00

4 hours after extraction: 1.11 mm²

Follicle List
Ellipse 4
Ellipse 3
Ellipse 2
Ellipse 1

☑ Show Triangulation
☑ Show Coloured Follicles

Metrics	Results
Height (mm)	6.0
Width (mm)	4.5
Area Of Interest (mm^2)	27.00
Mean Distance/Follicle (mm)	0.00
Hair/Background Ratio	0.00
Number of Hair	0
Number of Follicles	4
Ratio Of Donor (h/f)	0.00
Distance in mm	0.00
Dotted Area in mm^2	0.00
Angle in degrees	0.00
Ellipse Semiaxis A in mm^2	0.69
Ellipse Semiaxis B in mm^2	0.52
Ellipse Area in mm^2	1.11
x-Ref Ellipse Abs. Diff. in mm^2	0.00
x-Ref/Ref Ellipse Rel. Diff. in %	0.00
x-Ref Area Abs. Diff. in mm^2	0.00
x-Ref/Ref Area Rel. Diff. in %	0.00

STATISTICAL ANALYSIS FOR BOTH (Acute Extraction- AE & Vertical Extraction-VE) TECHNIQUES IN 13 CASES

| Mean	SAE1 (mm^2)	SAE2 (mm^2)	(SAE1-SAE2)/SAE1	SVE1 (mm^2)	SVE2 (mm^2)	(SVE1-SVE2)/SVE1
Values	1.39	1.25	10.21%	1.09	0.67	38.56%
Std.Dev		0.25			0.14	
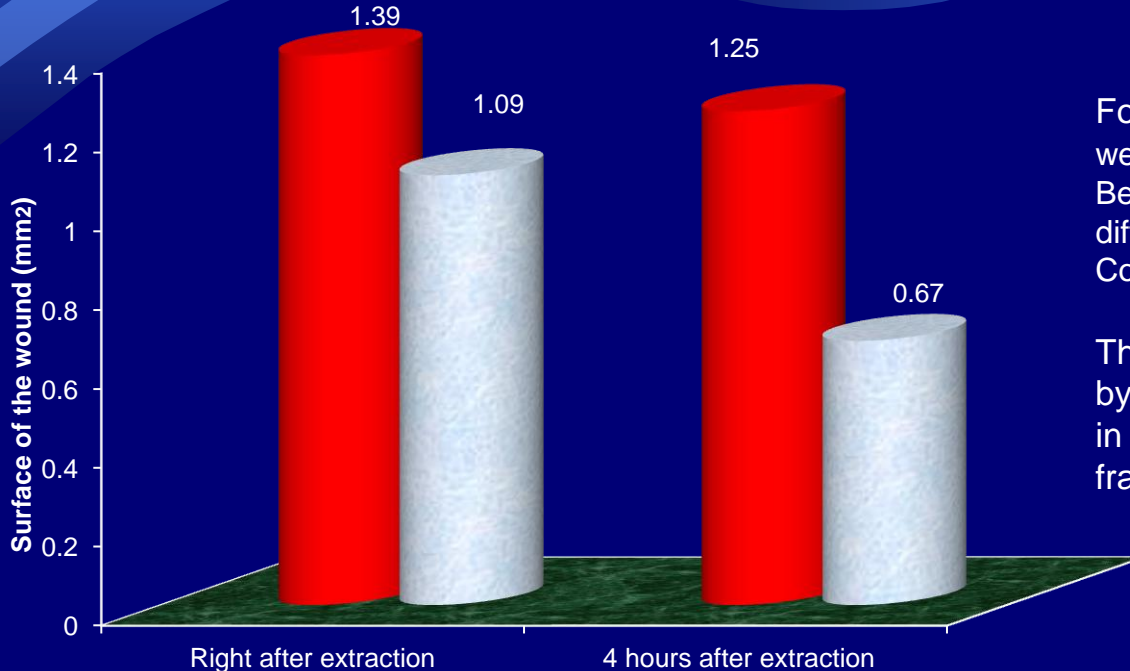
For SAE2 & SVE2 independent samples t-test, we found that Sig. (2-tailed) p= 0.000 < 0.05. Because of this, there is a statistically significant difference between the means, with 95% Confidence Interval of the Difference

The mean surface of the wound, in AE, reduces by 10.21%, while the mean value of the wound in VE reduces by 38.56 % within the same time frame.

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STATISTICAL ANALYSIS FOR BOTH (Acute Extraction- AE & Vertical Extraction-VE) TECHNIQUES IN 13 CASES

Mean Values	M % AE	Wound % AE
	356.17%	87.01%
Std.Dev.	119.81%	24.73%
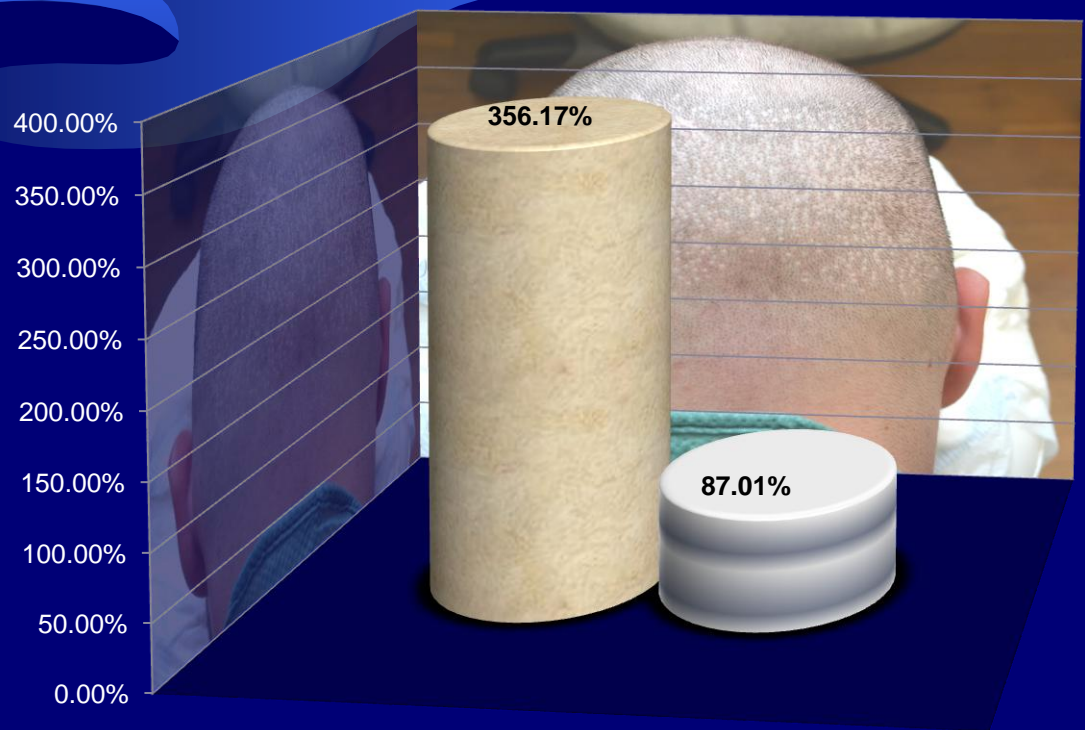
Based on formulas:

$$S_2 = \frac{S_1}{\sin z} \qquad 1, \qquad \frac{m}{m_x} = \frac{1}{\sin^2 z} \cdot \frac{S_x}{S} \qquad 3$$

in conjunction with advanced image processing, it was found that the mass removed in AE was 356.17% larger than the mass removed in VE.

The wound surface in AE was 87.01% larger than the wound surface in VE.

356.17%

87.01%

■ M % AE   ■ Wound % AE

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CONCLUSION

❑ *The injection of normal saline plays an extremely important role minimizing the tissue damage, by making the follicular units more vertical, while stretching the skin, thereby reducing the amount of skin mass which is removed by the punch.*

❑ *Image processing confirmed that the dimensions of the wound decrease after normal saline has drained away, leaving smaller holes and accelerating the healing process.*

❑ *Hence, the wound contracts controlling any possible blood loss, minimizing the extent of scar tissue on the donor area.*

Real cases

In Acute Extraction
2512 follicular units

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In Vertical Extraction
2487 follicular units

13

Thank you for your attention!