A scientific description of transection rate in FUE; reasons and solutions

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Objective

In this study we review the mechanisms of transection rate in FUE harvesting in order to prevent the circumstances under which a FU can be transected.

Figure 1

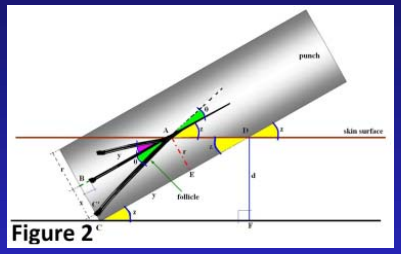

Figure 2

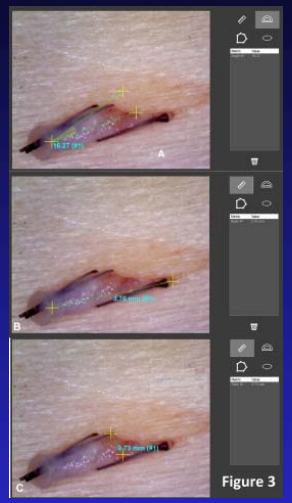

Figure 3

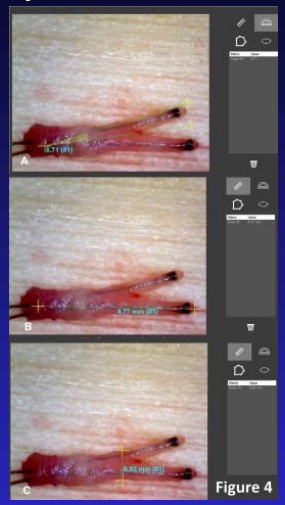

Figure 4

Material/Methods

To efficiently manage the problem of high transection rate we divided the FUE procedure into the following steps:

1) the initial contact of the punch with the skin
2) the linear motion of the punch
3) the twisting motion of the punch.
4) In addition, the important role of follicular splaying was thoroughly researched.

In each step the mechanism of FU transection was evaluated by approaching the harvesting process with the help of mechanics, trigonometry and physics.

High resolution digital images of the transected FUs were taken throughout each step. The images were processed with an advanced image processing system to justify the correlation between theory and practicality.

Results/Discussion

1) The analysis of the problem shows that if the static friction between the edge of the punch and the skin is not big enough the punch will slide causing an eccentric cut of the skin around the FU which may lead to a transected graft **(Fig.1)**

We proved that the condition for a perfect central cut is when the angle z between the punch and the skin is higher than 51o.

2) The physician pushes the punch downwards to penetrate the dermis applying an axial force Fa. This force develops a stress σ so that the surface of the skin is subjected to certain degree of tension and compression. This mechanism could result in bending and/or moving the follicles away from the punch lumen. The more the time needed to reach the rapture stress of the skin the higher the probability of transecting the underlying follicles.

3) After successfully cutting the epidermis and upper dermis of the skin the proximal part of the graft is inside the punch lumen. At this stage the graft is still attached to the lower dermis while the top adheres to the inner wall of the punch. As the punch advances into the skin and the physician continues twisting it, the upper part of the graft is subjected to a torsional loading. If torsional loading exceeds maximum shear stress τ_{max}, of the graft it will amputate a number of follicles within it.

4) The hair follicles within a FU are not always parallel to each other because of follicular splaying. To look at this further we applied the trigonometry of hair angulation as in **(Fig.2).**

At a given penetration depth the smaller the emerging hair angle the higher the lateral offset of the hair follicles and the higher the probability of transecting the FU.

In **Figure 3** although the physician has centrically scored the FU with a 1.00 mm punch and limited the penetration depth, the FU still has been transacted, because the emerging hair angle is too small so follicular splaying requires a significant larger size punch.

Solution - Conclusion

The emerging hair angle proved to be significant in avoiding sliding of the punch and increasing the lateral offset between the hair follicles. By intradermally injecting normal saline the hair follicles become more perpendicular to the skin's surface. In addition as per equation (ii) the emerging hair angle z is at 90o . Therefore the maximum lateral offset needed to avoid transection is equal to half the lateral distance between hair follicles **(Fig.4)**

Also the skin becomes firmer so that the downward pressure produced by the axial force Fa has a minimal impact on the hair follicle geometry. Similarly, the hair surgeon to efficiently dissect the upper layer of the skin without disturbing hair follicle geometry can benefit from the accumulative result of axial and tangential forces. As a motorized device exerts a high tangential force Ft, it is more efficient in cutting the skin at this step of the procedure.

After penetrating the epidermis and upper dermis the twisting motion is unnecessary. Instead a gentle linear push to a limited depth is suggested for harvesting intact FUs.

To minimize the negative affect of torsional loading we recommend the expansion of punch lumen right after the cutting surface, so the probability of graft adhering to the inner wall of the punch decreases significantly.