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Optimal Hair Transplant Recipient Site Slit Design: Minimizing Vascular Damage

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Abstract

An often overlooked aspect of hair transplantation is the art of recipient site design and slit creation. There is also a lack of consensus on which technique provides the optimum coverage while minimizing vascular damage. This paper aims to provide logical arguments to determine the optimal instrument and method of slit creation, in order to ensure maximum density, optimal survival, minimal pop-out, and minimal damage to scalp vascularity.

The use of semiconical blades reduces the damage to the dermis and vascular plexus as compared with rectangular blades and needles, as the depth of penetration required is lower. The use of acute angle reduces the depth of penetration for the same length of slit and decreases damage to deep plexus. Coronal slits produce less vascular damage than that of sagittal slits with the same size blades.

We believe that these recommendations provide the optimum volume slits while causing minimal vascular damage.

Keywords
- Hair transplantation
- follicular unit
- recipient site slit
- androgenic alopecia

Introduction

An often underlooked aspect of hair transplantation is the art of recipient site design and slit creation. There have been multiple articles published on optimizing donor site harvest and graft survival.[1–3] However, it is ultimately the recipient site design that dictates the aesthetics of the result.

The main methods of implantation are using forceps with slit creation or using implanters. The technique using forceps can work with premade slits/recipient sites or simultaneous creation of recipient site and implantation known as stick and place.[4] Premade slit creation is generally favored, especially in high-volume centers for their efficiency and also for the fact that significant part of the surgery (implantation in premade slits) could be delegated to assistants. There are multiple methods of creating slits. The most commonly used instruments include needles and blades, either for a single slit or multislit creation.[5–8] The orientation can be coronal or sagittal.[9] The angle and depth of the slit itself can also vary.[10]

However, with either of these techniques, the actual mechanics of slit creation has not been analyzed. There is also a lack of consensus on which technique provides the optimum coverage while minimizing vascular damage.

The key factors determining graft survival are graft viability and scalp vascularity. Better scalp vascularity ensures better graft survival. This paper aims to provide logical arguments, in order to determine the optimal instrument and method of slit creation to ensure maximum density, optimal survival, minimal pop-out, and minimal damage to scalp vascularity.

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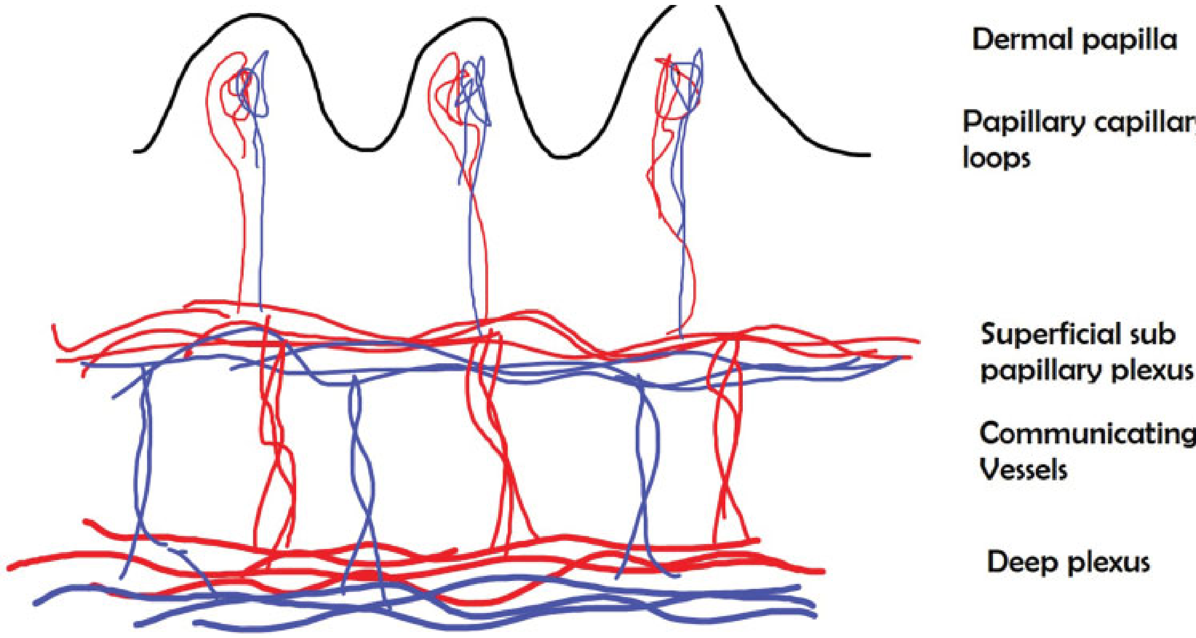


Fig. 1 Vascular architecture of dermis.

Anatomy of Scalp Vasculature

The main vessels supplying the scalp include the supratrochlear, supraorbital, superficial temporal, posterior auricular, and occipital vessels. These form an intricate network in the form of a deep plexus of vessels. This plexus gives out vertical communicating vessels which connect to a superficial subpapillary plexus. The superficial plexus gives out capillary loops into the dermal papilla (►**Fig. 1**).[11]

The deep plexus consists of large vessels which supply a correspondingly large area of skin. Any damage here can result in both ischemia and necrosis, adversely affecting the outcome. Hence, during slit making, it is imperative not to damage the deep plexus. This means our slits should not penetrate too deep to cause damage. One study quantified the average scalp thickness as 4.3 mm.[12] One important factor here is that skin thickness reduces with alopecia, which also has to be kept in mind.

The depth of slit required should be slightly shorter than that of the graft. Very deep slits can lead to the burial of the graft, causing folliculitis. Very superficial slits can cause popping out and cobble stoning.

With this understanding, we will analyze the different dimensions of slit creation to ascertain what would cause minimal damage to vascularity and ensure maximal graft survival.

Shape of Instrument

The shape of the instrument plays a role in determining incision volume, which is a more important factor in determining vascular damage than incision length, which ignores the three-dimensional nature of the vascularity. The shape of the slit should mimic the shape of the graft for proper accommodation and avoid unnecessary vascular damage. A typical graft is roughly cylindrical with an element of splay at the lower end near the roots. The upper part of the dermis contains a higher degree of collagen and elastin fibers, which are responsible for the elasticity of the skin. The elasticity of the slit depends on this portion of skin. If more volume of these fibers are cut, then the elasticity will reduce and, in turn, pop-out rate will increase. Hypodermis contains loose collagen and elastin fibers, so the elasticity is less, and it can easily accommodate the larger size bottom part of a hair follicle. Features of different instruments used to make slits are as follows:

Needles

Needles have a bevel that is used to make slits. The bevel has a wide upper segment and a narrow lower segment. The length of the bevel varies with the size of the needle (►**Table 1**).

The bevel of the needle has two edges—inner and outer. The lower conical part of the bevel of the needle helps in penetration. The outer edges are responsible for cutting till it starts curving inward, and then as the needle penetrates further, there will be more dilatation than cutting. The needle will create a bigger slit than its width, but the amount of the collagen and elastin fibers cut is less in the upper dermis, which helps in maintaining better elasticity and, in turn, less pop-out rate.

The slit created by the conical part of the bevel is narrow and hence not useful to accommodate the lower end of the graft. Hence, the needle has to penetrate deeper, causing unnecessary vascular damage. If this is not done, then the

Table 1 The length of the bevel of different needles

Needle size	Diameter	Bevel size
18 G	1.28 mm	5.25 mm
19G	1.06 mm	4.75 mm
20G	0.90 mm	4.25 mm

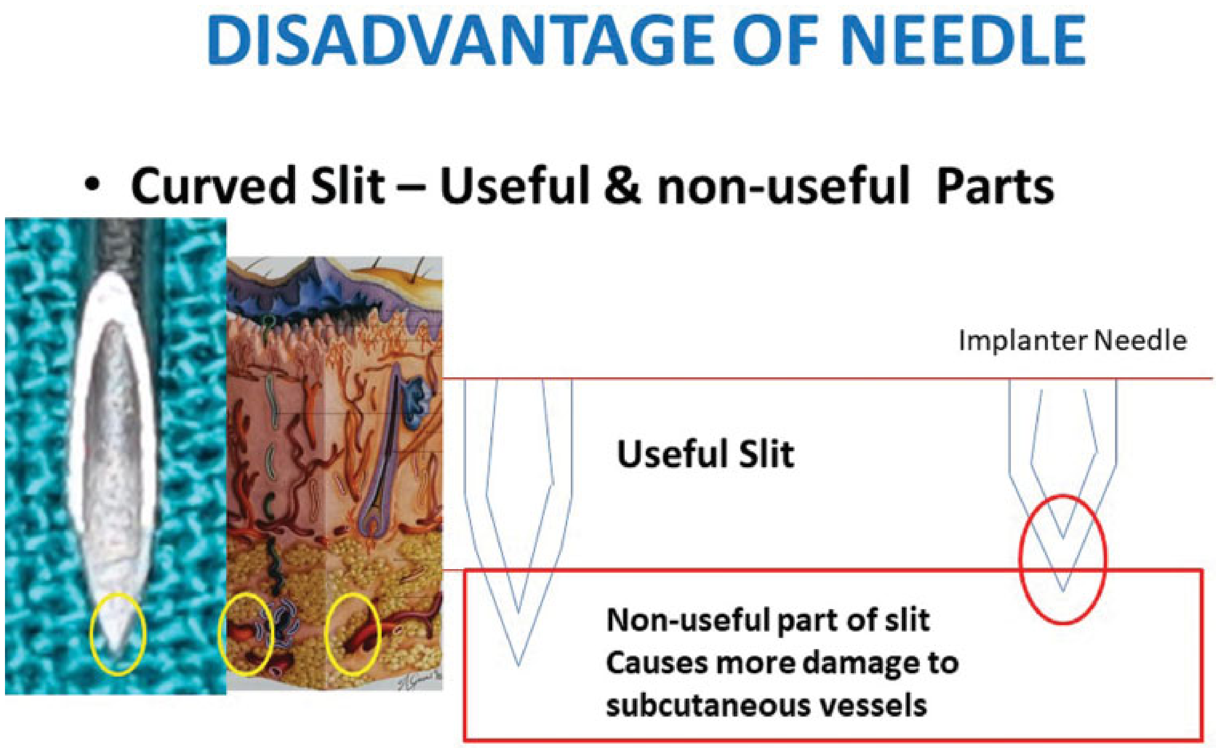


Fig. 2 Disadvantage of needles.

graft ends up in the upper part of the slit and might pop-out or cause cobble stoning (►**Fig. 2**).

Rectangular Blades

A straight edges blade, on the other hand, is wide at its lower end; hence, it has to penetrate less to accommodate the graft, thereby causing less vascular damage. In addition, it cuts more fibers in the upper dermis. So, the retaining power/elasticity of the slit is decreased, leading to an increased pop-out rate.

Conical Blades

These have to penetrate more to create the required size slit (similar to a needle). In addition, it cuts more fibers in the upper part, which leads to a greater pop-out rate.

Semiconical Blades

A semiconical knife has a narrow cutting edge at the bottom which cuts the entire slit, but as it penetrates deeper, the blunt tapered sides dilates more than it cuts. So, upper part of slit has less amount of damage to fibers, which will reduce the pop-out rate. The depth of penetration required for an optimum size slit is also less, which reduces vascular damage. Further, the narrow lower part of the knife also damages the vascularity less than a rectangular knife. Lower dermis and hypodermis containing less collagen and elastin fibers will easily accommodate the lower portion of the graft, while the upper dermis will help in retaining the graft (►**Figs. 3** and **4**).

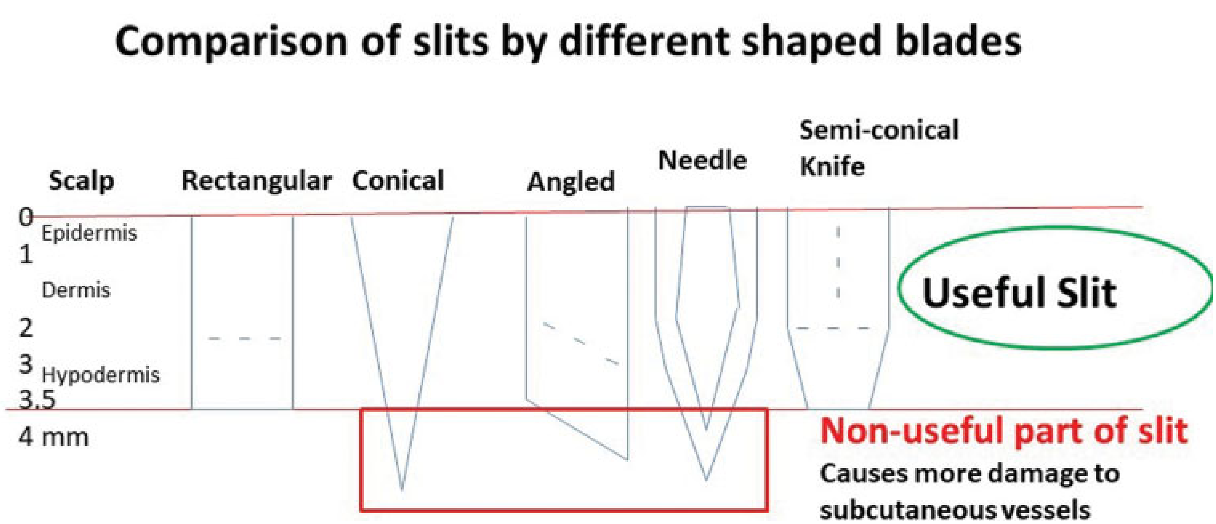
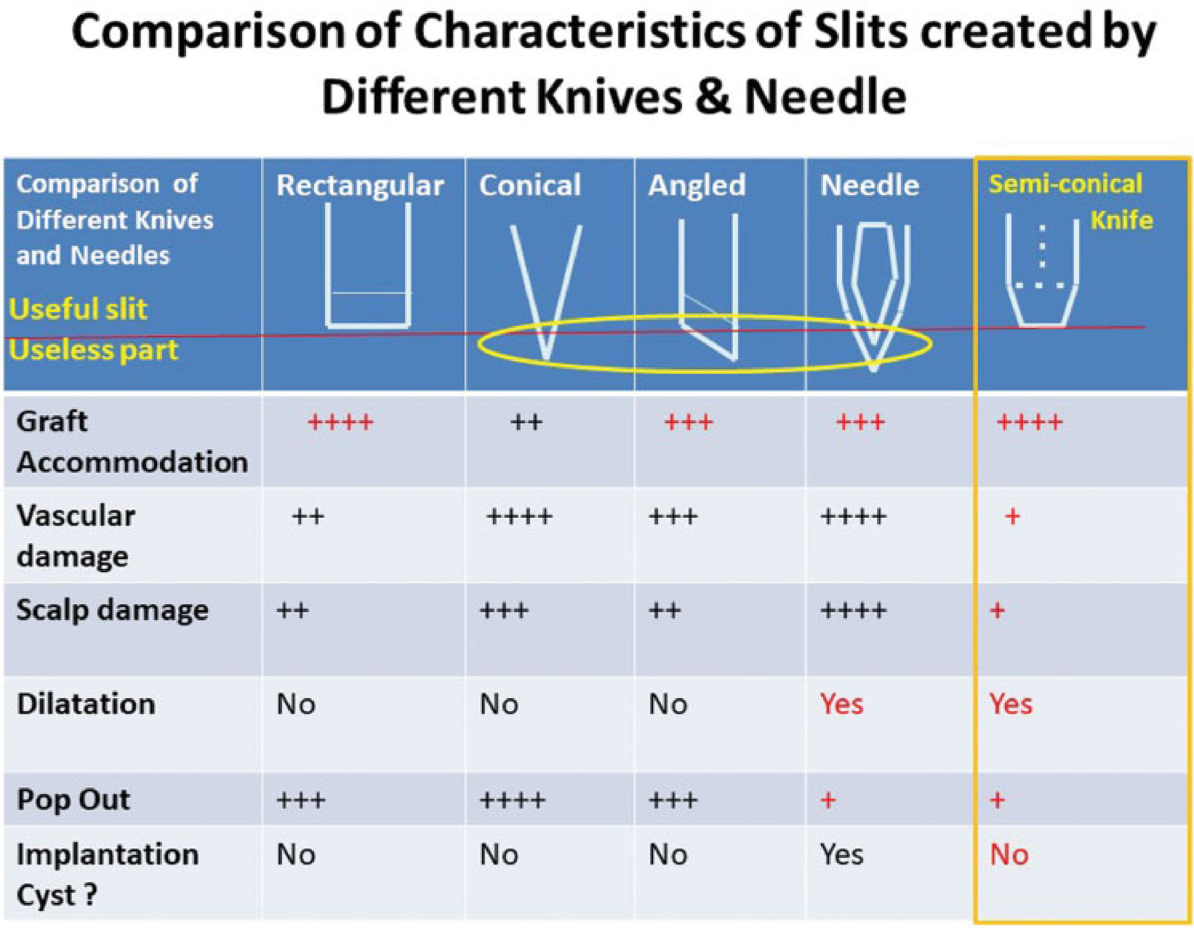


Fig. 3 Comparison of slits by different devices.



Comparison of Characteristics of Slits created by Different Knives & Needle

Comparison of Different Knives and Needles Useful slit Useless part	Rectangular	Conical	Angled	Needle	Semi-conical Knife
Graft Accommodation	++++	++	+++	+++	++++
Vascular damage	++	++++	+++	++++	+
Scalp damage	++	+++	++	++++	+
Dilatation	No	No	No	Yes	Yes
Pop Out	+++	++++	+++	+	+
Implantation Cyst ?	No	No	No	Yes	No

Fig. 4 Summary of slit creation options.

Inference—Semiconical blades offer the ideal slit with minimal vascular damage.

Angle of Slit

The next factor in slit making is the angle at which the slit is made. As the angle of entry becomes more acute, the depth of penetration for the same length of slit made reduces, as explained below (►**Fig. 5**).

We know that sin theta = opposite side/hypotenuse. In our situation, sin (angle of entry) = depth/length of slit. Using this formula, the depths of penetration for a slit of 5-mm length at various angles is shown in (►**Table 2**).

This equation shows that the lower the entry angle, the lesser the depth of penetration and lesser the chance of deep vascular injury. Hence, we should not use vertical angle and make our angle acute as far as possible, mimicking the natural exit of hairs angling from 15 to 60 degrees.

Hence, we infer that the more acute the angle, the less the depth of penetration (►**Fig. 6**).

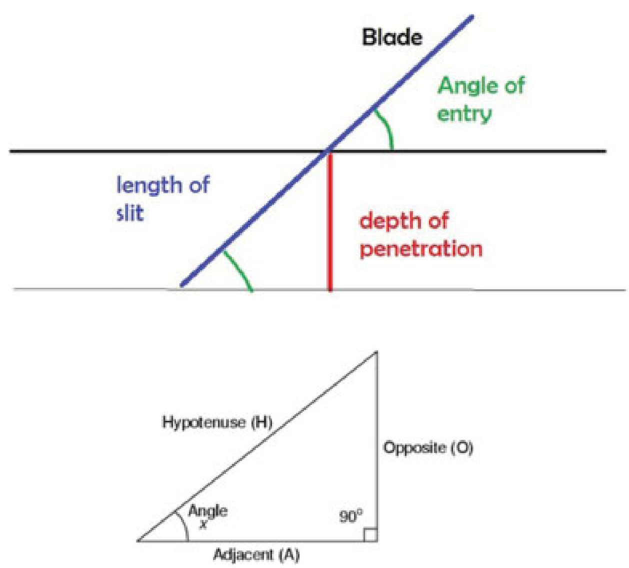


Fig. 5 Relation between angle of entry and depth of penetration.

Slit Orientation—Coronal Versus Sagittal

The next factor to consider in slit making is whether the surface orientation of the slit is coronal or sagittal. Coronal versus sagittal is an old debate. Coronal slit making was recommended as a better way to provide a better orientation of grafted hairs with respect to light reflectance; thereby, creating a better visual impact. However, the sagittal slit was

Table 2 Variation between the angle of entry and depth of penetration

Angle (in degree)	Depth (in mm)	Depth reduction (in percentage)
90	5	0
75	4.8	4
60	4.3	14
45	3.5	30
30	2.5	50
15	1.3	74

Table 3 Variation between the angle of entry and surface incision

Angle	Surface incision	Increase (%)
90	1	0
75	1.035	3.5
60	1.155	16
45	1.415	41
30	2	100
15	3.85	285

preferred by many as the more natural orientation and less likely to interfere with the vasculature.

We would like to consider a different factor—the surface incision, and whether it is the same as the width of the instrument.

In sagittal slits, the width of the blade is in the same axis as the angle of the slit. Hence, the length of the surface incision varies with the angle of the slit, similar to the above equation. Therefore, the following table shows the variation of surface incision for a blade of 1-mm width with angle (►**Fig. 7** and ►**Table 3**)

As we can see, at more acute angles, the surface incision increases in length significantly. This increases the trauma to the superficial plexus, thereby offsetting the benefits of the lower depth of penetration achieved at more acute angles. Also, the wider surface incision would decrease the density of packing.

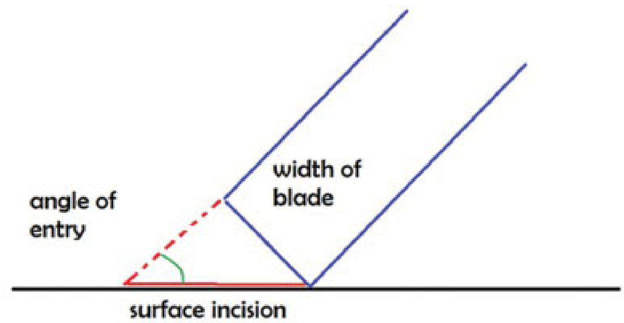


Fig. 7 Relation between angle of slit and length of surface incision for sagittal slits.

In coronal slits, the width of the blade is perpendicular to the axis of the angle of the slit. Hence, the length of the surface incision does not change and is always the same as the width of the slit. This reduces the trauma to the

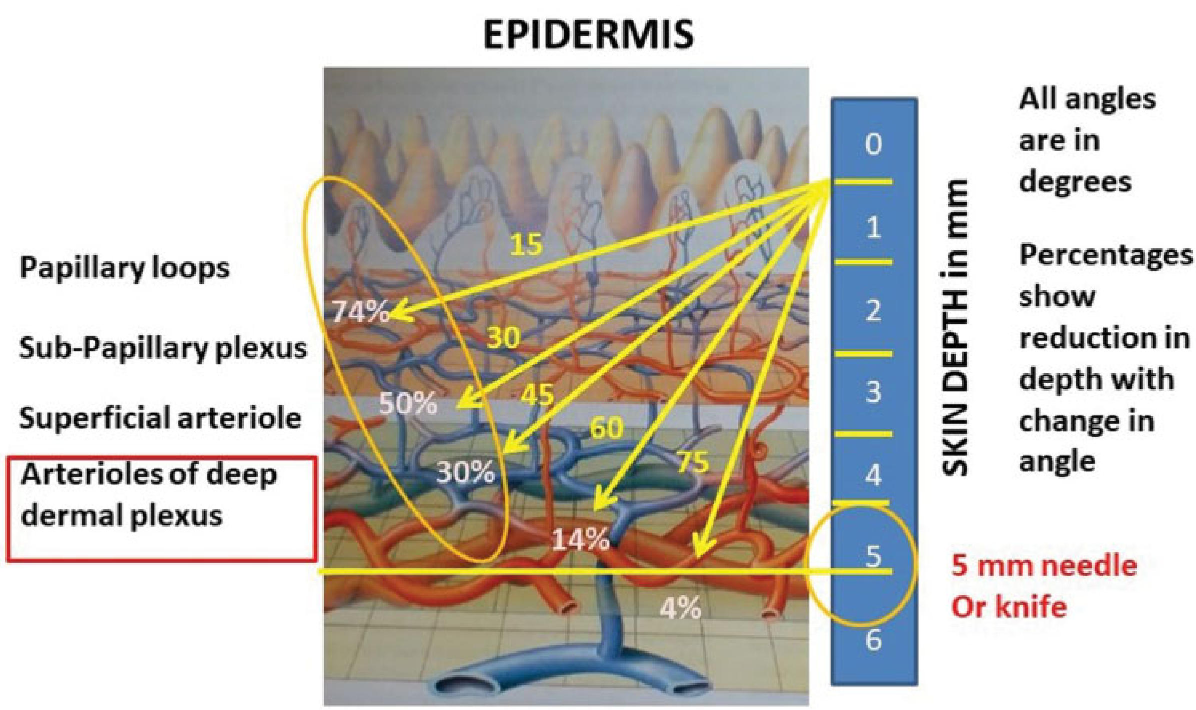


Fig. 6 Impact of penetration depth on vascular damage.

superficial plexus, while also preserving the deep plexus, as the angle becomes more acute. Hence, coronal slit would have this advantage of remaining the same width even after angulation.

We infer that the coronal slits do not increase the length of surface incision, while sagittal slits increase the surface incision as the angle reduces.

Conclusion

An ideal slit is one that allows easy implantation at an optimum depth without much pop-out, with minimal vascular damage at optimal density.

The slit technique which causes minimal vascular damage includes the following:

1. Use of semiconical blades will reduce the damage to the dermis and vascular plexus as compared with rectangular blades and needles, as the depth of penetration required is lower.
2. Use of acute angle to reduce the depth of penetration for the same length of slit and reduce damage to deep plexus.
3. Use smaller blades to create desired size slits in sagittal slit making.
4. Coronal slits will have lesser vascular damage than that of sagittal slits, regardless of whether one is using a single knife or multiple knives.

We believe that these recommendations provide the optimum volume slits while causing minimal vascular damage.

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Conflict of Interest

All the authors wish to report no conflicts of interest.

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