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Analysis of the Outcome of Scar Width after Linear Strip Excision (FUT) in Loose Scalp Laxity Compared with the Normal Scalp Laxity

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Abstract

Background: Follicular unit transplantation (FUT) or linear strip excision (LSE) is a well-known technique which can yield a high number of grafts in one session with good results and can save donor hair for the future. However, the downside of FUT is the white linear scar at the donor area. The preoperative assessment of scalp laxity is a vital step for FUT to determine the width of FUT excision. Mayer's scalp elasticity scale is generally used among hair restoration doctors to assess the scalp laxity. According to Mayer's scale, in patients with the scale more than 30% are referred as loose scalp or scalp hyperlaxity. It has been recognized that widened FUT scar is more common in patients with loose scalp than those who have normal scalp laxity.

Objective: The primary aim of this study is to compare the width of FUT scar in patients with loose versus normal scalp laxity. Secondary aim includes the comparison of bleeding in FUT with loose and normal scalp.

Materials and Methods: Sixty follow-up patients who underwent FUT strip excision more than 1 cm in width were randomly selected. Mayer's scalp elasticity scale and Laser Lax were performed on the surgery date to determine whether the patients have loose or normal scalp laxity. The FUT scar width in all participants were measured by the same examiner. The data of FUT scar width was collected from patients who follow up at DHT clinic in one year period from February 2022 to January 2023.

Results: All selected patients have a narrow FUT scar, which is less than 4 mm and there is no statistically significant difference in FUT scar width among loose and normal scalp laxity participants. During surgery, the bleeding grade at the donor FUT area in the loose scalp laxity group was higher than in the normal laxity group, with a statistically significant difference.

Conclusion: The scalp laxity is not the only factor that impacts on the width of the scar. There are other factors including FUT excision width, harvesting techniques, age, trichophytic closure technique and suturing technique, etc that also affect the outcome of the scar. Hence, in proper pre-operative evaluation, in good hands and in limited number of patients in the study, patients who have loose scalp should result in same width scar as patients with normal laxity scalp and should not always develop widening scar as discussed.

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Introduction

Follicular unit transplant (FUT) or linear strip excision (LSE) is a well-known technique and considered as the gold standard of hair restoration [1,2]. The steps of this technique include choosing the strip from save donor area and cutting the strip followed by dissecting into hair follicles. Donor area assessment is a vital step in hair transplantation and the evaluation of scalp laxity is necessary to calculate how wide the strip can be excised, especially in procedure with FUT excision width more than 1 cm [3]. Scalp contains five layers including skin, connective tissue, aponeurosis, loose areolar tissue, and pericranium. Ability of skin to return from stretching to normal is elasticity; whereas ability of loose fibroareolar tissue to glide over the pericranium of skull is called glidability. Both elasticity and glidability are individually affected on scalp laxity.

Various techniques have been proposed to assess the scalp laxity. Mohebi demonstrated Laxometer as a mechanical device to measure laxity [4]. Mayer and Puals presented Scalp elasticity scale, which is a commonly used and an objective measurement [3,5]. Mayer's scalp elasticity is a percentage of the distance between two 5-cm-horizontal-gap dots that were moved toward each other by examiner's thumbs as seen in figure 1 [3]. The formula is (50mm – x)(100%) / 50 mm, which x stands for the distance after scalp skin being compressed maximally by thumbs. The scale of this formula ranges from 10% to 45%, with an average at 24% [3]. A measurement of at least 30% represents a loose scalp laxity, also known as scalp hyperlaxity.

The marked area for FUT harvesting is varies among different hair surgeons. In our study, the center of FUT strip is usually located at either below or upper superior nuchal ridge depending on the degree of androgenetic alopecia in order to achieve safe donor area. The strip is outlined from the mid occiput extending to parietal area on both sides. Pathomvanich introduced Laser lax to evaluate real-time scalp laxity in horizontal plane [6]. This method is performed by turning on laser device, beam that is projected horizontal line over the targeted area and marked as the first reference line as seen in figure 2a. The skin above the line is pressed downward as far as possible while the laser line remains at the same position. The second line is marked at the level that is projected from laser as seen in figure 2b. The third

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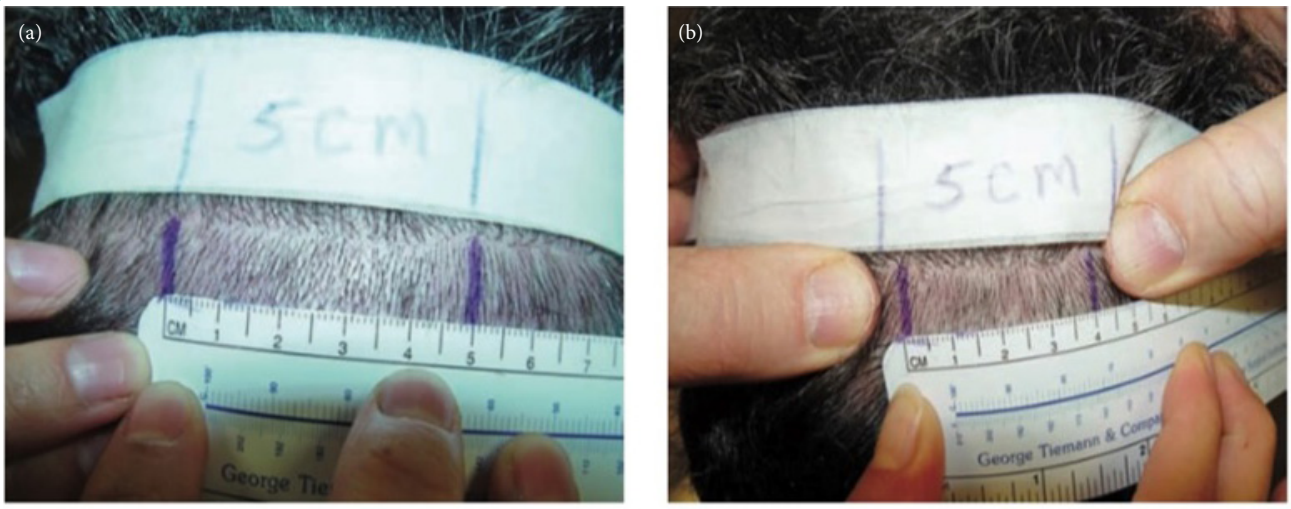

Figure 1 : The measurement method of Mayer's scalp elasticity.
(a) The initial marks of two 5-cm-horizontal-gap dots
(b) The measurement when scalp is compressed maximally

(a) The first reference line

(b) The scalp above the reference line is push downward, and the second line is marked.

(c) The scalp above the reference line is push upward, and the third line is marked.
Figure 2 : Laser Lax.

line is created by the same method, but the skin is pressed upward as seen in figure 2c. The maximal strip width is estimated from the distance between the second and third lines. Three points including occipital, left and right lateral areas of the planned area is performed to create the strip. The main benefit is to rapidly guide the surgeons on how wide the strip should be, to obtain the desirable number of grafts as well as wound approximation. However, this method is not quantifiable and cannot be used to compare scalp laxity among different patients.

The main concern of FUT consequence is a linear scar and the scar width more than 4 mm is identified as a wide scar which is not cosmetic acceptible [3,8]. Bernstein and Rassman mentioned that loose scalp laxity can result in widening donor FUT scar, known as Scalp Laxity Paradox [7]. However, this research is aimed to compare the width of FUT scar between loose and normal scalp whether loose scalp laxity patients result in wider scar more than those with normal laxity scalp.

Materials and Method

Patients

Sixty patients aged over 25 years old who underwent one FUT procedure or combination (combo) of FUT and follicular unit excision (FUE) from DHT clinic at least six months prior was randomly included. In combo, the FUE method was performed after the FUT excision closure and more than 1cm-interval below the FUT excision. The 0.95 mm FUE hybrid punch was used. Only patients with the strip that was excised from the middle of occipital protuberance extending to both sides of parietal areas and the FUT excision more than 1 cm in width were selected. Loose scalp is difficult to determine, nevertheless we used Mayer's scalp scale based on the majority of hair restoration doctors. The participants with the scale between 30% and 50% (30-50%) were classified as loose scalp laxity or hyperlaxity while those who had less than 30% (20-29%) were classified as normal scalp laxity. In other words, the patients who had a horizontal distance of less than 3.5 cm between two 5cm-horizontal-difference dots after pressing two thumbs, were identified as loose scalp laxity. In additions, Laser lax

was performed in selected patients. The scalp elasticity scale and Laser Lax in patients were measured by the same hair surgeon from the record. All participants underwent hair transplantation by the same doctor with lower trichophytic closure technique. The patients who have excision shorter than 14 cm, history of face-lift surgery, any trauma or surgery of the scalp, history of silicone gel use on FUT scar, and history of abnormal bleeding or abnormal coagulation test were excluded. All patients stopped taking blood thinning medications two weeks before surgery.

Study design

The observational study was conducted in one year period between February 2022 and January 2023 at DHT clinic, Bangkok, Thailand.

Details of the FUT excision and scar width were collected only by the researcher. The FUT excision widths and Mayer' scalp scale measurement was recorded in the patients' charts when the transplantations were done. This study also compared FUT excision width and scar width in the same measurement points.

FUT excision width (cm) from the middle of occipital protuberance (center), left and right parietal area (7 cm left/right from the middle of occipital protuberance) were collected from the patients' medical records. By the study's definition, center refers to the middle of the occipital protuberance, left and right areas are the left and right parietal area, respectively. Consequently, the width of the FUT scar was measured during patients' follow up (at least six months after procedure) at the three points described as seen in Figure 3. The bleeding grade in FUT were assessed by the same hair surgeon. There are 3 different grades: ranging from 1+(minimum), 2+ (average), and 3+(maximum).

Statistical analysis

Independent t-test or Chi-square test were used to compare the characteristic between two study groups, depending on the type of data. The comparison on FUT scar width was performed using independent t-test and bleeding grade was calculated by Chi-square test. Statistical testing was done at a two-sided significance level of α=0.05. All statistical tests were performed using Stata IC15 (StataCorp, 2017, College Station, TX, USA).

Results

Demographic data

A total number of participants were sixty including thirty patients with loose scalp laxity and thirty patients with normal scalp laxity (Table 1 and Figure 2). The age ranged between 25 and 74 years old and the mean age among two groups were 42.9 years in loose laxity

Figure 3: The measurement of width of FUT scar in 3 different locations; Left, Center, Right (above)Asian male with loose scalp laxity post combination of FUT and FUE 3 years (below)Asian male with normal scalp laxity post combination of FUT and FUE 1 year

group and 48.73 years in normal laxity group. Most of the participants were male, Asian and non-smoker. There were no statistic differences in age, gender, nationalities, history of smoking, surgical techniques, total number of transplanted hair grafts, FUT length, suture techniques, and years after the FUT procedure. Regarding the surgical technique, this study included patients with FUT only and patients with Combo in the same surgery, however the majority were the patients who underwent FUT only in both groups.

The majority of participants with loose scalp laxity had Mayer's scalp scale between 30% and 34% while six out of thirty participants had laxity scale more than 40%. In the normal laxity group, seventeen from thirty participants had scale ranged in 25-29% and thirteen participants had scale ranged from 20% to 24%. The average of the scale in loose and normal scalp were 33% and 25%, respectively. The highest and lowest scalp elastic scale were 46% and 20% as seen in Figure 4.

Demographic data		Loose scalp laxity (n=30)	Normal scalp laxity (n=30)	p-value
Scalp elasticity scale (%)	Mean (SD)	33.13 (4.51)	25.20 (1.94)	<0.001
Age (years)	Mean (SD)	42.90 (10.23)	48.73 (14.27)	0.074
Gender	Female	2 (6.67%)	4 (13.33%)	0.39
	Male	28 (93.33%)	26 (86.67%)	
Nationalities	African	1 (3.45%)	0 (0.00%)	0.45
	Asian	17 (58.62%)	21 (70.00%)	
	Caucasian	11 (37.93%)	9 (30.00%)	
Smoking	No	28 (93.33%)	29 (96.67%)	0.55
	Yes	2 (6.67%)	1 (3.33%)	
Technique	FUT	25 (83.33%)	24 (80.00%)	0.74
	Combo (FUT+FUE)	5 (16.67%)	6 (20.00%)	
Number of grafts	Median (IQR)	2805 (2068, 3270)	2533 (2164, 3045)	0.51
FUT length (cm)	Mean (SD)	22.61 (5.38)	23.48 (5.65)	0.54
Suture technique	Retention technique	21 (70.00%)	26 (86.67%)	0.12
	Knot-free technique	9 (30.00%)	4 (13.33%)	
When data collection after surgery (year)	Median (IQR)	3 (2, 7)	6 (3, 7)	0.21

Table 1 : Demographic data.

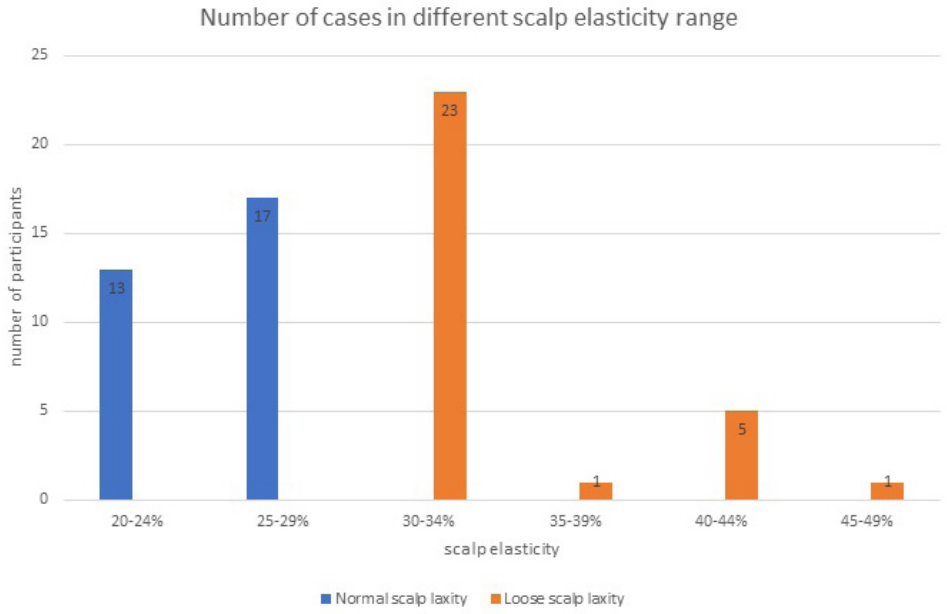

Figure 4 : Number of participants in different scalp elasticity range.

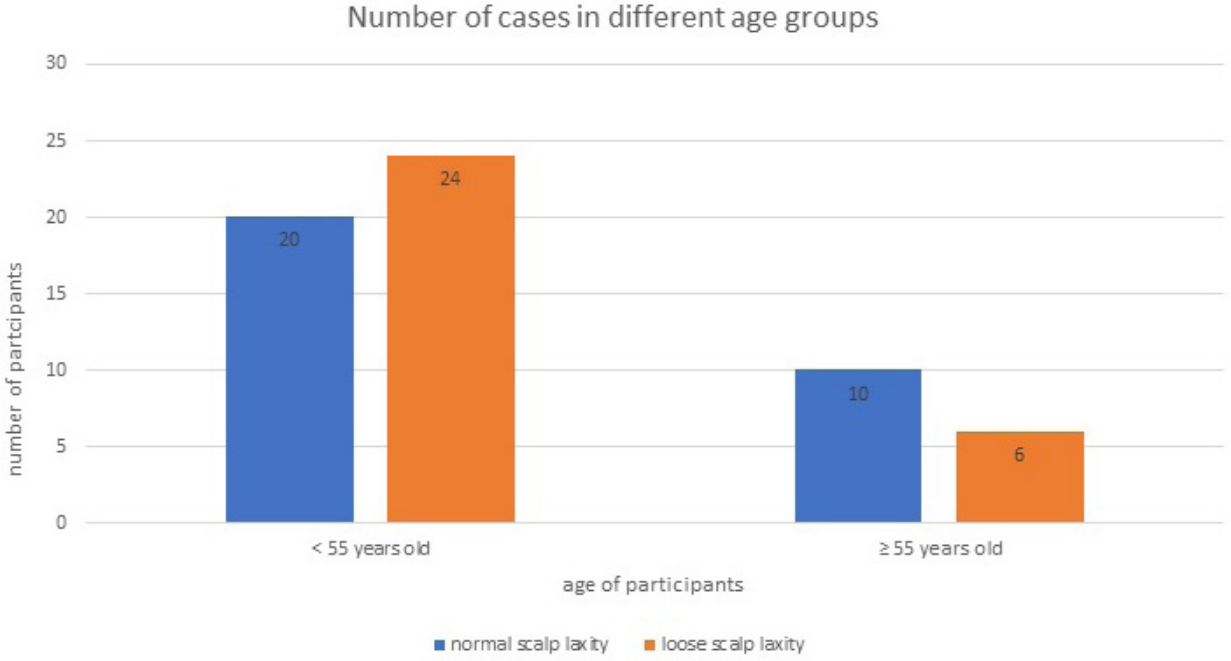

Figure 5: Number of participants in different age groups.

With regards to age group, the majority of participants were younger than 55 years old in both normal and loose scalp laxity. In loose scalp laxity group, there were six patients aged 55 years or more (≥ 55 years old), while there were ten patients over age 55 in normal laxity group as seen in Figure 5.

Regarding the diagnosis of participants, we collected data from fifty-four male patients with AGA Norwood class II to class VI and six female patients with high hairline and Ludwig type (Table 2). More than 50% of both groups included the male patients with AGA class IV and V, while high hairline is the majority of female participants. There is no statistic significant difference in the severity of AGA and female pattern hair loss among two study groups.

	Diagnosis	Loose scalp laxity	Normal scalp laxity	p-value
Male AGA type	II	3 (10.00%)	0 (0.00%)	0.53
	III	5 (16.67%)	7 (23.33%)	
	III vertex	1 (3.33%)	2 (6.67%)	
	IV	6 (20.00%)	8 (26.67%)	
	V	9 (30.00%)	7 (23.33%)	
	VI	4 (13.33%)	2 (6.67%)	
Female	High hairline	2 (6.67%)	3 (10.00%)	
	Ludwig 2	0 (0.00%)	1 (3.33%)	

Table 2 : Diagnosis of participants.

FUT excision width data

The mean FUT width at the Left, Center, and Right locations in the loose scalp laxity group were 1.37, 1.64 and 1.37 cm, whereas the mean FUT width in the normal laxity group were 1.37, 1.67 and 1.37 cm, respectively. Comparing FUT excision between two groups, there was no statistically significant difference in the mean FUT excision width at all three locations as seen in Table 3.

FUT excision width (cm)	Mean (SD)		p-value
	Loose scalp laxity	Normal scalp laxity	
Left	1.37 (0.14)	1.37 (0.12)	0.92
Center	1.64 (0.27)	1.67 (0.28)	0.64
Right	1.37 (0.14)	1.37 (0.12)	1.00

Table 3 : Mean FUT excision width in three different locations among loose and normal scalp.

FUT scar width data

In the loose laxity group, the mean width of FUT scar were 0.21, 0.19 and 0.21 cm at the Left, Center, and Right whereas the mean width of FUT scar in normal laxity group were 0.23, 0.18 and 0.23 cm, respectively. There were no statistically differences in FUT scar in three locations of both groups as seen in Table 4. To our surprise, the loose scalp laxity did not show a wider scar compared to the normal scalp laxity as seen in Figure 6.

FUT scar width (cm)	Mean (SD)		p-value
	Loose scalp laxity	Normal scalp laxity	
Left	0.21 (0.07)	0.23 (0.08)	0.25
Center	0.19 (0.08)	0.18 (0.09)	0.76
Right	0.21 (0.07)	0.23 (0.08)	0.25

Table 4: The comparison of FUT scar width in three different locations among loose and normal scalp groups

We divided patients into two groups according to the hair transplantation technique; FUT only and Combo. In loose scalp laxity group, the median of FUT scar width at all three locations in both subgroups were 0.2 cm. The median of FUT scar width, in normal laxity, at the Center were 0.1 and 0.2 in FUT and in the Combo group, respectively. There were no statistically significant differences in these subgroups of both types of scalp laxity as seen in Table 5.

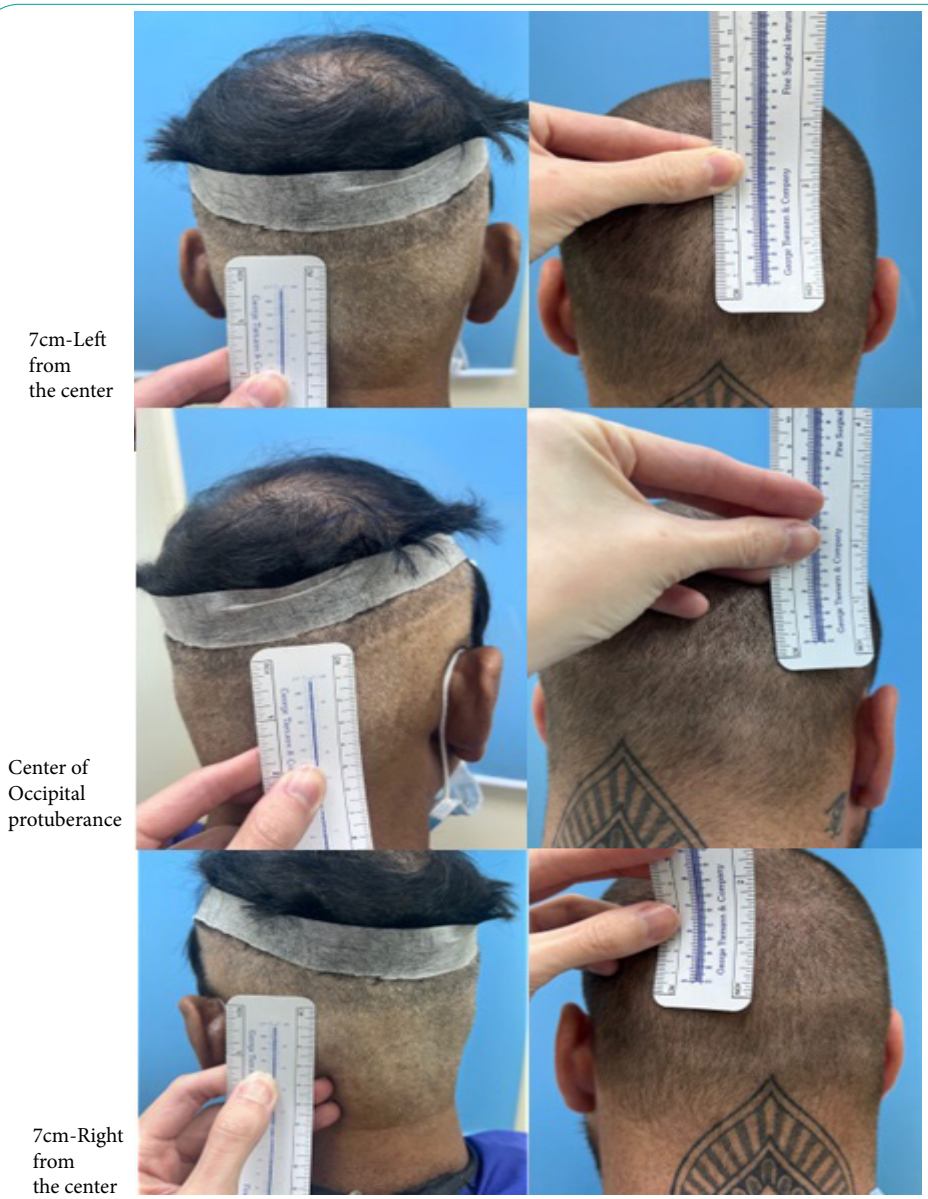

Figure 6: Comparison between the width of FUT scar in 3 different locations at 1 year after the first FUT in the loose scalp patient with 40%of Mayer's laxity scale (left-side photos) and the normal scalp laxity patient with 28%of Mayer's laxity scale (right-side photos)
Subgroup analysis between patients who underwent FUT only versus Combo

Loose scalp laxity	**FUT (n=25)**	**Combo (FUT+FUE) (n=5)**	**p-value**
Scar width at the Left	0.2 (0.2, 0.2)	0.2 (0.2, 0.2)	0.84
Scar width at the Center	0.2 (0.1, 0.2)	0.2 (0.1, 0.2)	0.88
Scar width at the Right	0.2 (0.2, 0.2)	0.2 (0.2, 0.2)	0.84
Normal scalp laxity	**FUT (n=24)**	**Combo (FUT+FUE) (n=6)**	**p-value**
Scar width at the Left	0.2 (0.2, 0.3)	0.3 (0.2, 0.3)	0.24
Scar width at the Center	0.1 (0.1, 0.3)	0.2 (0.2, 0.3)	0.22
Scar width at the Right	0.2 (0.2, 0.3)	0.3 (0.2, 0.3)	0.24

Table 5: The comparison of median scar width among 2 subgroups; FUT and Combo.

Bleeding at FUT area during surgery

In loose scalp laxity group, 73.33% of the patients had bleeding grade 2+ at FUT donor area while 53.33% of normal scalp laxity patient had bleeding 1+. There was a statistically significant difference (p-value=0.004) in bleeding grade among these two study groups as seen in Table 6.

Bleeding grade at donor area	Loose scalp laxity	Normal scalp laxity	p-value
1+	6 (20.00%)	16 (53.33%)	0.004
2+	22 (73.33%)	9 (30.00%)	
3+	2 (6.67%)	5 (16.67%)	

Table 6: Bleeding grade at donor (FUT) area during surgery.

Dicussion

The width of FUT scar that is less than 4 mm is considered as a narrow scar since it is not cosmetically detectable scar and unnecessary to repair [8]. From our study, all participants have FUT scar width less than 3 mm at all three landmark locations. At the left and right parietal locations in all cases have wider scar than at the center. It can be explained by the fact that the left and right parietal locations that we measured are located at or closed to the mastoid area which have less laxity than the center location. However, there were no statistic significant differences at all three locations among two study groups. To our surprise, both loose and normal scalp laxity groups which were classified based on Mayer's laxity scale have a narrow scar. Hence, the scalp laxity might not be the only factor that impacts on the width of FUT scar.

The final FUT scar width is greatly determined by the width of the excision excised during FUT at the occipital and both parietal areas. To calculate the maximum width that can be excised from a patient and at the same time minimize FUT scar width, most hair transplant surgeons refer to Mayer's scalp elasticity scale. The scale suggests that the widest part of the strip should be taken at the occipital or center of the FUT excision and that the width at left and right parietal area (where the FUT excision extends from) should be 20% less than the width at the center [5]. For patients with a scalp laxity of 20%, the maximum strip width that can be excised at the center and lateral areas are 2 cm and 1.5 cm, respectively. And, for patients with scalp laxity of 30%, the maximum width would be 2.2 cm and 1.5 cm at the center and lateral areas. Hence, based on this recommendation, the higher the scalp laxity, the wider the excision that can be done without compromising the final scar width. In our study, the mean FUT excision widths were less than the maximum widths in Mayer's recommendation. It was found through comparison of FUT excision width and their corresponding final FUT scar width at all three measured locations, that there was no significant difference between loose and normal scalp laxity group. This is not congruent with the standard practice that dictates that the laxity of the scalp is contributory to the width of the scar. This implies that to gain more grafts, it might be better to extend the length of FUT excision without extending beyond the ears, rather than increasing excision width.

Beside the Mayer's laxity scale, the participants were evaluated by Laser Lax to determine scalp laxity since it reflects scalp elasticity in horizontal plane. It helps the surgeon to predict the widest FUT excision width with adequate tension closure, however it cannot be compared between patients as it is not quantifiable. The width from Laser Lax was not used as the final excision width in this study. It was used to evaluate that the calculated FUT excision widths would not exceed the maximum width that result in good approximate wound closure. Therefore, Laser Lax is another tool that impact on preoperative assessment. It is important for the surgeons to evaluate laxity in horizontal properly to get adequate closure tension which can result in narrow FUT scar.

Park suggested a new method to evaluate skin elasticitiy and glidibility which is more accurate and reduce mimic effect from each other [9]. From 88 participants in the study showed that the patients with higher elasticity resulted in wider FUT scar than lower elasticity. However, in subtype group, 2 out of 61 patients with normal elasticity presented wide (> 4mm) scar. It is also commented that scalp laxity contains of 45% component from elasticity and 55% component from glidability. It can be implied that the width of FUT scar depends on glidability as same as scalp elasticity. However, in our study, there were no measurement records regarding glidability.

In subgroup comparison, the patients who underwent combination of FUT and FUE in both groups have same scar width as the patients who had only FUT. The affected from FUE scoring in this study has no impact on FUT scar width. Moreover, it was reported that FUE method adjuvanted to the FUT method can reduce strip wound closure tension force and result in acceptable cosmetic scar [10]. This can imply that a combination of FUT and FUE or combo can reduce the widened FUT scar as it can reduce the FUT excision width as well as the number of FUE scoring at the same session, however it does not increase the width of FUT scar.

Aging is another highlight factor to be considered. It was supported that the patients who are older than 55 years old are more likely to have invisible scar as the depletion of collagen [11]. In other word, the younger the patient, the wider FUT scar will present since the younger have higher collagen. According to our results, age also contributes on FUT scar width. The older in both study groups tend to have narrower scar in this study. However, the majority of participants were younger than 55 years old. The mean age in our study were 42.9 and 48.73 in loose and normal scalp laxity groups and there were no statistic significant differences between mean age and age range among two study groups. Hence, age is not only factor that impacts on the scar width, but other factors also impact.

Wound healing is another factor to concern. In this study, there were no patients who were heavy smoker (more than 20-pack-yr) and most of the patients are non-smoker. Closure and suturing technique also impact on wound healing process. In 2005, Marzola reported that trichophytic closure, de-epithelializing one or two follicular units at FUT donor areas, can camouflage the linear scar as some of the trimmed follicles will regrow at the established scar [12]. However, he also mentioned that if the scar is wider than 3 mm, trichophytic closure might not be able to provide better cosmetic coverage. All of our participants' records showed that the procedures were performed with lower trichophytic closure by trimming follicles only at the inferior edge of FUT excision. All participants had FUT scar width less than 3 mm, hence single trichophytic closure technique can reduce the width of FUT scar and provide good cosmetic appearance.

Regarding suturing technique, the majority of participants were sutured by 3/0 Nylon retention interruption deep to below dermal papillae together with 4/0 Vicryl rapide running to approximate

epidermis and some of the participants were sutured by 4/0 Nylon with the knot-free closure technique that is innovated by Pathomvanich to minimize postoperative pain. With regards to the new technique, it is conducted by three continues running in epidermis followed by a suture deep just below the dermal papillae and three continues running in epidermis followed by a suture deep to mid follicular level. This sequence is repeated to complete the whole wound and both ends are knot-free as tying the knot can cause more post-operative pain. Both suturing techniques use towel clamp while suturing to keep the approximated edges. It was supported that both absorbable and non-absorbable suturing materials have no differences in functional and cosmetic results of scalp wound [13]. In our study, there was no difference in scar width among absorbable versus non-absorbable sutures as well as two different suturing techniques in two different laxity groups.

According to scalp skin anatomy, FUT is cutting deep just below the dermal papilla or above the deep fascia as this layer can minimize bleeding complication and fasten the strip removal [2]. However, in loose scalp group, it is noticed that the bleeding is obviously more than normal laxity group. From our study, in loose scalp laxity group, the majority of the patients had bleeding grade 2+ at FUT donor area while most of normal scalp laxity patient had bleeding grade 1+.

However, the size of the study is small, and the collecting data should be done by double blinding technique. We will continue collecting data to support this research and encourage other doctors to study regarding this interesting issue.

Conclusion

The scalp laxity might not be the only factor that effect on the width of FUT scar. Other factors including excision width, harvesting techniques, age, trichophytic closure technique and suturing technique also have an impact on the scar width. Hence, in appropriate pre-operative assessment, in good hands and in limited number of patients in this study, loose scalp laxity patients should result in same FUT scar width as patients who have normal laxity. In additions, the patients with loose scalp laxity have more bleeding during FUT harvesting at donor area than the normal laxity. However, larger controlled-group population need to be investigated.

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Competing Interests

The author declare that he has no competing interests.

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