

A Novel Approach for Linear Strip Excision (FUT) Closure: Knot-free to Minimize Post-operative Pain

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Abstract

Background: Follicular unit transplantation (FUT), otherwise known as linear strip excision (LSE), is the practice of harvesting from a strip at the safe donor area (SDA) followed by individual dissection of the follicular units for hair transplantation. With LSE, there is the advantage of preserving the SDA for future transplant; however, the anticipated post operative outcomes that occur including pain, shock loss, and linear scar have frequently discouraged patients to choose this technique; thus, prompting the authors to formulate a new method of wound closure to minimize such consequences – the knot-free closure technique.

Objective: The primary objective of the study is to evaluate the outcome this technique in linear strip excision closure with regards to post operative pain, bleeding, shock loss and scar width – one, three and six months after surgery. Secondary objectives include evaluating whether the number of grafts, technique used in harvesting (LSE or combination of LSE and follicular unit extraction), number of hair transplantation sessions, area of the strip harvested and suture used, in relation to post operative pain, bleeding, shock loss and linear scar width.

Method: Post operative outcomes of the strip closure technique were examined and follow up consultation was done among these patients monthly and data were collected at 1,3 and 6 months' post surgery. Among the outcomes that were evaluated included pain severity using pain score at Day 1 and Day 7 post-operatively, absence and presence of bleeding at Day 1 and Day 7, shock loss and keloid scarring one month, three months and six months, after surgery. Final scar width was measured (in cm) at the occipital and mastoid area at 6 months. These outcomes were also studied in correlation with AGA severity, number of grafts harvested, technique used (whether FUT or in combination with FUE), total area of the strip excised in cm², and suture utilized (absorbable or non-absorbable). Photographic documentation was also done.

Results: The use of knot-free, continuous closure technique for LSE resulted in minimal to no post operative pain, less than 2% prevalence of shock loss and scarring three to six months after surgery. The resulting mean scar width was 0.28-0.33 cm in the occipital and mastoid area, respectively regardless of the number of hair transplantation sessions.

Conclusion: This novel technique resulted in minimal post operative pain. Other complications seen in linear strip excision such as bleeding, shock loss and scarring were also minimal, if not none. Thus, making linear strip excision procedure more acceptable for patients who want to benefit from the advantages of doing LSE but are hesitant to do so because of the of its possible complications.

Recommendations: We recommend to evaluate the measured outcomes long term and to compare the technique with other existing methods of linear strip excision closure.

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Introduction

Follicular unit transplantation (FUT), otherwise known as linear strip excision (LSE), is the method of harvesting a strip at the safe donor area (SDA) on the scalp, followed by individual microscopic dissection of the grafts to produce the follicular units for hair transplant. It is considered the gold standard in the field of hair restoration surgery [1,2].

Its involves the selection and preparation of the donor area for harvest, administration of local and tumescent anesthesia, dissection of the donor strip, and after, wound closure. Traditionally, several techniques can be used for donor wound closure single-layer and double layer closure, use of retention stitches, incorporation of an upper and/or lower trichophytic closure as well as staple closure [3]. These techniques have their own advantages. Nevertheless, there are complications seen in LSE postoperatively that can be, although not entirely, attributed to wound closure technique and these include post operative pain, post operative telogen effluvium or shock loss, linear scar as well as changes in the direction and angle of the hair below the scar [4,5].

One of the most expected postoperative outcome which discourages patient to do LSE is pain. The pain associated with LSE is one of its main disadvantages [6,7]. Over the past two decades of hair transplantation with linear strip excision, retention sutures have been utilized with closing the skin at our clinic. In practice, this resulted in minimal donor scar in majority and less to no bleeding post operatively; however, the use of this technique resulted in moderate to severe post operative pain, with pain score severity of more than 5 (on a scale of 1-10) and this pain would usually last for several days to a week. The anticipation of pain has caused high anxiety to patients and although most hair surgeons have adopted various methods in trying

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to reduce post operative pain, there is still not one single method that have been proven to be generally effective [8]. The pain is thought to be related to how the surgeon tie the knot of the suture. If it is too tight, it might cause more pain and swelling between the retention sutures which can result to consequent strangulation of the hair follicle because of the temporary lack of blood supply. This temporary lack of blood supply can also lead to shock loss which almost always recover three to four months after the procedure. There are also other factors to consider when it comes to the post operative pain such as the width of the scar excised as discussed by Dr. A. and S. Garg in their study; moreover, hematoma and infection can also cause pain post operatively.

In FUT, the harvested strip would also result in a linear scar. In the hands of an experienced and skilled surgeon, the scar might be minimal and indiscernible. However, even so, such scar might be of concern to patients who wish to completely shave their hair. Moreover, the final width and appearance of the scar is not only dependent on the surgeon's skill, it is also highly correlated with the patient's age, healing tendencies, and other factors such as preoperative laxity, elasticity, and glidability [9]. In personal practice, it has been observed that when it comes to age, the younger the patient is, the tendency for a wider scar is higher. Moreover, patients who have loose scalp/increased scalp laxity and those with an underlying condition such Ehlers Danlos syndrome are also more prone to a wider scar [10].

Other complications that may arise from the technique include swelling, bleeding and shock loss. Given such, the premise of possibly reducing such complications have prompted the authors to modify the technique in closing the donor scar [11,12].

In this novel technique, wound closure begins by passing the suture needle approximately 2.0 cm distal to wound edge and leaving the distal end of the suture at least 3-4 cm in length and knot free. This is to create less tension and irritation over the wound. Since this technique is a running stitch and there is no tie at the end, it will allow the wound to breathe or expand post operatively and will not lead to strangulation and lack of blood supply.

After which, three continuous running sutures at the level of the epidermis is made, making sure that the wound edges are approximate each other. After, the suture needle is passed perpendicular to the skin wound edge and made to exit at the mid follicular level on one side and entering at the same level on the other side. Another three continuous running sutures, as previously described is done and thereafter, a suture is made to exit just below the dermal papillae on one side and to enter the same level on the other side. This deep stitch mimics the role of the retention stitch used traditionally in wound closure. This sequence is repeated until the wound is closed entirely. At the end, the suture is made to exit 2.0 cm distal to the wound edge and is again kept at 3-4 cm in length and knot free.

Objectives of the Study

Primary objective

The primary objective of this study is to describe the outcome of the knot free, continuous closure technique in terms of post operative pain, bleeding, shock loss and linear scar width.

Secondary Objectives

1. To describe the demographic profile of patients in terms of:
 - a. Age
 - b. Gender
 - c. Ethnicity
 - d. Severity of Androgenetic Alopecia
 - e. Number of hair transplantations done
 - f. Technique of hair transplantation done – whether FUT alone or in combination with FUE
 - g. Use of Medications – Finasteride and/or oral Minoxidil
2. To evaluate the following factors and its relationship to post operative pain using the Wong Baker Face scale on Day 1 and Day 7:
 - a. Number of grafts
 - b. Technique used in donor harvesting – linear strip excision alone or combination of linear strip excision and follicular unit extraction
 - c. Number of session of hair transplantation – whether single or multiple
 - d. Area (in cm²) of strip harvested
 - e. Suture used
3. To evaluate the following factors and its relationship to the absence or presence of shock loss:
 - a. Number of grafts
 - b. Technique used in donor harvesting – linear strip excision alone or combination of linear strip excision and follicular unit extraction
 - c. Number of session of hair transplantation – whether single or multiple
 - d. Area (in cm²) of strip harvested
 - e. Suture used
 - f. Use of medications – Finasteride and/or oral Minoxidil
4. To evaluate the following factors and its relationship to the absence or presence of keloid scarring:
 - a. Number of grafts
 - b. Technique used in donor harvesting – linear strip excision alone or combination of linear strip excision and follicular unit extraction
 - c. Number of session of hair transplantation – whether single or multiple
 - d. Area (in cm²) of strip harvested
 - e. Suture used
5. To evaluate the following factors and its relationship with scar width on month 1, 3 and 6:
 - a. Number of grafts
 - b. Technique used in donor harvesting – linear strip excision alone or combination of linear strip excision and follicular unit extraction
 - c. Number of session of hair transplantation – whether single or multiple
 - d. Area (in cm²) of strip harvested
 - e. Suture used

Materials and Methods

Patients

63 consecutive patients who underwent linear strip excision (alone or in combination with follicular unit excision) were evaluated for bleeding, shock loss and linear scar width; and, post operative pain score was assessed in a total of 100 patients.

Study design

This is a prospective observational study done at DHT Clinic, Bangkok, Thailand, from September 2021 to December 2021. 63 patients were recruited and evaluated for all postoperative outcomes; an additional 37 patients were included and evaluated for post operative pain alone to make up 100 patients in the evaluation for post-op pain. Follow up consultation was done among these patients monthly and data were collected at 1, 3 and 6 months' post surgery.

In order to assess pain severity, Wong–Baker Faces Pain Rating Scale was utilized on Day 1 and on Day 7 post operatively. The absence and presence of bleeding at Day 1 and Day 7, shock loss and keloid scar one month, three months and six months, after surgery, was also evaluated. Retraction of the suture was checked as well since wound closure was knot free [13].



Final scar width was measured at the occipital and mastoid area at 6 months. These outcomes were studied in correlation with AGA severity, number of grafts harvested, technique used (whether FUT or in combination with FUE), total area of the strip excised in cm², number of hair transplant sessions done and suture utilized (absorbable or non-absorbable). Photographic documentation was also done.

Statistical analysis

Descriptive statistics such as mean and standard deviation were used to present continuous variables while frequency and percentage for categorical data. Pearson r correlation was utilized to test the relationship while independent to test for test of difference. Level of significance is at 5%.

Discussion and Results

Of the 63 patients, majority of them were male, Asian and diagnosed with AGA type III. They had a mean age of 41-years-old. There was almost an equal number of patients who did FUT alone and a combination of FUT and FUE. 65% of the patients took oral Finasteride and 85.7% of patients took oral Minoxidil as seen in Table 1.

Values	
Age (years), mean ± sd	41.2 ± 9.8
Gender, n, %	
Male	56 (88.9)
Female	7 (11.1)
Ethnicity, n, %	
Asian	41 (65.07)
Caucasian	22 (34.9)
AGA Classification, n, %	
AGA II	13 (20.6)
AGA III	26 (41.3)
AGA IV	8 (12.7)
AGA V	11 (17.5)
AGA VI	5 (7.9)
Technique, n, %	
Combination FUE/FUT	31 (49.2)
FUT	32 (50.8)
Finasteride, n, %	41 (65.1)
Oral Minoxidil, n, %	54 (85.7)

Table 1: Demographic and Clinical Profile.

In the study, the mean number of grafts harvested for hair transplantation was 2,647 grafts with an area of 32 cm². Majority, 39 patients (61.9%) underwent their first hair transplant session and non-absorbable (4/0 Nylon) suture was used (Table 2).

Values	
Number of grafts, mean ± sd	2647.7 ± 703.4
Type of suture, n, %	
Absorbable	25 (39.7)
Non-absorbable	38 (60.3)
Strip Area (cm), mean ± sd	32.7 ± 7.1
Hair transplant session, n, %	
I	39 (61.9)
II	17 (27.0)
III	3 (4.8)
IV	2 (3.2)
V	1 (1.6)
VI	1 (1.6)
Suture used, n, %	
3/0 Vicryl Rapide	19 (30.2)
3/0 Nylon	4 (6.3)
4/0 Nylon	34 (53.9)
4/0 Vicryl Rapide	6 (9.5)
Bleeding donor area (none)	63 (100.0)

Table 2: Nature of Grafts, Type of Suture, Hair Transplant session

For the clinical outcome (Table 3), the mean pain score on Day 1 (one-day post operatively) is 1.37 while the score was 0 or no pain for all patients at Day 7 using the Wong–Baker Faces Pain Rating Scale. This highlights the minimal pain associated with the technique. In the past, the use of retention stitches has resulted in moderate to severe post operative pain. In personal practice, post operative pain using retention stitches was scored at 5 or more out of 10. The pain score observed in this new technique is remarkably lower. In a study done by Yang Seok, Kim et. al, on the comparison of postoperative pain according to the harvesting method used in hair restorative surgery, postoperative pain in those who underwent hair transplantation by the linear strip excision method was rated at 2.03 and 0.21 points on Day 1 and Day 7 respectively (pain score used was only 1-5, 5 being the most severe; so, using the same scale as the study, the pain score becomes 4.06). Moreover, pain score by FUE method was 1.26 at Day 1 which is almost similar to the pain score noted through this wound closure technique. Results of the study is also incongruent with the study done by S. Garg where he noted that the severity of the pain is in direct relation to the width of the strip harvested [14]. However, there are many factors that can cause pain, not just the width of the strip, that we have already mentioned.

The prevalence of shock loss at the donor area after a month is 11.1%, and went down to 1.6% three months after surgery. Moreover, the occurrence of a keloid after a month is 6.3%, same figures resulted after 3 months while down to 4.8% after 6 months. The appearance of the keloid scar is dependent on several factors, not just by surgical technique alone. Factors such as age, having darker skin, genetic predisposition, all play a role in the formation of keloid scar [15].

The resulting mean scar width in cm, regardless of number of hair transplant sessions, at the occipital area is 0.28 cm (SD=0.1) while 0.33 cm for the mastoid area (SD=0.12). Both mean scar width at the occipital and mastoid were less than 0.40 cm in the span of six months.

As seen in Table 4, resulting p value of 0.0003 implies that mean scar with mastoid is significantly lower in single session among all patients (0.24 vs 0.39), among those underwent FUT technique (0.24 vs 0.37) and combo (0.30 vs 0.40). The resulting scar width in patients who underwent their first hair transplantation was 0.24 cm in the mastoid area and 0.20 cm at the occipital area. Likewise, scar width occipital is significantly lower among all patients (0.21 vs 0.33) and those who underwent combo technique (0.26 vs 0.35).

22 patients also enrolled in the study were able to do follow up 8 months after the surgery and the scar width measured did not have any difference with the scar width measured at 6 months.

Values	
Pain score, mean ± sd	
Day 1	1.37 ± 1.31
Day 7	0.0
Shock Loss One month	7 (11.1)
Shock Loss Three months	1 (1.6)
Keloid Scar One month	4 (6.3)
Keloid Scar Three months	4 (6.3)
Keloid scar Six months	3 (4.8)
Scar Width Occipital (cm), mean ± sd	0.28 ± 0.1
Scar width Mastoid (cm), mean ± sd	0.33 ± 0.12

Table 3: Clinical Outcome.

	Single	Multiple	p value		
	Mean	SD	Mean	SD	
Scar Width Mastoid					
All Patients	0.24	0.1	0.39	0.11	0.0003*
FUT	0.24	0.1	0.37	0.08	0.0279*
Combo	0.3	0.11	0.4	0.12	0.0253*
Scar Width Occipital					
All Patients	0.21	0.08	0.33	0.11	0.0004*
FUT	0.20	0.07	0.29	0.09	0.1641ns
Combo	0.26	0.09	0.35	0.11	0.0137*

Table 4: Scar Width during 1ST versus multiple sessions; FUT alone vs combination of FUE and FUT.

The number of grafts and the area of the strip excised were not significantly related to the occurrence of shock loss, keloid scar and linear scar width (Table 5). However, the scar at the occipital area is related with the technique used and the number of hair transplant sessions done by the patient. Doing a combination technique with FUE and FUT and having multiple sessions (more than 1) of hair transplantation is likely to result to a larger scar at the occipital and mastoid area. This is in part, because, when doing a second session

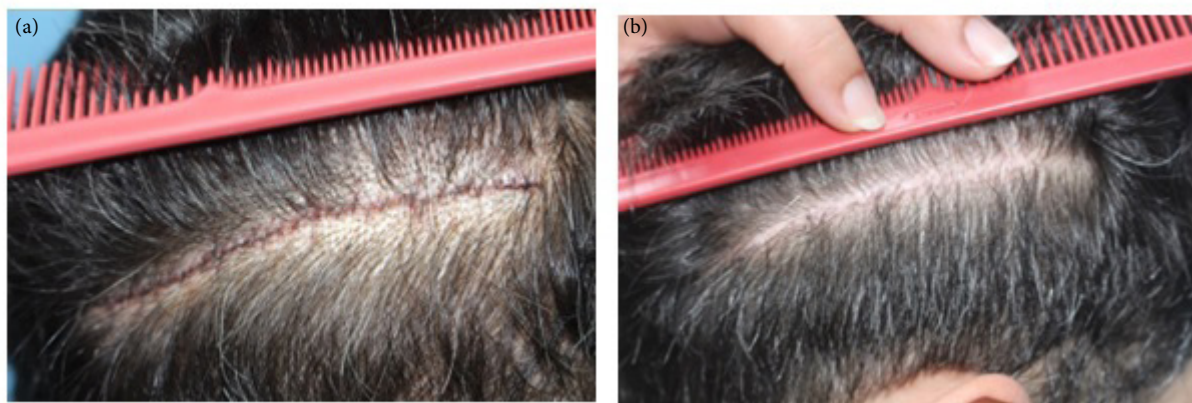


Figure 1: (a) Immediately after surgery, Linear strip excision (LSE) alone; (b) six months after surgery.

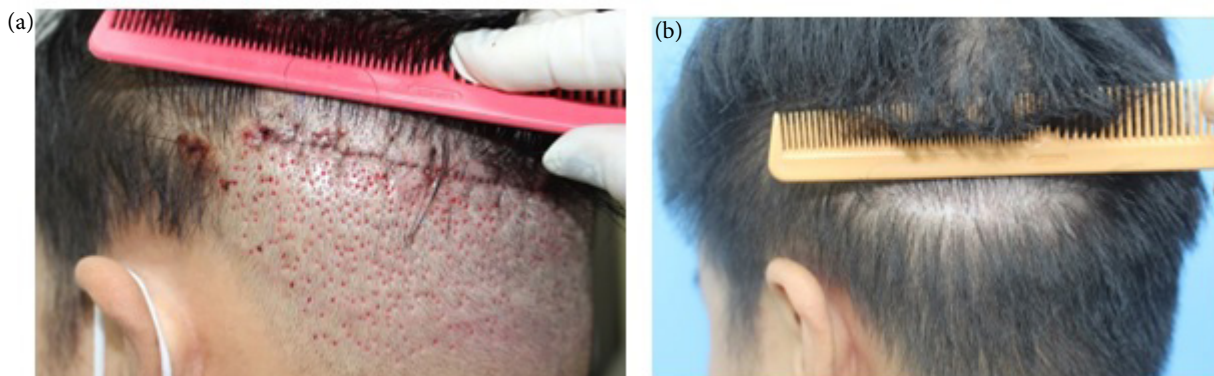


Figure 2: (a) Immediately after surgery, Linear strip excision (LSE) and Follicular unit excision; (b) six months after surgery

of hair transplantation, the scar might not be completely but just partially excised before wound closure. Moreover, results highlight that the scar width is not just dependent on the area excised [16] but other factors play a role as well such as number of hair transplant sessions and technique used whether FUT alone or in combination with FUE.

On the other hand, shock loss and keloid scarring is not significantly associated with technique used, number of session and treatment given. Furthermore, suture, whether it was absorbable or not, is not significantly related with the occurrence of shock loss, keloid scarring and scar width. Although not significant statistically, it can be noted the shock loss occurred more frequently in patients who had done the combination technique or those who had multiple sessions of hair transplantation [17].

Conclusion

This novel technique resulted in minimal post operative pain. Other complications seen in linear strip excision such as bleeding, shock loss and scarring were also minimal, if not none. Thus, making linear strip excision procedure more acceptable for patients who want to benefit from the advantages of doing LSE but are hesitant to do so because of the of its possible complications.

Table 5: Factors Related to Shock loss, occurrence of keloid scar, linear scar Width.

	Coefficient	p value
Shock loss	-0.087	0.4961 ^{ns}
Keloid scar	0.074	0.5663 ^{ns}
Scar Width Occipital (cm)	-0.031	0.8104 ^{ns}
Scar width Mastoid (cm)	0.027	0.8359 ^{ns}

Table 5a: Number of Grafts vs.

	Coefficient	p value
Shock loss	0.014	0.9161 ^{ns}
Keloid scar	0.162	0.2052 ^{ns}
Scar Width Occipital (cm)	0.148	0.2466 ^{ns}
Scar width Mastoid (cm)	0.081	0.5286 ^{ns}
Pain	0.0277	0.2413

Table 5b: Strip Area (cm) vs.

Scar Width Occipital (cm) vs	Coefficient	p value
Technique (FUT vs Combo)	0.305	0.0151 [*]
Session (Single vs Multiple)	0.433	0.0004 [*]
Finasteride (user vs non user)	0.152	0.2350 ^{ns}
Oral Minoxidil (user vs non user)	-0.086	0.5023 ^{ns}
Scar width Mastoid (cm) vs	Coefficient	p value
Technique (FUT vs Combo)	0.248	0.0499 [*]
Session (Single vs Multiple)	0.445	0.0003 [*]
Finasteride (user vs non user)	0.273	0.0302 [*]
Oral Minoxidil (user vs non user)	-0.105	0.4109 ^{ns}

	Shock loss	Without Shock loss	p value
Technique			
FUT	3 (42.9)	29 (51.8)	0.7078 ^{ns}
Combination of FUE/FUT	4 (57.1)	27 (48.2)	
Session			
Single	3 (42.9)	36 (64.3)	0.4119 ^{ns}
Multiple	4 (57.1)	20 (35.7)	
Finasteride			
User	5 (71.4)	36 (64.3)	1.0000 ^{ns}
Non user	2 (28.6)	20 (35.7)	
Oral Minoxidil			
User	7 (100)	47 (83.9)	0.5799 ^{ns}
Non user	0 (0.0)	9 (16.1)	
	Keloid scar	Without Keloid scar	p value
Technique			
FUT	2 (50.0)	29 (49.2)	1.0000 ^{ns}
Combination of FUE/FUT	2 (50.0)	30 (50.8)	
Session			
Single	1 (25.0)	38 (64.4)	0.1504 ^{ns}
Multiple	3 (75.0)	21 (35.6)	
Finasteride			
User	2 (50.0)	39 (66.1)	0.6063 ^{ns}
Non user	2 (50.0)	20 (33.9)	
Oral Minoxidil			
User	3 (75.0)	51 (86.4)	0.4691 ^{ns}
Non user	1 (25.0)	8 (13.6)	

Table 5c: Technique, Number of Session and treatment

	Shock loss	Without Shock loss	p value
3/0 Vicryl rapide	9 (42.9)	9 (16.1)	0.3575 ^{ns}
3/0 Nylon	0 (0.0)	4 (7.1)	
4/0 Ethlion	0 (0.0)	6 (10.7)	
4/0 Nylon	4 (57.1)	24 (42.9)	
4/0 Vicryl Rapide	0 (0.0)	6 (10.7)	
	Keloid scar	Without Keloid scar	p value
3/0 Vicryl rapide	0 (0.0)	12 (20.3)	0.3759 ^{ns}
3/0 Nylon	0 (0.0)	4 (6.8)	
4/0 Ethlion	0 (0.0)	6 (10.2)	
4/0 Nylon	4 (100)	24 (40.7)	
4/0 Vicryl Rapide	0 (0.0)	6 (10.2)	

Occipital	Mean	SD	p value
3/0 Vicryl rapide	0.29	0.12	0.193 ^{ns}
3/0 Nylon	0.25	0.1	
4/0 Ethlion	0.25	0.08	
4/0 Nylon	0.30	0.09	
4/0 Vicryl Rapide	0.20	0	
Mastoid	Mean	SD	p value
3/0 Vicryl rapide	0.32	0.13	0.098 ^{ns}
3/0 Nylon	0.25	0.1	
4/0 Ethlion	0.27	0.08	
4/0 Nylon	0.36	0.12	
4/0 Vicryl Rapide	0.27	0.05	

Table 5d: Suture used.

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Recommendations

We recommend to evaluate the measured outcomes long term and to compare the technique with other existing methods of linear strip excision closure.

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Competing Interests

The authors declare that they have no competing interests.

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Supplementary File

