

MODIFIED LIMBERG FLAP COVER FOR RECURRENT SACROCOCCYGEAL PILONIDAL SINUS: OUR EXPERIENCE AT A MEDICAL COLLEGE IN NEPAL

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ARTICLE INFO

Received : 09 July, 2020

Accepted : 28 January, 2021

Published : 15 June, 2021

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ORA 219

DOI: <https://doi.org/10.3126/bjhs.v6i1.37555>

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Citation

Budhi Nath Adhikari Sudhin, Abhishek Bhattarai, Pragya Devkota, Sushma Khatiwada. Modified Limberg Flap Cover for Recurrent Sacrococcygeal Pilonidal sinus: Our Experience at a Medical College in Nepal. BJHS 2021;6(1)14. 1274 - 1279.

ABSTRACT

Introduction

Pilonidal sinus is an inflammatory disease seen mostly in the intergluteal region of young males. Although any treatment strategy of this condition is generally free of life-threatening complications due to its superficial nature, it is still a feared disease because of recurrence which greatly increases the morbidity.

Objective

To investigate the results of wide rhomboid excision and modified Limberg transposition flap reconstruction to treat recurrent pilonidal sinus.

Methodology

Well-documented records of all patients with recurrent sacrococcygeal pilonidal sinus who underwent wide excision and a modified Limberg transposition flap at our center during the past 3 years and followed up for longer than 12 months were analyzed. The modification primarily consisted of an asymmetrically rotated rhomboid excision and lateralization of the lower midline. Patient demographics, days of hospitalization, complications, patient satisfaction and recurrence rates were evaluated.

Result

Most patients in the study were overweight. No relationship was detected between BMI and number of sinus openings, hospital stay, drain placement or recurrences but an association with infection was noted. The number of pilonidal sinus orifices did not have a correlation with age, number of previous surgeries, duration of hospital stay or drains placement. The mean duration of hospitalization was 7.89 ± 3.41 days and the mean duration of suction drainage was 6.33 ± 2.87 days. Half of our patients developed complications in the postoperative period. The only patient who developed superficial wound infection stayed the most in the hospital. All patients had some complaints regarding the operation site; however, they were satisfied with the result of the operation and had no recurrence at 12 months of follow-up.

Conclusion

Rhomboid excision of recurrent sacrococcygeal pilonidal sinus with modified Limberg flap closure is a promising surgical technique with advantages of a good patient satisfaction and no recurrence after a year of surgery.

KEYWORDS

Modified limberg flap (mLF), pilonidal sinus, pilonidal cyst recurrent pilonidal disease, rhomboid excision.



INTRODUCTION

Chronic pilonidal sinus is a common acquired disease usually found in the midline of the sacrococcygeal region of young hirsute men.

The management of pilonidal sinus disease remains controversial, and gold standard treatment modality has yet to be established.¹ Among different surgical modalities, flap reconstruction technique is desirable as it not only eradicates the etiology of the disease by flattening the intergluteal sulcus but also shortens the overall healing time. It also has better outcome in terms of postoperative pain, recurrence rate and the patient's return to everyday activities.² The classic Limberg flap is still considered the best available surgical modality for pilonidal sinus, as it can be used to tackle larger involved areas and is easy to design and execute. The presence of the lower pole at the intergluteal sulcus, however, increases the risk of wound maceration and recurrence.

To tackle this problem, Menten et al. in 2004 introduced the modified Limberg flap (mLF) technique by moving the lower

METHODOLOGY

In this study, data of all 9 patients with a follow-up period of more than 12 months who had previously undergone the mLF for recurrent pilonidal sinus at our center during the last 3 years were retrospectively analyzed. All of our patients were healthy adults without any major coexisting diseases. Informed consent was taken from all subjects and Ethical clearance was obtained from the Institutional review board. Hair of the gluteal and sacral region was shaved a day before the operation and rectal cleansing with an enema was performed four hours before the operation. Patients were operated under spinal anesthesia in the prone jackknife position. Appropriate cleansing of the operation area was performed with 10 percent povidon-iodine. One gm of Cefazolin was given intravenously as a prophylactic antibiotics. The surgical area was exposed by lateral traction of the buttocks with adhesive tapes. The extent of the sinus tract was determined with methylene blue injection through the sinus orifices. The excision area was delineated according to the sinus orifice localizations and the expanse of natal cleft.

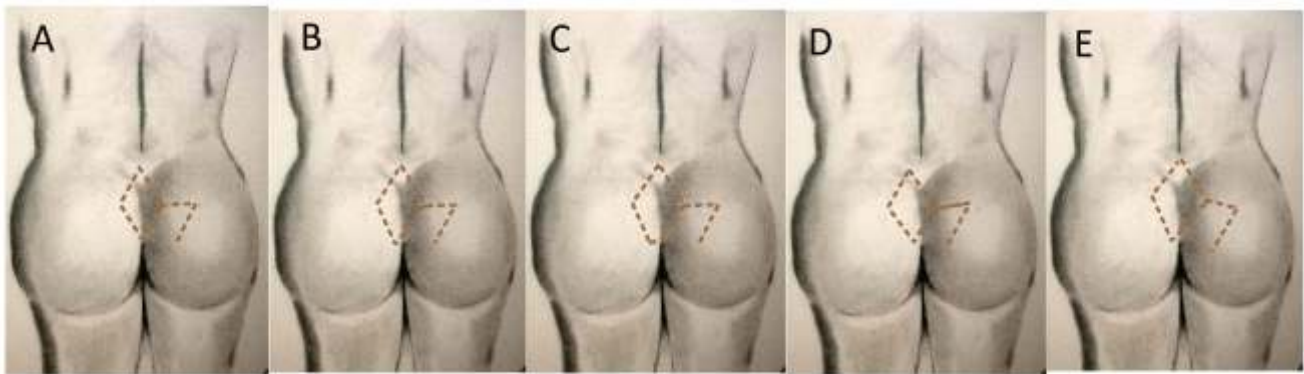


Figure 1: Spectrum of Limberg flap modifications for Pilonidal sinus. A. Classical Limberg flap. B. Menten's modification (Asymmetrical lower half displaced 1-2 cm off-midline). C. Tekin modification (Like Menten's, but only left lower limb (J shaped) of rhomboid altered to place lower end 1.5-2 cm off midline). D. Kaya modification (Completely lateralized the rhomboid by symmetrically moving both upper and lower end off the center). E. Afsarlar modification (Symmetrically tilted the flap making the lower end to the side).

Figure 1: Spectrum of modifications of the Limberg flap for sacrococcygeal pilonidal sinus

half of the rhomboid laterally by 1-2 cm (B in Figure 2) and obtained 0% recurrence rate and 0.8% wound infection rate without any dehiscence or flap necrosis.³

The word modified in "Modified Limberg flap", however, has not been used uniformly (mainly 5 main groups of modifications exists as illustrated and explained in Figure 2) and is being utilized by various authors to denote a Limberg flap with either sides or angles not corresponding to a classical midline rhomboid. Tekin's modification (C in Figure 2) consisted of altering the left lower limb to keep the final scar off the midline.⁴ Kaya et al (D in Figure 2) symmetrically shifted the whole flap laterally while Afsarlar et al (E in Figure 2) tilted it to the side.^{5,6} Leaving aside these major modifications, other modifications such as the ones described by Abdelnaby et al and Yoldas et al may represent confusion in describing or naming the flap.^{7,8}

The purpose of this study was to analyze the results of modified Limberg flap (mLF) done at our center for recurrence of pilonidal sinus.

An asymmetrical rhomboid excision area was marked taking care that the lower end was 1 cm lateral to the midline away from the natal cleft. A fasciocutaneous flap, containing skin, subcutaneous tissue, and fascia of the gluteal muscle, of sufficient length was marked from non-diseased tissue along the right inferior border of the defect. Following skin incision with a scalpel, the diseased tissue was dissected with diathermy down to the presacral and gluteal fascia and was excised in toto. If any visible sinus tracts were encountered, the excision was further extended into the subcutaneous tissue without any additional skin incision. The flap was elevated off the gluteal fascia to achieve a tensionless rotation with careful dissection to avoid damaging the feeding arteries located in the inferior aspect of the flap. After releasing the traction tapes, a suction drain was placed on the presacral fascia and was brought out several centimeters away from the wound. The flap was then secured with a few deep, interrupted 2-0 polyglactin-910

sutures passing through the flap and the defect margins at a similar level. The subcutaneous layer was approximated with 3-0 polyglactin-910 interrupted sutures, and the skin was closed with 3-0 polypropylene or nylon sutures.

Postoperatively, oral intake was started after 4 hours. Patients were encouraged to ambulate after 8 hours following the surgery, but were advised to limit sudden movements of the sacral region. The suction drain was removed after the drainage decreased to 10 cc/day for at least 2 days; patients received Cefazolin (1 g per dose IV, three times a day) and Metronidazole (500 mg per dose IV, three times a day) during this period. The skin stitches were removed on postoperative day 14, and patients were advised not to sit directly on their buttocks until the third postoperative week. Additionally, patients were instructed for maintaining self-hygiene, using depilatories and avoiding contact sports for three months.

All patients were asked to report immediately for any local pain, redness, swelling or discharge or to follow up routinely at 3 months, 6 months and at the end of 12 months. The patients were also reminded to keep the perineal and gluteal region clean and dry during every visit to the clinic. Patients unable to report at 6 and 12 months were asked about their well-being via telephone contact.



Figure 2: Immediate postoperative picture of a modified Limberg Flap.

The data were presented as means \pm standard deviation or medians and interquartile ranges. The clinical and demographic variables were compared using the Student's t test for continuous variables with a normal distribution and the Wilcoxon rank sum test for non-parametric variables or the Chi-square test (or Fisher's exact test) for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 9 adults, including 8 males (88.89%) and 1 female (11.11%), comprised the study group. Individual patient demographic details are tabulated below in Table 1.

Table 1. Demographic details of individual patients

Case no.	Age/Sex	BMI (kg/m ²)	No of previous operations	Time gap of previous operation (months)	Number of openings	Hospital stay (days)	Drain kept (days)
1	34/M	28.7	2	12 and 73	3	15	12
2	22/F	27.7	1	3	2	12	11
3	28/M	25.2	1	8	3	4	4
4	26/M	25	2	4 and 24	2	6	5
5	24/M	27.6	1	6	3	5	4
6	17/M	31.2	1	1	4	8	6
7	24/M	28.4	2	2 and 8	3	7	6
8	27/M	26.6	1	12	1	9	5
9	26/M	26	1	12	1	5	4

All the patients were young with a mean age of 25.55 ± 4.4 years. The mean Body Mass Index (BMI) of the patients was 27.37 ± 1.8 years. Of the patients, none were underweight or healthy (BMI < 18.5 and $18.5 - 24.5$ respectively), 88.89% ($n = 8$ with BMI $18.5-24.9$) were overweight and 11.11% ($n = 1$ with BMI > 30.0) were obese. No relationship was detected between BMI and number of sinus openings ($p = 0.061$), hospital stay ($p = 0.230$), number of days the drain was kept ($p = 0.289$) or recurrences ($p = 0.405$) but association with infection was noted ($p = 0.02$ and f value on regression analysis = 20.69).

The mean number of previous operations was 1.37 ± 0.48 days. The mean duration of hospitalization was 7.89 ± 3.41 days and the mean duration of suction drainage placement was 6.33 ± 2.87 days.

Table 2: Surgical outcome of individual patients

Case no.	Seroma	Hematoma	Tip ischemia	Maceration	Dehiscence	Infection	Recurrence 12 months	Satisfaction (Yes/No)	Complains
1	No	No	No	No	No	Yes	No	Yes	Dimple
2	Yes	No	No	No	No	No	No	Yes	Pain/discomfort
3	No	No	No	No	No	No	No	Yes	Pain/discomfort
4	No	No	No	No	No	No	No	Yes	Decreased sensation
5	No	No	No	Yes	No	No	No	Yes	Numbness
6	No	No	No	No	No	No	No	Yes	Tingling
7	No	No	No	No	Yes	No	No	Yes	Tingling
8	No	No	No	No	No	No	No	Yes	Numbness
9	No	No	No	No	No	No	No	Yes	Decreased sensation

All the patients have had a previous history of surgery elsewhere; most patients, however, were not aware of the name or nature of the procedure done. Local examination, however, showed that 7 patients had midline longitudinal scars, 1 had a longitudinal scar on the left side while 1 had multiple irregular scars.

Four (44.44%) of our patients developed complications in the postoperative period—each of infection, seroma, dehiscence and maceration of the wound.

All the patients were satisfied with the overall result of the surgery; however, each patient had a complain regarding the operation site—2 each had numbness, occasional pain/discomfort and tingling whereas 1 patient had dimpling at the lower left side of the flap. All the patient have been recurrence free for more than a year now.

DISCUSSION

Pilonidal disease (PD) is a chronic inflammatory disease, usually located on the intergluteal region and seen mostly in the younger population.⁹ The estimated incidence is 26 per 1,00,000 population and the disease is observed at a rate of 0.7% in the general population.¹⁰ It generally presents as a cyst, abscess or sinus tracts with or without discharge. Men are affected more often than women, it is rare both before puberty and after the age of 40 years.⁵

We adopted the Mentès modification of the Limberg flap and, like them, have had no recurrences in our follow-up period which was at least 1 year in all cases.³ Other authors who adopted similar modification with the lower end 1 cm off-midline had recurrence rates ranging from zero to 2.5%.¹⁰⁻¹³ The recurrence rates seemed to increase to a range of zero to 13.3% for cases undergoing the same modification but with longer lateralizing distance of 1.5 to 2.5 cm.^{4,8,11,14,16-24}

Patients in various other studies rarely stayed in the hospital for more than 5 days except for a mean 6.5 days in 94 cases reported by Abdelinaby et al.⁷ The average duration of hospital stay in our study was 7.89 ± 3.41 days. The seemingly longer duration is something unique to our population who wish to stay longer in the hospital. People seem to believe that staying longer in the hospital would decrease the risk of infection and that infection would be detected earlier at the hospital bed.

Ischemia of the flap tip has been reported in up to 6.6% cases in the Mentès modification.^{8,10,23} Gandhi et al encountered 11% tip ischemia in their Kaya like Limberg flap modification.²⁶ Their 27 cases included 13 recurrent cases with much scarring and extension; this, rather than the type of modification would explain the high rate of vascular insufficiency of those flaps. We did not encounter any ischemia of the flap tip which is a welcome sign probably due to wider base of the flap and taking care while dissection the inferior aspect of the flap to avoid damaging the feeding arteries.

Maceration has been less frequently reported as a complication of the operative procedure; we encountered it in a single case (~11%). It has been, however, reported in up to 27% of cases with Mentès modification.^{13,15,17,20} Kaya et al noted it in 8.5% cases in their modification.⁵ Kerakas et al encountered more maceration with Mentès modification utilizing the 1 cm lateralization as compared to 2 cm (35% Vs 20%); but the difference was not found to be statistically significant.¹³

Only 2.7% cases utilizing Tekin modification and 7.4% cases of Gandhi et al utilizing the Kaya modification had seroma.^{4,26} In the Mentès variation, seroma was not mentioned in the original series.³ Bessa et al in their 60 cases as well as Gaber et al in their 15 cases of recurrent pilonidal sinus encountered no cases of postoperative seroma.^{10,21} Others had seroma in 3.3–13.9% of their cases.^{8,13,14,17,18,20,24} Sarhan reported combined seroma/hematoma to be 5% in their 100 cases.²² We encountered a single case (11.11%) of seroma in our series. It was the case (Case 2) where extensive dissection and liberal use of cautery was done; the presence of

recurrent cases with extensive scarring may be a reason for the high incidence of seroma.

Mentes et al in their study did not note wound dehiscence in any of their 198 cases of mLF.³ Cihan et al adopting the Mentès variation, had mixed results with zero cases in their 44 cases included in their 2004 series and a single case in their 33 cases included in their 2005 series.^{12,15} Other series utilizing the Mentès modification had seroma in zero to up to 15.9% of cases.^{8,10,18,11,13,20,22,23,27,28} Kaya et al in their original modification had it in 1% of their cases.⁵ Afsarlar modification by Elshazly et al had it in 1.67%; and Kaya like modification by Yildiz et al had it in 6.25% whereas Gandhi et al had it in 3.7% of their cases.^{26,29,30} We also encountered a single case of wound dehiscence. This 24 years old gentleman (case 7) was previously operated twice, had an extensive disease with 3 external openings and was discharged in a week. Early ambulation and not paying attention to perianal hygiene were probably other contributors to his complication.

None of our cases had hematoma as a post-operative complication. The literature review of Mentès modification shows incidence of hematoma to be 2.78% for Arslan et al, 2.5% for Karakas et al, 4.76% for Hussain et al and 18% for Bayham et al.^{13,20,27,28} Afsarlar et al as well as Abdelnaby et al in their modification encountered a single case of hematoma in 15 and 94 cases respectively.^{6,7} Liberal use of cautery and repeated checking of flap may be the reason for the absence of hematoma in our patients.

The infection rates for the Mentès modification ranged from 0 to 11.4%.^{10,12-15,17-21,23,24,27} We had encountered a single case (11.11%) of infection. Similar modifications had infections in up to 18.1% of cases.^{4,5,6,17,26,28,29,31,39} The patient (Case 1) who developed superficial wound infection had it started from the middle part of the wound; no organisms could be grown and it healed spontaneously with conservative management within 2 weeks. This was also the patient who stayed longest (15 days) at our hospital for wound care. Alptekin et al. found that the volume of the excised specimen in pilonidal disease procedures correlates with surgical site infection.³¹ Due to the wide en bloc excision, he advised using an empiric broad-spectrum antibiotic (extended post-discharge) as a preventive measure.

There is a lack of strong data that would support the routine use of drainage in all patients; the decision should be based at the discretion of the surgeon and patient related factors.³² Due to the extensive nature of dissection and excision, we chose to use it for all cases. The mean duration of its removal was 6.33 ± 2.87 days.

All of our patients were satisfied with the overall result of the operation. Absence of recurrence, quicker healing, lesser pain and complete relief of the disease could be the reason for the same. Surgeries involving selective excision or the use of the newer minimally invasive techniques may decrease the overall length of the resultant scar and improve the overall cosmetic result, but the extent of resection may not suffice for recurrent cases or cases with



extensive diseases like most of our cases.³² Youssef et al noted better patient satisfaction with tensionless primary closure as compared to the mLF.³³ Similarly, Tavassoli et al also noted more completely satisfied patients in the primary closure group as compared to the cLF group.³⁴ Topgul et al reported that satisfaction was higher in the primary repair group as compared to the rhomboid group whereas patients were satisfied more with the Karydakias flap as compared to the primary group in the study group by Can et al.^{18,34,35} Sabry et al noted significantly better cosmetic (rather than overall) satisfaction in patients undergoing lateral advancement flap as compared to those undergoing mLF.²⁴ However, Ertan et al cautioned against using primary closure under tension or in inappropriate cases as it may cause more postoperative problems and lesser patient satisfaction.³⁶

Each patient in our study had a complain regarding the operation site-2 each had numbness, occasional pain/discomfort and tingling whereas 1 patient had dimpling at the lower left side of the flap. El-Khadwary et al reported numbness over the operative site in 18.3% of their 60 cases.¹⁶ They postulated that it may be due to interference with the nerve supply of the flap, especially large ones. Akin et al reported decreased sensation in 8.65% of their cases.¹⁷ Eryilmas et al reported numbness in 19% of their 63 cLF cases.³⁸ 60% of the patients had postoperative numbness in a study of 50 mLF cases from Nepal by Thapa et al.²⁵

Duman et al considered tingling as a symptom of anxiety and showed that patients undergoing the cLF had less anxiety scores than those undergoing primary closure.³⁶ They also noted lesser pain while walking and sitting on toilet in cLF group as compared to primary closure group. Aithal et al noted very less postoperative pain in 30 patients undergoing cLF.⁴⁰ As compared to primary closure, Youssef et al found better pain scores with mLF on 1st day, 7th day as well as on 2nd and 4th week as compared to primary closure group but it showed statistical significance only for day 1.³³

The single patient with the dimple would like to remove it to decrease the chances of recurrence. Considering his compliance and adherence to strict post-surgical care as well as regular follow-up, revision of the area has not been done till date.

CONCLUSION

The Menten modification of the Limberg flap is a promising surgical technique for the treatment of recurrent pilonidal sinuses with few manageable complications, no recurrence and a good patient satisfaction. In the future, proper randomized studies comparing various techniques including surgical or non-surgical methods for sacrococcygeal PD are required to determine the most appropriate treatment option. Till then, newer flaps and better modifications would continue to evolve in a quest to achieve better results in recurrence, complications and postoperative morbidities.

LIMITATIONS OF THE STUDY

This is a retrospective study of a small number of cases in which a pilonidal sinus was operated on at various other center previously by different surgeons. Thus the amount of tissue to be removed varied greatly between individual cases and the wide excision was performed in an area already having volume deficit. It may have been an over-treatment as well for recurrent cases with smaller sinus, single midline opening and limited lateral extensions. Any recommendations could not be given as this is a small study which does not truly compare different flap techniques. Follow up period of few patients was just over a year. Recognition of asymptomatic cases could have been missed as some of our late follow-ups were made via telephone conversation. Other confounding or co-factors which may have been associated with the complications were not evaluated as well.

ACKNOWLEDGEMENT

All patients who agreed to be part of the study.

CONFLICT OF INTEREST

None to disclose.

FINANCIAL DISCLOSURE

We didn't receive any financial support to prepare this article.

REFERENCES

1. Yogishwarappa CN, Abhishek V. Limberg Flap Reconstruction for Pilonidal Sinus. *International journal of Biomedical and Advanced research*. 2016;7:165-8. doi: <https://doi.org/10.7439/ijbar.v7i4.3184>.
2. Sebastian M, Sroczyński M, Rudnicki J. The Dufourmentel modification of the limberg flap: Does it fit all? *Adv Clin Exp Med*. 2017;26(1):63-7. doi: <https://doi.org/10.17219/acem/44483>.
3. Menten BB, Leventoglu S, Cihan A, Tatlicioglu E, Akin M, Oguz M. Modified Limberg transposition flap for sacrococcygeal pilonidal sinus. *Surg Today*. 2004;34:419-23. doi: <https://doi.org/10.1007/s00595-003-2725-x>.
4. Tekin A. A simple modification with the Limberg flap for chronic pilonidal disease. *Surgery*. 2005;138:951-3. doi: <https://doi.org/10.1016/j.surg.2005.05.019>.
5. Kaya B, Eris C, Atalay S, Bat O, Bulut NE, Montoglu B et al. Modified Limberg transposition flap in the treatment of pilonidal sinus disease. *Tech Coloproctol*. 2012;16:55-9. doi: <https://doi.org/10.1007/s10151-011-0799-9>.
6. Afşarlar CE, Yılmaz E, Karaman A, et al. Treatment of adolescent pilonidal disease with a new modification to the Limberg flap: Symmetrically rotated rhomboid excision and lateralization of the Limberg flap technique. *J Pediatr Surg*. 2013;48:1744-9. doi: <https://doi.org/10.1016/j.jpedsurg.2013.01.029>.
7. Abdelnaby M, Emile SH, El-Said M, AbdelMawla A, Elgendy H et al. Rotational gluteal flap versus modified Limberg flap in treatment of sacrococcygeal pilonidal disease. *J Surg Res*. 2018 Mar;223:174-82. doi: <https://doi.org/10.1016/j.jss.2017.11.017>.
8. Yoldas O, Dizen H, Cilekar M, Yildiz M, Dilektasli E. Comparison of modified limberg flap and modified elliptical rotation flap for pilonidal sinus surgery: A retrospective cohort study. *International Journal of Surgery*. 2015;16:74-7. doi: <https://doi.org/10.1016/j.ijss.2015.02.024>.
9. Sabuncuoğlu MZ, Sabuncuoğlu A, Dandin O et al. Eyedrop-shaped, modified Limberg transposition flap in the treatment of pilonidal sinus disease. *Asian J Surg*. 2015;38:161-7. doi: <https://doi.org/10.1016/j.asjsur.2015.03.007>.



10. Gaber AR,, Yousef AM. A Modified Limberg Flap versus Z Plasty Flap Technique in Management of Recurrent Pilonidal Disease: A Comparative Prospective Study. *Open Access Library Journal*. 2018;5:1-14. doi: <https://doi.org/10.4236/oalib.1104715>.
11. Karaca T, Yoldas O, Bilgin BC, Özer S et al. Comparison of short-term results of modified Karydakias flap and modified Limberg flap for pilonidal sinus surgery. *International Journal of Surgery*. 2012;10:601-6. doi: <https://doi.org/10.1016/j.ijisu.2012.10.001>.
12. Cihan A, Menten BB, Tatlicioglu E, Ozmen S, Leventoglu S, Ucan BH. Modified Limberg flap reconstruction compares favourably with primary repair for pilonidal sinus surgery. *ANZ J. Surg.* 2004; 74:238–42. doi: <https://doi.org/10.1111/j.1445-2197.2004.02951.x>.
13. Karakas BR, Aslaner A, Gunduz, Calis H, Ongen AN et al. Is the lateralization distance important in terms of patients undergoing the modified Limberg flap procedure for treatment of pilonidal sinus? *Tech Coloproctol*. 2015 May;19(5):309-16. doi: <https://doi.org/10.1007/s10151-014-1252-7>.
14. Ahmed A, Billa S. Case series on modified Limberg flap technique in management of pilonidal disease. *Int. J. Pharm. Med. & Bio. Sc.* 2013 April;2(2):51-6. Available from: <http://www.ijpmb.com/uploadfile/2015/0412/20150412032131726.pdf>
15. Cihan A, Ucan BH, Comert M, Cesur A, Cakmak GK, Tascilar O. Superiority of symmetric modified Limberg flap for surgical treatment of pilonidal disease. *Dis Colon Rectum*. 2006;49:244-9. doi: <https://doi.org/10.1007/s10350-005-0253-z>.
16. el-Khadrawy O, Hashish M, Ismail K, Shalaby H. Outcome of the Rhomboid Flap for Recurrent Pilonidal Disease. *World J Surg*. 2009;33:1064–8. doi: <https://doi.org/10.1007/s00268-009-9920-x>.
17. Akin M, Leventoglu S, Menten BB et al. Comparison of the classic Limberg flap and modified Limberg flap in the treatment of pilonidal sinus disease: a retrospective analysis of 416 patients. *Surg Today*. 2010;40:757–62. doi: <https://doi.org/10.1007/s00595-008-4098-7>.
18. Can MF, Sevinc MM, Hancerliogullari O, Yilmaz M, Yagci G. Multicenter prospective randomized trial comparing modified Limberg flap transposition and Karydakias flap reconstruction in patients with sacrococcygeal pilonidal disease. *The American Journal of Surgery*. 2010; 200,:318–27. doi: <https://doi.org/10.1016/j.amjsurg.2009.08.042>.
19. Tokac M, Dumlu EG, Aydin MS, Yalcin A, Kilic M. Comparison of Modified Limberg Flap and Karydakias Flap Operations in Pilonidal Sinus Surgery: Prospective Randomized Study. *Int Surg*. 2015; 100:870-7. doi: <https://doi.org/10.9738/INTSURG-D-14-00213.1>.
20. Arslan K, Kokcam SS, Koksali H, Turan E, Atay A, Dogru O. Which flap method should be preferred for the treatment of pilonidal sinus? A prospective randomized study. *Tech Coloproctol*. 2014 Jan;18(1):29-37. doi: <https://doi.org/10.1007/s10151-013-0982-2>.
21. Bessa S. Comparison of Short-term Results Between the Modified Karydakias Flap and the Modified Limberg Flap in the Management of Pilonidal Sinus Disease: A Randomized Controlled Study. *Dis Colon Rectum*. 2013;56:491–8. doi: <https://doi.org/10.1097/DCR.0b013e31828006f7>.
22. Sarhan A, Sherifa T, Zakariab Y. A prospective randomized trial comparing modified Limberg flap and cleft lift procedure in the treatment of uncomplicated sacrococcygeal pilonidal disease. *The Egyptian Journal of Surgery*. 2016;35:89–95. doi: <https://doi.org/10.4103/1110-1121.182781>.
23. Saydam M, Ozturk B, Sinan H et al. Comparison of modified Limberg flap transposition and lateral advancement flap transposition with Burrow's triangle in the treatment of pilonidal sinus disease. *Am J Surg*. 2015.Oct;210(4):772-7. doi: <https://doi.org/10.1016/j.amj surg.2015.03.031>.
24. Sabry A, Selima A. Modified limberg versus lateral advancement flaps in the surgical treatment of pilonidal sinus. *The Egyptian Journal of Surgery*. 2018;37:355–60. doi: https://doi.org/10.4103/ejs.ejs_30_18.
25. Thapa PB, Maharjan DK, Ghimire R, Shrestha SK. Modified Limberg Flap for Pilonidal Sinus. *Nepal Journal of Dermatology, Venerology & Leprosy*. 2017;15(1)35-8. doi: <https://doi.org/10.3126/njdvl.v15i1.18050>.
26. Gandhi JA, Shinde PH, Pandrowala SA, Digarse RD. A modified surgical approach to sacrococcygeal pilonidal disease: Our experience. *Int Surg J*. 2016 Nov;3(4):1831-6. doi: <http://dx.doi.org/10.18203/2349-2902.isj20162884>.
27. Hussain SM, Farees SN, Abbas SJ, Vakati Raghavendra SK. Rhomboid excision with modified Limberg flap in the treatment of sacrococcygeal pilonidal disease. *Archives of International Surgery*. 2015 April-June;5(2):74-7. doi: <https://doi.org/10.4103/2278-9596.158818>.
28. Bayhan Z, Zeren S, Duzgun SA, Ucar B et al. Crystallized phenol application and modified Limberg flap procedure in treatment of pilonidal sinus disease: A comparative retrospective study. *Asian J Surg*. 2016 Jul;39(3):172-7. doi: <https://doi.org/10.1016/j.asjsur.2015.12.007>.
29. Yildiz T, Ilce Z, Küçük A. Modified Limberg flap technique in the treatment of pilonidal sinus disease in teenagers. *J Pediatr Surg*. 2014 Nov;49(11):1610-13. doi: <https://doi.org/10.1016/j.jpedsurg.2014.06.011>.
30. Elshazly WG, Said K. Clinical trial comparing excision and primary closure with modified Limberg flap in the treatment of uncomplicated sacrococcygeal pilonidal disease. *Alexandria Journal of Medicine*. 2012;48:13–8. doi: <https://doi.org/10.1016/j.ajme.2011.10.002>.
31. Alptekin H, Yilmaz H, Kayis SA, Sahin M. Volume of the excised specimen and prediction of surgical site infection in pilonidal sinus procedures (surgical site infection after pilonidal sinus surgery). *Surgery Today*. 2012;43(12):1365–70. doi: <https://doi.org/10.1007/s00595-012-0444-x>.
32. Müller K, Marti L, Tarantino I, Jayne DG, Wolff K, Hetzer FH. Prospective analysis of cosmesis, morbidity, and patient satisfaction following Limberg flap for the treatment of sacrococcygeal pilonidal sinus. *Dis Colon Rectum*. 2011 Apr;54(4):487-94. doi: <https://doi.org/10.1007/DCR.0b013e3182051d96>.
33. Youssef T, El-Awady S, Farid M. Tension-free primary closure compared with modified Limberg flap for pilonidal sinus disease: a prospective balanced randomized study. *The Egyptian Journal of Surgery*. 2015;34:85–9. doi: <https://doi.org/10.4103/1110-1121.155716>.
34. Tavassoli A, Noorshafiee S, Nazarzadeh R. Comparison of excision with primary repair versus Limberg flap. *International Journal of Surgery*. 2011;9:343e346. doi: <https://doi.org/10.1016/j.ijisu.2011.02.009>.
35. Topgül K. Surgical treatment of sacrococcygeal pilonidal sinus with rhomboid flap. *J Eur Acad Dermatol Venereol*. 2010;24(1):7e12. doi: <https://doi.org/10.1111/j.1468-3083.2009.03350.x>.
36. Ertan T, Koc M, Gocmen E, Aslar AK, Keskek M, Kilic M. Does technique alter quality of life after pilonidal sinus surgery? *The American Journal of Surgery*. 2005;190:388–92. doi: <https://doi.org/10.1016/j.amjsurg.2004.08.068>.
37. Duman K, Ozdemir Y, Yucel E, Akin ML. Comparison of depression, anxiety and long-term quality of health in patients with a history of either primary closure or Limberg flap reconstruction for pilonidal sinus. *Clinics (Sao Paulo)*. 2014.Jun;69(6):384-7. doi: [https://doi.org/10.6061/clinics/2014\(06\)03](https://doi.org/10.6061/clinics/2014(06)03).
38. Eryilmaz R, Sahin M, Alimoglu O, Dasiran F. Surgical treatment of sacrococcygeal pilonidal sinus with the Limberg transposition flap. *Surgery*. 2003 Nov;134(5):745-9. doi: [https://doi.org/10.1016/s0039-6060\(03\)00163-6](https://doi.org/10.1016/s0039-6060(03)00163-6).
39. Khan KJ, Ghaffer A, Choudhry S, Irshad K. Comparison of Early Outcome between Modified Limberg and Karydakias Flap Procedures in Patients with Sacrococcygeal Pilonidal Sinus. *Pakistan Journal of Medical and Health Sciences*. 2016 Apr–Jun;10(2): 631-4. Available from: http://pjmhsonline.com/2016/april_june/pdf/631.pdf.
40. Aithal SK, Rajan CS, Reddy N. Limberg Flap for Sacrococcygeal Pilonidal Sinus a Safe and Sound Procedure. *Indian J Surg*. 2013 July–August; 75(4):298–301. doi: <https://doi.org/10.1007/s12262-012-0489-5>.

