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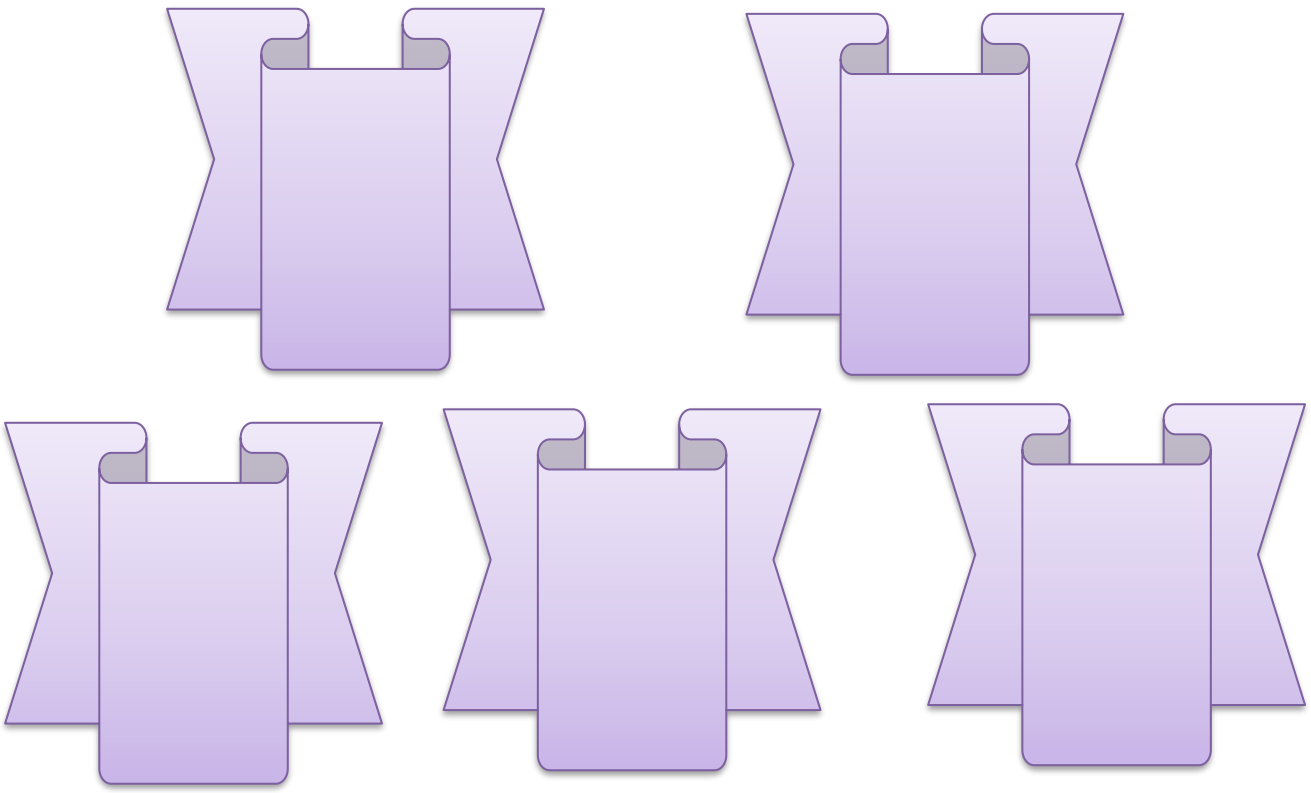

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Original Article

Reconstruction of Scalp Defects: A Meta-Analysis Study

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ABSTRACT

Background: Scalp deficiencies can be caused by a number of different etiological reasons, including tumor extirpation, infection, burns, or trauma to this special region of the human body. The scalp can be reconstructed in a number of ways, including through primary closure, skin grafting, local flaps, tissue expansion, or free tissue transfer.

Aim of the work: To evaluate the various methods utilized for reconstructing scalp deformities; to get better surgical choice, through meta-analysis regarding defect size, depth, location, hair line, alopecia risk and aesthetic appearance.

Patients and Methods: Recent clinical trials or cluster trials, as well as retrospective compared cohort studies, were included in this Meta-analysis. Study was conducted on human subjects with reconstruction of scalp defects. Review of the Methods Used in Reconstructing Scalp Defects; to get better surgical choice, through meta-analysis regarding defect size, depth, location, hairline, alopecia risk and aesthetic appearance.

Results: A total of 393 cases had complete healing as regard complications founded in form of Hematoma in 18 cases, infection in 4 cases, seroma in 3 cases, wound dehiscence in 63 cases, Distal flap necrosis in 1 case, Partial flap loss in 13 cases, total Graft loss in 13 cases.

Conclusion: Using local flaps to repair scalp abnormalities is a straight forward operation that does not often require extensive postoperative care and can be completed in a short amount of time with minimal risk. A local scalp flap is the preferred method for reconstructing even a big and complex scalp defect, such as one that involves the cranium or the dura. Our findings suggest that problems from local axial flap applications were infrequent and did not significantly impact flap survival.

Keywords: Scalp reconstruction; Tissue expanders; Local flaps.

INTRODUCTION

The scalp is an integral part of the body, serving to insulate the brain from the environment by covering the skull bones. Its hair-bearing structure is both functional and aesthetically significant. Poor quality of life, alopecia, and deformities can arise from deformities to this structure brought on by trauma, burns, radiation, or the removal of a tumor [1].

Several surgical algorithms have been devised and used for the treatment of scalp abnormalities [2]. **1. Primary closure:** when dealing with minor defects, this is the first surgical option to take [3], **2. Skin graft:** are not frequently option one for scalp restorations as they can result in poor cosmetic outcomes such as alopecia, color mismatch, and height difference. Nonetheless, if a well-vascularized tissue bed persists, a skin graft may be considered as a viable alternative in some circumstances [4], **3. Local flap:** in terms of surgical options, it is the gold standard for repairing holes in the scalp. Beneficial when health is low, as while undergoing radiation [1], **4. Regional flap:** A vascularized flap is used to cover a defect in the scalp after the vascular pedicle has been dissected. Surgical excision is a common method for treating significant abnormalities in the scalp. Several variants exist, including the temporoparietal fascia flap [5], **5. Tissue expander:** Patients with post-surgical scalp baldness should seriously consider this surgery [6], **6. Drilling of the diplopic space and skin grafting:** The outer table of the skull can be drilled to access the diplopic area. By regularly changing the dressings, we encourage the formation of granulation tissues, which eventually creep to coat the outer table bones. The granulation tissues will be covered with skin grafts during a second procedure [7, 8], **7. Free flap** from remote zones in wide scalp defect, all of these previous techniques were used with different algorithms, advantages and disadvantages of every technique through scattered publication [2].

PATIENTS AND METHODS

This meta-analysis study aimed to investigate different interventions for scalp defects reconstruction. The study included recent clinical trials, cluster trials, prospective and retrospective comparative cohort studies. The search strategy involved using databases such as PubMed, Cochrane, PLOS, and Web of Science, as well as the Egyptian Knowledge Bank. The search terms used were related to "scalp," "reconstruction," "treatment," "management," and "plastic surgery." Only studies published in English within the last five years were included.

The search results underwent manual screening for eligibility based on the inclusion and exclusion criteria. After screening, 15 studies were included in the meta-analysis. Ethical approval was obtained from the committee of Al-Azhar University. The study aimed to analyze different techniques used for scalp defects reconstruction, taking into consideration factors such as defect size, depth, location, hairline, and alopecia risk.

The screening process involved removing duplicate citations and conducting title and abstract screening, followed by full-text screening. The data from the included trials were combined using systematic review management software. The Cochrane collaboration tool for assessing the risk of bias was used to evaluate the possible risk of bias in each study. Data extraction involved using a standardized Excel sheet, and reviewers independently extracted data from the included studies.

In total, 3828 titles were initially identified, leading to the selection of 15 studies for inclusion in the final database. Among the included studies, 12 were retrospective studies, and 3 were case report studies. The statistical analysis was conducted using MedCalc software, with confidence intervals and p-values used to determine statistical significance. The study characteristics extracted included study identification, methods and inclusion criteria, study procedures, and outcome measures used.

RESULTS

Study characteristics: 12 study were retrospective studies; 3 studies were case report studies as 517 cases were included with mean age was 55.9 years

Regarding Type of reconstruction, musculo-cutaneous latissimus dorsi [LD], LD muscle, free anterolateral thigh [ALT], vastus lateralis muscle, and rectus abdominis muscle were all used in the various reconstructions performed. Omental flap, 2-staged reconstruction with an initial peri-cranial flap and dermal substitute placement followed by the placement of a split-

thickness skin graft, acellular dermal matrix, split-thickness skin graft, full-thickness skin graft, dermal wound matrix, local tissue rearrangement, free flap, titanium mesh exposure, fascio-cutaneous flap, smooth rectangular tissue expander, serratus anterior muscle flap, parascapular flap , flap with STSG, rotation advancement flap, double hatchet flap, bipedicle flap and double transposition

Outcome and complication: A total of 393 cases had complete healing as regard complications founded in form of hematoma in 18 cases, infection in 4 cases, seroma in 3 cases, wound dehiscence in 63 cases, distal flap necrosis in 1 case, Partial flap loss in 13 cases, total Graft loss in 13 cases. Skin necrosis founded in 4 cases, flap congestion in 1 case, Donor site morbidity in 8 cases and Revision surgery in 36 cases

Meta-analysis

Fifteen studies showing healing rate with total event rate 86.495% with significant heterogeneity between studies as shown in table [1], three studies showing hematoma with total number 124, with insignificant heterogeneity between studies as shown in table [2], three studies showing Infection rate with total event rate 3.876 with insignificant heterogeneity between studies as shown in figure [1], two studies showing seroma rate with total event rate 8.545 with insignificant heterogeneity between studies as shown in figure [2].

Regarding wound, 10 studies showing wound dehiscence with total event rate 13.839 with insignificant heterogeneity between studies as shown in table [3].

As regard flap loss, seven studies showing partial flap loss with total event rate 9.010 with insignificant heterogeneity between studies as shown in table [4]; eight studies showing total graft loss with total event rate 7.323 with significant heterogeneity between studies table [5], and two studies showing donor site morbidity with total event rate 19.869 with significant heterogeneity between studies as shown in figures [3]; five studies showing Revision surgery with total event rate 16.128 with insignificant heterogeneity between studies as shown in table [6].

Table [1]: Meta-analysis for healing

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Bas *et al.* [5]	14	14	100.0	76.840–100.0
Del Castillo *et al.* [9]	30	30	100.0	88.430–100.0
Chaiyasate *et al.* [10]	13	13	100.0	75.295–100.0
Aronson and Ellis [11]	9	8	88.889	51.750–99.72
Jang *et al.* [12]	94	6	6.383	2.378–13.38
Tecce *et al.* [13]	189	164	86.772	81.096–91.25
Chen *et al.* [14]	8	8	100.0	63.058–100.0
Shin *et al.* [15]	2	2	100.0	15.811–100.0
Ehrl *et al.* [16]	38	34	89.474	75.195–97.06
Gupta and Srivastava [17]	54	54	100.0	93.397–100.00
Zhou *et al.* [18]	1	1	100.0	2.500–100.0
Weitz *et al.* [19]	17	15	88.235	63.559–98.54
Wolff *et al.* [20]	33	31	93.939	79.774–99.26
Kim *et al.* [21]	1	0	0.0	0.000–97.50
Lamaris *et al.* [22]	14	13	92.857	66.132–99.82
Total [fixed effects]	517		79.548	75.867–82.90
Total [random effects]	517		86.495	66.611–98.15
Test for heterogeneity				
Q	356.8123			
DF	14			
Significance level	P <0.0001*			
I^2 [inconsistency]	96.08%			
95% CI for I^2	94.73 –97.08			

Q: Total variance for heterogeneity; I^2: Observed variance for heterogeneity; CI: Confidence interval [LL: Lower limit – UL: Upper Limit]

Table [2]: Meta-analysis for Hematoma

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Chaiyasate *et al.* [10]	13	1	7.692	0.195–36.030
Jang *et al.* [12]	94	15	15.957	9.215–24.950
Weitz *et al.* [19]	17	2	11.765	1.458–36.441
Total [fixed effects]	124			9.487–22.701
Total [random effects]	124			9.552–21.993
Test for heterogeneity				
Q	0.4037			
DF	2			
Significance level	P = 0.8172			
I^2 [inconsistency]	0.00%			
95% CI for I^2	0.0 –83.38			

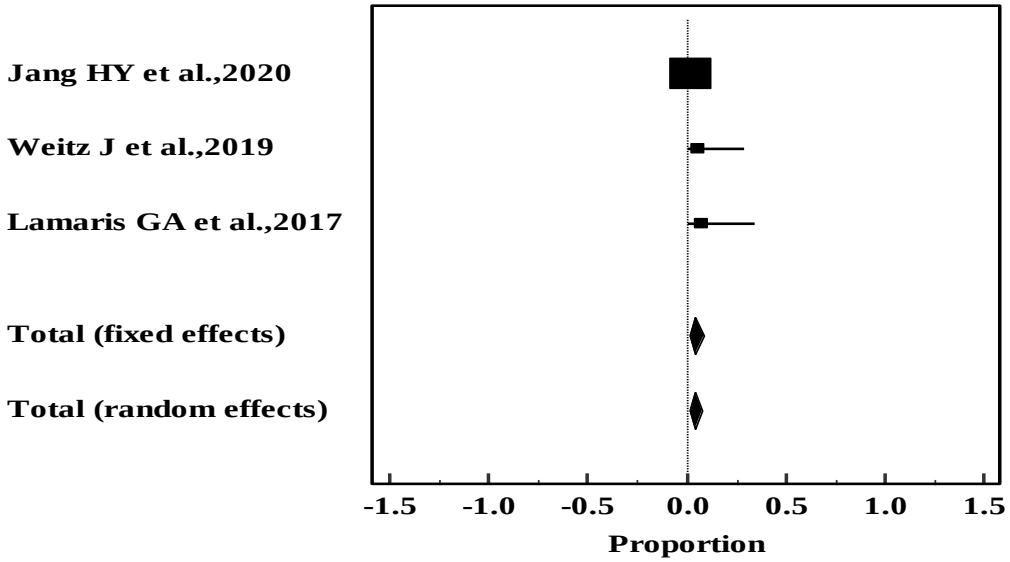

Figure [1]: Forest plot for infection

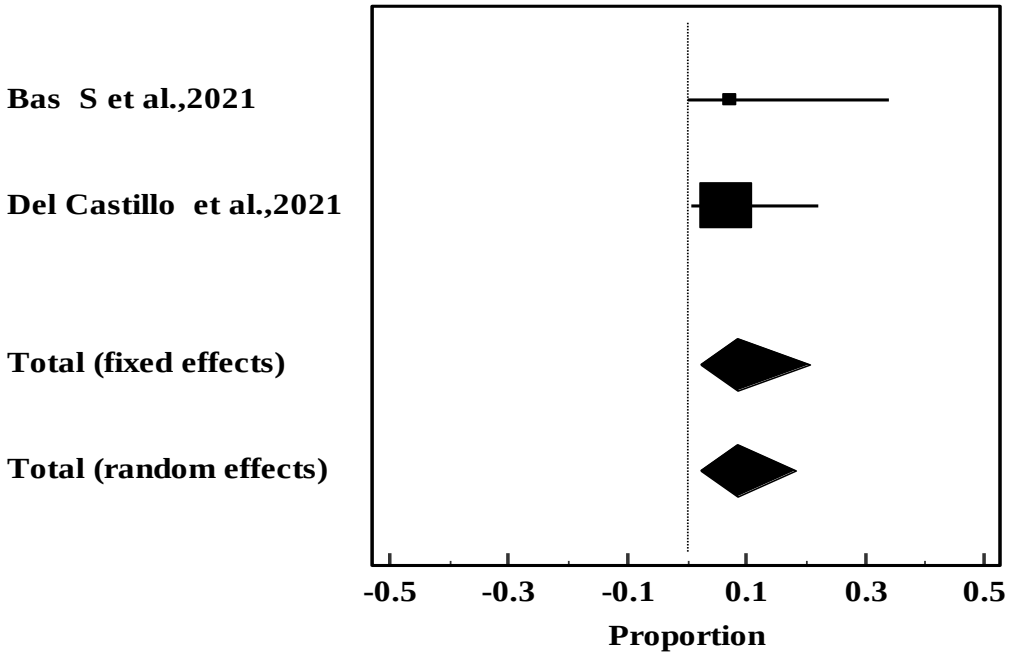

Figure [2]: Forest plot for seroma

Table [3]: Meta-analysis for wound dehiscence

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Bas *et al.* [5]	14	1	7.143	0.181– 33.868
Del Castillo *et al.* [9]	30	2	6.667	0.818 – 22.074
Aronson and Ellis [11]	9	1	11.111	0.281 – 48.250
Jang *et al.* [12]	94	1	1.064	0.0269 – 5.785
Tecce *et al.* [13]	189	48	25.397	19.358 – 32.225
Chen *et al.* [14]	8	2	25.000	3.185 – 65.086
Gupta and Srivastava [17]	54	2	3.704	0.452 – 12.747
Zhou *et al.* [18]	1	1	100	2.500 – 100.0
Weitz *et al.* [19]	17	2	11.765	1.458 – 36.441
Lamaris *et al.* [22]	14	3	21.429	4.658 – 50.798
Total [fixed effects]	430		13.182	10.164 – 16.706
Total [random effects]	430		13.839	5.696 – 24.806
Test for heterogeneity				
Q	56.2468			
DF	9			
Significance level	P < 0.0001*			
I^2 [inconsistency]	84.0%			
95% CI for I^2	72.15 – 90.81			

Table [4]: Meta-analysis for Partial flap loss

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Bas *et al.* [5]	14	1	7.143	0.181 – 33.868
Del Castillo *et al.* [9]	30	4	13.333	3.755 – 30.722
Chaiyasate *et al.* [10]	13	1	7.692	0.195 – 36.030
Ehrl *et al.* [16]	38	3	7.895	1.659 – 21.377
Gupta and Srivastava [17]	54	2	3.704	0.452 – 12.747
Zhou *et al.* [18]	1	0	0.000	0.000– 97.50
Lamaris *et al.* [22]	14	2	14.286	1.779 – 42.813
Total [fixed effects]	164		9.010	5.176 – 14.339
Total [random effects]	164		9.010	5.194 – 13.745
Test for heterogeneity				
Q	3.6128			
DF	6			
Significance level	P = 0.728			
I^2 [inconsistency]	0.0%			
95% CI for I^2	0.00 – 52.32			

Table [5]: Meta-analysis for total Graft loss

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Jang *et al.* [12]	94	3	3.191	0.663 – 9.045
Ehrl *et al.* [16]	38	4	10.526	2.943 – 24.805
Gupta and Srivastava [17]	54	0	0.000	0.000 – 6.603
Zhou *et al.* [18]	1	0	0.000	0.000 – 97.500
Weitz *et al.* [19]	17	2	11.765	1.458 – 36.441
Wolff *et al.* [20]	33	2	6.061	0.743 – 20.226
Kim *et al.* [21]	1	1	100.0	2.500 – 100.000
Lamaris *et al.* [22]	14	1	7.143	0.181 – 33.868
Total [fixed effects]	252		5.156	2.804 – 8.590
Total [random effects]	252		7.323	2.531 – 14.332
Test for heterogeneity				
Q	18.1727			
DF	7			
Significance level	P = 0.011*			
I^2 [inconsistency]	61.48%			
95% CI for I^2	16.67 – 82.19			

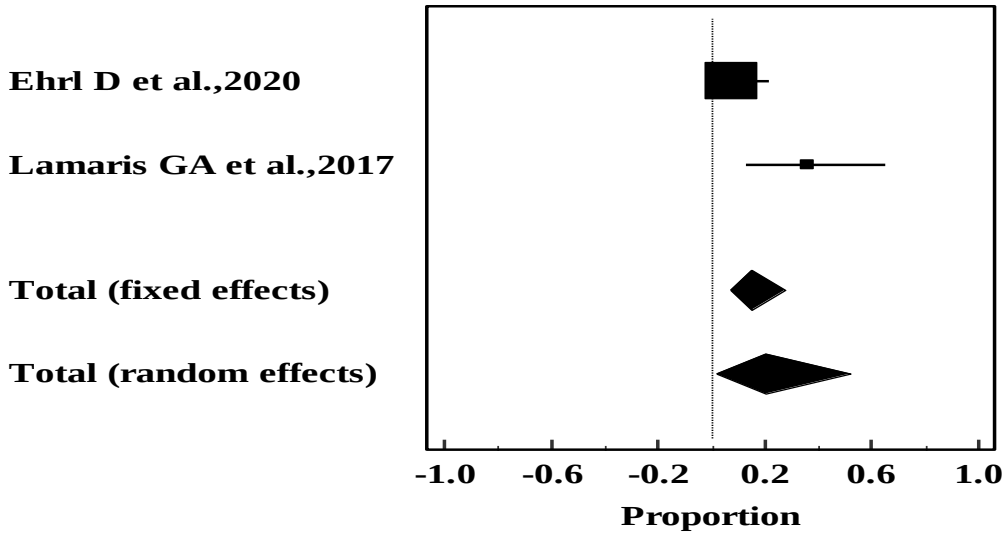

Figure [3]: Forest plot for Donor site morbidity

Table [6]: Meta-analysis for Revision surgery

Study	Total number	Event	Event rate [%] [Proportion]	95% CI of rate [%]
Aronson and Ellis [11]	9	1	11.111	0.281 – 48.250
Tecce *et al.* [13]	189	25	13.228	8.746 – 18.904
Ehrl *et al.* [16]	38	7	18.421	7.743 – 34.326
Weitz *et al.* [19]	17	2	11.765	1.458 – 36.441
Kim *et al.* [21]	1	1	100	2.50 – 100.0
Total [fixed effects]	254		14.748	10.662 – 19.661
Total [random effects]	254		16.128	9.509 – 24.092
Test for heterogeneity				
Q	5.7618			
DF	4			
Significance level	P = 0.217			
I^2 [inconsistency]	30.58%			
95% CI for I^2	0.00 – 73.29			

DISCUSSION

Scalp defects may occur following trauma, radiotherapy, oncologic resection, and recurrent surgeries. The hair-bearing scalp has a dual role, which consists of protecting the calvarium and contributing to esthetic appearance, while the "reconstructive ladder" approach may be used to close small and medium-sized scalp defects, it is not the case for larger ones involving the calvarium or with a radiation therapy history [23].

Hair follicles and the inelastic nature of the scalp make rebuilding difficult. Because of the significant impact this area has on people's overall aesthetic, cosmetic concerns are equally relevant. When reconstructing the scalp, local flaps are preferred wherever possible since they make use of the patient's own tissue and, hence, are more likely to produce a natural appearance; this is especially important when dealing with hair-bearing tissue. Patients with lesions bigger than 50 cm^2 or requiring significant undermining may find the use of local flaps to be impractical, and cicatricial alopecia can result from an overuse of tension [24].

The primary focus of this research was to analyze the different techniques used for reconstruction of scalp defects; to get better surgical choice, through meta-analysis regarding defect size, depth, location, hair line, alopecia risk and aesthetic appearance.

This meta-analysis involved 15 studies, including 517 patients of 12 retrospective studies [5, 9-14, 16, 17, 19, 20, 22] and three case report studies [15, 18, 21].

The current meta-analysis included 517 patients with mean age of 59.94 years. There were 330 males and 187 females.

The meta-analysis by **Goel *et al.*** [25] showed that the majority of patients with head tumors need scalp defect reconstructions were males.

The current study showed that most of the studied patients have scalp defect due to scalp malignancy at different sites of the head including temporo-parietal, fronto-parietal, fronto-temporo-parietal, parieto-occipital, temporal and Orbitofrontal.

Regarding defect size, the pooled data showed that the mean defect size was 93.614 mm and ranged from 12 mm as reported by **Weitz *et al.*** [19] to 230 mm as reported by **Chaiyasate *et al.*** [10]. Regarding depth it was found that the majority of the studied cases have skin and bony defect.

Regarding surgical method of reconstruction, **Bas *et al.*** [5] used flaps musculocutaneous latissimus dorsi [LD] in 4 cases, LD muscle in 3 cases, anterolateral thigh [ALT] in 4 cases, musculocutaneous ALT in one case, vastus lateralis muscle in one case, and rectus abdominis muscle in one case.

Gupta and Srivastava [17] used trans-position flap in 36 cases, Rotation advancement flap in 11 cases, double hatchet flap in 2 cases, bipedicle flap in 2 cases, double transposition in 3 cases.

Lamaris *et al.* [22] used ALT free flap in all his studied 14 cases.

The previous data indicated that there was a variety of surgical techniques can be used in scalp defect reconstruction, the selection of appropriate technique was determined by the size, depth and the localization of flaw.

The simplest method should always be tried as the starting point in surgery. However, in the case of extensive lesions without pericranium, healing by secondary intention is not an option for mending the scalp. Any later radiotherapy should not compromise the ideal reconstructive approach, which should be sufficient to cover the defect with the appropriate tension in the shortest amount of time possible during surgery. It's crucial that reconstructive surgery be well-vascularized, waterproof, and able to ward off infection [26].

As regard healing rate, the pooled analysis of the included studies showed that the mean healing rate was 86.495%. Healing was reported by 15 studies [5, 9-22] with major heterogeneity between studies.

In the current meta-analysis pooled data showed that the overall complication rate was 120/517 [23.2%] patients the most common complication was wound dehiscence, hematoma, total graft loss and flap loss.

Regarding Wound dehiscence; 10 studies [5, 9, 11-14, 17-19, 22] showed that the total event rate 13.839% with insignificant heterogeneity between studies.

Also, 7 studies [5, 9, 10, 16-18, 22] reported Partial flap loss with total event rate 9.010% with insignificant heterogeneity between studies.

Moreover, 8 studies [12, 16-22] reported total graft loss with total event rate 7.323% with significant heterogeneity between studies.

In the current meta-analysis 3 studies [10, 12, 19] have reported Hematoma with total number 18 with insignificant heterogeneity between studies.

Also, 3 studies [12, 19, 22] showing Infection rate with total event rate 3.876% with insignificant heterogeneity between studies.

As well, regarding seroma, the pooled data of 2 studies [5, 9] showed that the seroma rate was 8.545% with insignificant heterogeneity between studies.

Furthermore, 2 studies [16, 22] reported donor site morbidity with total event rate 19.869% with significant heterogeneity between studies.

The minimum complications rate was reported by **Wolff *et al.*** [20] who used full-thickness skin grafts in all 33 cases with 6% complications followed by **Gupta and Srivastava** [17] who used Transposition flap in 36 cases, Rotation advancement flap in 11 cases, Double hatchet flap in 2 cases, Bipedicle flap in 2 cases, Double transposition in 3 cases with 9.3% complications.

In the current meta-analysis pooled data of 5 studies [11, 13, 16, 19, 21] reported the need for revision surgery with total event rate 16.128 with insignificant heterogeneity between studies.

The maximum rate of revision surgery was 18.4% as reported by **Ehrl *et al.*** [16] who used transposition flap in their studied cases.

In the current meta-analysis pooled data of 8 studies [13-19, 21] reported mortality with total event rate 9.195 with significant heterogeneity between studies.

The maximum rate of mortality was 24.9% as reported by **Tecce *et al.*** [13] followed by **Weitz *et al.*** [19] who reported a rate of 5.9%.

Moreover, **Ehrl *et al.*** [16] revealed that there was no correlation between re-operation rates or wound problems and age, sex, comorbidities, histological diagnosis, recurrence history, post-operative radiation, chemotherapy, or reconstructive modality. On multivariate analysis, preoperative radiation was a significant predictor of death [OR, 3.34; 95% CI, 1.2-9.7; p = 0.022], as was immunosuppressed status [OR, 2.88; 95% CI, 1.2-7.1; p= 0.021].

Conclusion: Local flap reconstruction of scalp abnormalities is a simple, quick, and low-risk technique that often requires no particular care afterward. The local scalp flap is the preferred form of reconstruction for even the largest and most intricate scalp defects, such as those involving the skull or dura. The findings of local axial flap applications show that problems occurred seldom and did not significantly reduce flap survival. To corroborate findings and uncover risk factors of adverse events, additional prospective comparison studies are required with bigger sample size and longer follow up.

Conflict of Interest and Financial Disclosure: None.

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