

SCALP COMPLICATIONS OF CRANIOFACIAL SURGERY: A COMPREHENSIVE SYSTEMATIC REVIEW

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ABSTRACT

Background: Scalp complications, defined in this paper as surgical complications on the scalp after craniofacial approaches, can increase morbidity, mortality, and healthcare costs. Several risk factors influence the appearance of these complications. Its prevention begins with a good review of the patient's medical history, continuing with proper surgical planning in which a complete understanding of the anatomy of the scalp, its layered structure, irrigation, and innervation is necessary.

The aim: The aim of this study to show about scalp complications of craniofacial surgery.

Methods: By the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. This search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like Pubmed, SagePub, and Google Scholar were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.

Result: In the PubMed database, the results of our search get 21 articles, whereas the results of our search on SagePub get 87 articles, on Google Scholar 2350 articles. Records remove before screening are 1983, so we get 475 articles for screening. After we screened based on record exclude, we compiled a total of 10 papers. We included five research that met the criteria.

Conclusion: For craniofacial surgery, understanding the surgical anatomy, identifying risk factors, adequate surgical planning, and interdisciplinary cooperation between neurosurgeons, plastic surgeons, and the interdisciplinary team are essential to prevent and treat scalp complications.

Keyword: Craniofacial, surgery, complications, scalp.

INTRODUCTION

Neurosurgical craniotomy is performed for a variety of indications, including the resection of benign or malignant tumors, hematoma evacuation, and for the management of intractable seizure disorders. Despite an overall low complication rate of intervention, due to the high frequency at which scalp incisions are performed at busy tertiary care centers, wound healing complications such as dehiscence, surgical site infection, and cerebrospinal fluid (CSF) leak are not uncommon. Furthermore, craniectomy, in which the bone “flap” (actually a by definition a graft as there is no blood supply) is not immediately replaced, incurs a wound complication rate purportedly higher than that of standard craniotomy (3–40 %).¹

The incidence of scalp complications varies widely depending on the type of surgery performed and the complication itself. For instance, wound defects can vary between 6–20% within the reviewed literature. Golas et al. performed a retrospective review of 64 patients who underwent craniofacial surgery, of which 16.7% required additional interventions for wound complication. Additionally, Butenschoen et al. also performed a retrospective review on neurosurgical intervention and reconstructive surgery procedures in which scalp wound healing problems occurred in 12.8%. On the other hand, complications like temporal hollowing (TH), specifically related to incisions and dissections that compromise the temporal area, for example, the pterional approach, can vary between 30 and 75%.²

The high rate of complex microsurgical free-flap reconstructions was associated with the relatively high proportion of reoperations (30.9%), which were mostly carried out to revise vascular anastomoses. Even though free-flap reconstructions and reoperations were not associated with perioperative deaths according to the multivariate analysis, their high frequencies indirectly reflect the complexity of these operations. Brazilian demographic and socioeconomic characteristics strongly influenced the high proportion of patients with skin cancer (63.4%), many (51%) of whom underwent skull-convexity resections, meaning that this was a unique cohort. Skin cancers with cranial invasion usually reflect a long clinical course of untreated disease, and the excision of skin and soft tissue in addition to the cranial base may predispose patients to complications.³

Reconstruction of scalp defects after oncologic surgery in plastic and reconstructive surgery still remains a challenge given the limited elasticity of the scalp soft tissue, with only defects 3 cm in diameter or smaller being able to be closed primarily. The anatomy of galea and pericranium play a crucial role in the inelasticity of the scalp. Depending on the underlying pathology of the scalp defect, exact localization on the scalp, risk of tumor recurrence, tumor management in terms of previous surgeries or radiotherapy, the subsequent tissue fibrosis or atrophy, vascular compromise, as well as patient's age, and comorbidities, the range of methods of choice for scalp defect reconstruction narrows.⁴

METHODS

Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

Criteria for Eligibility

For the purpose of this literature review, we compare and contrast scalp complications of craniofacial surgery. It is possible to accomplish this by researching or investigating scalp complications of craniofacial surgery. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it needs to determine about scalp complications of craniofacial surgery. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2014, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

Search Strategy

We used "scalp complications of craniofacial surgery." as keywords. The search for studies to be included in the systematic review was carried out using the PubMed and SagePub databases by inputting the words: ("Craniofacial surgery"[MeSH Subheading] OR "Scalp complications"[All Fields] OR "Complications of craniofacial surgery" [All Fields]) AND ("scalp complications of surgery"[All Fields] OR "Craniofacial surgery complications"[All Fields]) AND ("Scalp complications and craniofacial surgery"[All Fields] OR ("management of scalp complication" [All Fields])) used in searching the literature.

Data retrieval

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to

the same trend, this conclusion was drawn. All submissions need to be written in English and cannot have been seen anywhere else.

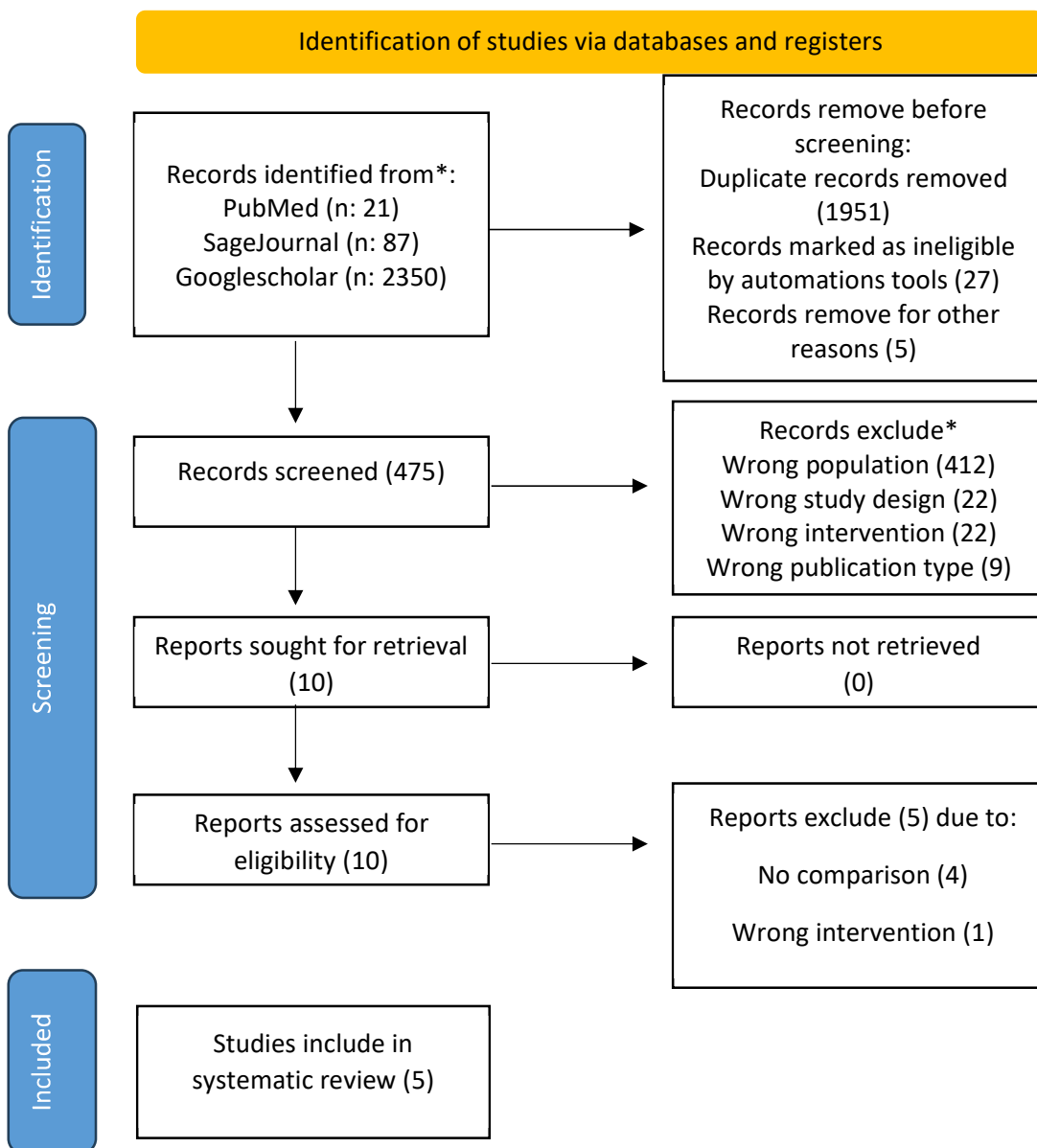


Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

Quality Assessment and Data Synthesis

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. In order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

RESULT

From the PubMed database, the results of our search get 21 articles, whereas the results of our search on SagePub get 87 articles, on Google Scholar 2350 articles. Records remove before screening are 1983, so we get 475 articles for screening. After we screened based on record exclude, we compiled a total of 10 papers. We included five research that met the criteria.

Jang, HU & Choi, YW (2020)⁵ showed multiple factors affect the choice of scalp reconstruction method. As there was no previously established algorithm approach for scalp reconstruction, we suggest that this algorithm, based on our 10 years of experience, will help surgeons better choose successful surgical managements for these patients.

Grzegorz, K et al (2020)⁶ showed thinning of the native scalp occurred over both autogenous and alloplastic materials. This was most evident in the first 2 years following reconstruction and then stabilized in the case of autogenous bone and methylmethacrylate. This process continued after 2 years when titanium mesh was used. Although we did not demonstrate an increase in complications when titanium mesh was used, this may have been due to the relatively small number of patients in our cohort groups. Other risk factors for scalp atrophy included radiation, temporal location, and type of surgical exposure.

Table 1. The literature include in this study

Author	Origin	Method	Sample Size	Result
Jang, HU & Choi, YW., 2020 ⁵	Korea	A retrospective study	98	Ninety-four patients were selected in total and 98 cases, including revision surgery, were performed for scalp reconstruction. Scalp reconstruction was performed by primary closure (36.73%), skin graft (27.55%), local flap (17.34%), pedicled regional flap (15.30%), and free flap (3.06%). The ratio of primary closure to more complex procedure on loose scalps (51.11%) was significantly higher than on tight scalps (24.52%) ($p= 0.011$). The choice of scalp reconstruction method was affected significantly by the defect size ($R = 0.479, p < 0.001$) and depth ($p < 0.001$). There were five major complications which were three cases of flap necrosis and two cases of skin necrosis. Hematoma was the most common of the 29 minor complications reported, followed by skin necrosis.
Grzegorz, K et al., 2020 ⁶	USA	A retrospective study	101	One hundred one patients treated with autogenous bone ($N = 38$), polymethylmethacrylate ($N = 33$), and titanium mesh ($N = 30$) were identified. Mean skull defect size was $104.6 \pm 43.8 \text{ cm}^2$. Mean length of follow-up was 5.6 ± 2.6 years. Significant thinning of the scalp occurred over all materials ($P < 0.05$). This was most notable over the first 2 years after reconstruction. Risk factors included the use of titanium mesh ($P < 0.05$), use of radiation ($P < 0.05$),

				reconstruction in temporal location ($P < 0.05$), and use of a T-shaped or “question mark” incision ($P < 0.05$).
Chung, J et al., 2020⁷	South Korea	A retrospective study	482	A total of 482 cerebral revascularization procedures using the superficial temporal artery were included. Wound complications developed in 32 cases (6.6% of the total), including 7 classified as major in severity (1.5% of the total). The multivariate analysis revealed diabetes mellitus (odds ratio 4.058, $p = 0.001$), low body mass index (odds ratio 1.21, $p = 0.009$), and thin scalp (odds ratio 1.82, $p < 0.001$) as the main risk factors for wound complications. Every 1-mm increase in scalp thickness was associated with a protective effect on wound complications (odds ratio 0.549).
Shay, T et al., 2020⁸	USA	A retrospective study	506	The primary CP group experienced a major complication rate of 9% (26/279). In comparison, the revision CP group demonstrated a major complication rate of 32% (73/227). For the revision CP group, the rate of major complications rose with each additional surgery, from 4% (1 prior surgery) to 17% (2 prior surgeries) to 39% (3–4 prior surgeries) to 47% (5 prior surgeries).
Reddy, S et al., 2014⁹	USA	A retrospective study	180	Materials used for cranioplasty included alloplastic for 42.6 percent (83 of 195), autologous for 19.0 percent (37 of 195), and both combined for 38.5 percent (75 of 195). Mean defect size was 70.5 cm ² . A subset of patients had undergone previous irradiation (12.2 percent; 22 of 180) or had preoperative infections (30.6 percent; 55 of 180). The most common complication was postoperative infection (15.9 percent; 31 of 195). Factors that significantly predisposed to complications included preoperative radiation, previous infection, and frontal location. Preoperative radiation was the strongest predictor of having any postoperative complications, with an adjusted odds ratio of

				6.91 (p < 0.005). Irradiated patients (OR, 7.96; p < 0.05) and patients undergoing frontal cranioplasties (OR, 2.83; p < 0.05) were more likely to require repeated operation. Preoperative infection predisposed patients to exposure of hardware in alloplastic reconstructions (OR, 3.13; p < 0.05).
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Chung.J et al (2020)⁷ showed Cerebral revascularization using the superficial temporal artery was associated with a relatively high risk of wound complications compared with general neurosurgical procedures. Diabetes mellitus, low body mass index, and thin scalp were found to be independent risk factors for wound complications. The thickness of the scalp could be a useful predictor of wound complications, so special care is needed when harvesting the superficial temporal artery, when planning the incision, and when closing the wound in patients with a thin scalp and in those with diabetes mellitus.

Shay, T et al (2020)⁸ showed it is challenging to achieve a durable scalp closure and aesthetically pleasing, symmetric results in CP, while at the same time minimizing complications. In order to better evaluate best practices, a detailed risk stratification is required. This retrospective, case series of 506 consecutive patients identified a three-fold increased risk of major complication in those undergoing revision versus primary CP. Further stratification found complication risks in patients undergoing revision CP to approximately double with sequentially increasing numbers of previous neuro-cranial surgeries. These important findings may allow us to better counsel our patients in need of CP reconstruction. Furthermore, such results lend support for utilizing a center-of-excellence care model, especially for patients with an extensive history of neuro-cranial procedures and/or history of multiple revision CP procedures.

Reddy, S et al (2014)⁹ showed advancements in cranioplasty methods have enhanced the predictability and aesthetic results of repairs, these procedures still have a high incidence of complications. In the setting of previous irradiation or infection, the odds of subsequent complications are significantly increased. We advocate the use of autogenous tissues in these scenarios to achieve more durable repairs.

DISCUSSION

Cranioplasty is more than a cosmetic repair of cranial defects; it is part of the rehabilitation process following a patient’s neurological injury. Recent studies have shown that cranioplasty may improve the patient’s psychological status, social performance, and neurocognitive functioning. The factors that contribute to periprocedural complications, including patients’ demographic information, comorbidities, surgical procedure, and underlying disease, need to be thoroughly evaluated. Previous studies that were intended to answer these questions were limited by their design or by their sample size. Our aim was to evaluate risk factors that predispose patients to an increased risk of cranioplasty complications. Recent evidence in the literature emphasizes patient-specific factors over surgery-specific factors as major predictors of cranioplasty complications.¹⁰

Regardless of etiology, there are many approaches used currently for replacing large-sized defects of the cranial skeleton, if and when the patient’s own bone flap is no longer viable. Some surgeons employ split-calvarial bone grafts obtained via a contralateral craniotomy, while others prefer cadaveric bone allograft. However, most commonly, surgeons choose either an approach with “cranial defect bridging” using off-the-shelf, hand-cut pieces of one millimeter thick titanium mesh or “anatomical replacement” by the way of prefabricated, computer-aided-designed and manufactured, patient-specific customized cranial implants (CCIs).⁸

The most important factor in management of complex cranial defects is a tension-free closure with adequate soft tissue coverage. This may be accomplished via simple layered closure, local scalp flaps, tissue expansion with subsequent flap closure, or microvascular free tissue transfer. As the plastic surgeon is well versed in the application of these tools, as well as the overall management of complex wounds, it follows that plastic surgery closure of complex scalp wounds may lead to a lower incidence of wound complications than standard neurosurgical closure, particularly when plastic surgery closure is performed prophylactically (i.e., in the absence of pre-existing wound complications). We therefore reviewed our experience with plastic surgery closure of craniotomy, craniectomy and other neurosurgical scalp incisions in an effort to delineate the utility of this strategy and potentially identify patients at high risk for wound healing complications who might benefit from involvement of the plastic surgeon at the time of their neurosurgical procedure.¹

The reconstruction of scalp defects after tumor resection represents a difficult surgical challenge, especially considering the mounting incidence of skin cancer among elderly patients.¹ Standard reconstructive techniques follow a step-wise approach that incorporate principles of the reconstructive ladder. Free tissue transfers, local flaps, or skin grafts are usually used in cases of smaller-medium wounds, while larger or infected or previously irradiated wounds can be treated by free

tissue transfer.^{2,3} Each of these options has advantages and limitations, and is chosen based on anatomical characteristics of the lesion, as size, depth, and quality of regional tissue, and patient-related factors, including physical and mental health, comorbidities, and patient preferences.¹¹

Patients with convexity cranioplasty had a higher risk of infections and postoperative hematoma requiring reoperation for evacuation when compared with bifrontal and suboccipital cranioplasties. We also found bifrontal cranioplasty to be associated with a higher risk of both seizure and death. Bifrontal defect was identified by Gooch et al.¹⁷ to be the only location significantly associated with cranioplasty complications. The authors postulated several reasons for this finding, such as a longer incision, a longer operative time, less soft-tissue coverage, and a possible violation of the frontal sinus. Indeed, frontal sinus breach has been reported to increase the risk of infection after cranioplasty.¹⁰

CONCLUSION

For craniofacial surgery, understanding the surgical anatomy, identifying risk factors, adequate surgical planning, and interdisciplinary cooperation between neurosurgeons, plastic surgeons, and the interdisciplinary team are essential to prevent and treat scalp complications.

REFERENCES

- [1] Golas AR eiffe., Boyko T, Schwartz TH, Stieg PE, Boockvar JA, Spector JA. Prophylactic plastic surgery closure of neurosurgical scalp incisions reduces the incidence of wound complications in previously-operated patients treated with bevacizumab (Avastin®) and radiation. *J Neurooncol.* 2014;119(2):327–31.
- [2] Pedroza Gómez S, Gómez Ortega V, Tovar-Spinoza Z, Ghotme KA. Scalp complications of craniofacial surgery: classification, prevention, and initial approach: an updated review. *Eur J Plast Surg [Internet].* 2023;46(3):315–25. Available from: <https://doi.org/10.1007/s00238-022-02008-2>
- [3] Leite AKN, de Alvarenga GF, Goncalves S, Dos Santos AB, Neto HS, Cernea CR, et al. Short-term survival in extensive craniofacial resections. *Clinics.* 2021;76:1–6.
- [4] Nikolić Živanović M, Jurišić M, Marinković M, Grujičić D, Stanimirović A, Šćepanović V, et al. Reconstruction of Moderately and Severely Atrophic Scalp—A Multicentric Experience in Surgical Treatment of Patients Irradiated for Tinea Capitis in Childhood and Surgical Algorithm. *Med.* 2023;59(9).
- [5] Jang HU, Choi YW. Scalp reconstruction: A 10-year experience. *Arch Craniofac Surg.* 2020;21(4):237–43.
- [6] Kwiecien GJ, Sinclair N, Coombs DM, Djohan RS, Mihal D, Zins JE. Long-term Effect of Cranioplasty on Overlying Scalp Atrophy. *Plast Reconstr Surg - Glob Open.* 2020;(2):1–8.
- [7] Chung J, Lee S, Park JC, Ahn JS, Park W. Scalp thickness as a predictor of wound complications after cerebral revascularization using the superficial temporal artery: a risk factor analysis. *Acta Neurochir (Wien).* 2020;162(10):2557–63.
- [8] Shay T, Belzberg M, Asemota AO, Mitchell KA, Wolff A, Santiago GF, et al. Risk of Complications in Primary Versus Revision-Type Cranioplasty. *J Craniofac Surg.* 2020;31(2):423–7.
- [9] Reddy S, Khalifian S, Flores JM, Bellamy J, Manson PN, Rodriguez ED, et al. Clinical outcomes in cranioplasty: Risk factors and choice of reconstructive material. *Plast Reconstr Surg.* 2014;133(4):864–73.
- [10] Zanaty M, Chalouhi N, Starke RM, Clark SW, Bovenzi CD, Saigh M, et al. Complications following cranioplasty: Incidence and predictors in 348 cases. *J Neurosurg.* 2015;123(1):182–8.
- [11] Magnoni C, De Santis G, Fracalvieri M, Bellini P, Portincasa A, Giacomelli L, et al. Integra in Scalp Reconstruction After Tumor Excision: Recommendations From a Multidisciplinary Advisory Board. *J Craniofac Surg.* 2019;30(8):2416–20.