

The Utility of Bone Burring for the Clearance of Locally Advanced Scalp Malignancies: A Scoping Review

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Background: The scalp harbors a range of neoplasms occurring at inordinate rates and associated with poorer outcomes. Its unique anatomy poses surgical challenges, including clear deep margins when resecting these lesions. For malignancies extending to the pericranium, removal of outer cortical cranial bone is ideal and routinely achieved with a burr. This review aims to investigate the literature to ascertain the utility and safety of this technique while highlighting evidence gaps.

Methods: A literature search was conducted systematically using MEDLINE, Embase, and PubMed. Articles were reviewed for inclusion, and eligible studies were analyzed for study design, patient and intervention details, and outcome measures. A formal statistical analysis was not conducted.

Results: The original search yielded 1506 unique results, and eight studies met the inclusion criteria: four case series, two retrospective analysis of records, two case reports. A number of tumor types were identified, but the burring method used was consistent in all studies. Despite reassuring primary outcome measure results, specifically in terms of local control rates, the overall evidence quality is limited by the nature of the included studies. Few adverse events were reported.

Conclusions: Evidence for the oncological efficacy of scalp bone burring remains limited. Although the technique seems relatively safe, further investigation is required into its utility and drawbacks. Future studies should aim to report more technical details and more information about outcomes. It may also be worth comparing burring to alternatives such as outer cortical splitting, curettage, and high-dose curative radiotherapy. (*Plast Reconstr Surg Glob Open* 2023; 11:e5191; doi: 10.1097/GOX.0000000000005191; Published online 11 August 2023.)

INTRODUCTION

Rationale

The scalp, as a region, presents a number of clinical challenges due in parts to its position and unique topographic anatomy. It is composed of layers forming the

acronym of its name: SCALP (skin, connective tissue, galea aponeurosis, loose areolar connective tissue, and the pericranium, which covers the outer cortical bone of the calvaria).¹ It has been estimated that in terms of all malignant cutaneous neoplasms, up to 13% are localized to the scalp²: an overrepresentation considering the total body surface area this region comprises. The skin of the scalp is concealed by dense hair rendering self-inspection difficult and as a result, these lesions often remain undetected for prolonged periods, eventually presenting at more advanced stages.³ Moreover, primary malignancies of the scalp such as melanoma, basal and squamous carcinomas, angiosarcoma, dermatofibrosarcoma, and Merkel carcinoma carry the capacity to invade critical neighboring structures, namely the bone of the cranium, dura, and brain, which can give rise to

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dangerous complications.⁴⁻⁷ These factors likely contribute to the worse prognosis observed for scalp cancers compared with those found elsewhere on the body.^{3,4} Optimizing the local control of these tumors should be a priority.

When excising malignant neoplasms, paramount to adequate clearance and minimizing the risk of recurrence is to attain sufficient margins in all planes. It has been observed that a large proportion of incomplete excisions of cutaneous lesions are at the deep margin.⁸ As with other soft-tissue malignancies, when excising tumors of the scalp, it is most ideal to excise one tissue plane deeper than the involved tissue plane.⁹ If the deep margin involves the pericranium, these principles suggest excision of the outer cortex/outer table of the calvaria. This is routinely achieved using a burr or surgical drill to excise the bone down to the diploic space, denoted by characteristic bleeding.¹⁰ However, the evidence for this technique is sparse and limited discussion is apparent in the published literature about efficacy and risks associated with it.

OBJECTIVES

This scoping review aims to identify and evaluate the available evidence regarding the usefulness of bone burring for the oncological clearance of primary scalp malignancies while highlighting any gaps present. Although outcomes such as local control rate, overall recurrence rates and disease-related mortality will be the focus, secondary outcomes, particularly adverse event rates, will be of interest with the goal of informing best practice.

METHODS

The PRISMA-ScR guidelines were the foundation on which this method was devised.¹¹ A structured search of the literature was conducted using the MEDLINE, Embase, and PubMed databases. The search terms (which were applied to titles and abstracts) and Boolean operators used to devise this search included:

("scalp") AND ("cancer*" OR "malignan*" OR "carcinoma" OR "melanoma" OR "tumour" OR "tumour" OR "neoplas*") AND ("burr*" or "drill*" or "milling" or ("outer table" or "outer cortex" or "outer tabula*" or "crani*" or "bone" or "bony" or "calvari*") AND ("resect*" or "excis*" or "remov*"))

The reference lists of relevant records were inspected for other relevant articles to increase the breadth of the evidence gathered. The resultant studies were reviewed using the systematic review platform Covidence¹²; studies were initially screened by title and abstract only, and the relevant studies identified received full-text analysis for definitive inclusion or exclusion. The identification, screening, and inclusion processes were conducted solely by the primary author (OA) and concerns, especially regarding eligibility, were addressed by the two supervising senior authors.

Inclusion Criteria

- Randomized controlled trials
- Cohort studies (prospective and retrospective)

Takeaways

Question: What evidence exists for the commonly used technique of burring cranial bone to ensure a clear deep margin in the excision of scalp tumors?

Findings: This scoping review identified eight studies incorporating this technique of low-quality evidence level. Although burring appears to be effective at establishing local control in these cases, it is not possible to ascertain its true oncologic utility given the quality of the available evidence. The reporting of technical details and secondary outcomes was suboptimal.

Meaning: There exists major knowledge gaps about the oncological benefits and drawbacks associated with burring in this context, and further robust investigation is required.

- Case series
- Case reports
- Studies involving patients with scalp malignancy receiving cortical bone burring to ensure the deep margin
- Studies recording relevant outcomes such as tumor recurrence, systemic recurrence, overall mortality, or adverse events such as infection rate or damage to adjacent structures

Exclusion Criteria

- Studies in which the full-text article was unobtainable
 - Studies published in languages other than English
 - Studies involving nonhuman participants
 - Studies involving child/adolescent patients
 - Studies investigating bone burring in a reconstructive context (to improve vascularization for skin grafts, etc.)
 - Studies in which there was significant bony, dural, or deeper involvement from the scalp tumors (the management for these cases routinely involve more invasive measures out of the scope of this study)
 - Studies in which the technique for outer table resection (ie, burring) was not specified or not relevant
- Studies were not excluded based on year of publication

Data Extraction

The articles included were thoroughly investigated for the extraction of relevant details, namely:

- Study design and level of evidence as per OCEBM¹³
- Tumor type
- Number of patients receiving the intervention of interest as well as key oncological details (eg, depth of invasion & prior treatments)
- Surgical technique used for tumor resection
- Primary (eg, local control rate, tumor recurrence rate, disease-related mortality) and secondary outcomes (rates of infection, damage to adjacent structures) regarding excision

Outcome measures were either recorded as reported or extrapolated from the presented data if applicable.

Statistical Analysis

Due to the lack of homogeneity observed in the patient populations, methodologies and outcome measures of the

included articles, a formal statistical analysis was determined to be unfeasible.

RESULTS

As evidenced in Figure 1, the literature search of the aforementioned databases yielded 2656 studies for screening. Additionally, three records were sourced externally to the search. Following the removal of duplicates, 1501 studies were screened based on their titles and abstracts, and 25 potentially suitable articles were identified. The full texts of these were inspected in their entirety, and ultimately, eight studies were determined to be suitable for inclusion.

Notably, numerous studies encountered particularly in the full-text analysis referred to outer table resection but did not specify whether this was achieved through burring or via other means and were deemed to not be worth including in this study. Another common reason for exclusion was the employment of burring in a reconstructive context.

Supplemental Digital Content 1 summarizes the pertinent characteristics of the studies included for review, which were published between the years 2010 and 2023. (See table, Supplemental Digital Content 1, which displays the characteristics of included studies. <http://links.lww.com/PRSGO/C721>.) As expected, with regard to the nature of the intervention of interest, the bulk of the evidence garnered is in the form of case reports and case series articles. No controlled cohort studies or randomized trials were identified from the search, and thus, the overall level of evidence is low.

The number of patients included in each study ranged from one to 17, and their demographic details varied. As the database search was not limited to a particular tumor type, studies involving patients with a range of these were included, namely cutaneous squamous carcinoma

(n = 3), atypical fibroxanthoma (n = 2), angiosarcoma (n = 2), basal carcinoma (n = 1), adnexal carcinoma (n = 1), and dermatofibrosarcoma protuberans (n = 1). The manner in which burring was implemented, as reported by these articles, was consistent despite this variation.

Essentially all the reports described a technique composed of wide local excision of the tumor, stripping of the pericranium and the burring of bone down to the diploic space. Notably, Chou et al¹⁴ did not specify the depth to which the cortex was burred in their study. Some patients received adjuvant radiotherapy, chemotherapy, and in the study by Lim et al,¹⁵ ipsilateral superficial parotidectomy. The results of these studies broadly, in the reporting of outcomes, did not stratify by therapies received, and hence, it is not possible to ascertain the effect adjuvant therapies had on patient outcomes.

In terms of the outcome measures reported, a modest amount of homogeneity was observed amongst the included studies, with most studies reporting local control rate or overall tumor recurrence rate. The local control rates as attributable to burring ranged from 50% to 100% among the studies. The outcome, disease-related mortality, was extrapolated from data reported by Leach et al¹⁰ and Ziegler et al.¹⁶ A pertinent secondary outcome was reported in only one study (Sleiwah et al¹⁷) with one patient developing an infection. The majority of the included studies reported reconstructive details of their cases, but this aspect is outside the scope of this study.

DISCUSSION

The use of bone burring to ensure the deep margin during the resection of scalp malignancy extending to the pericranial layer is a widely adopted technique. However, as determined by the results of this study, the evidence

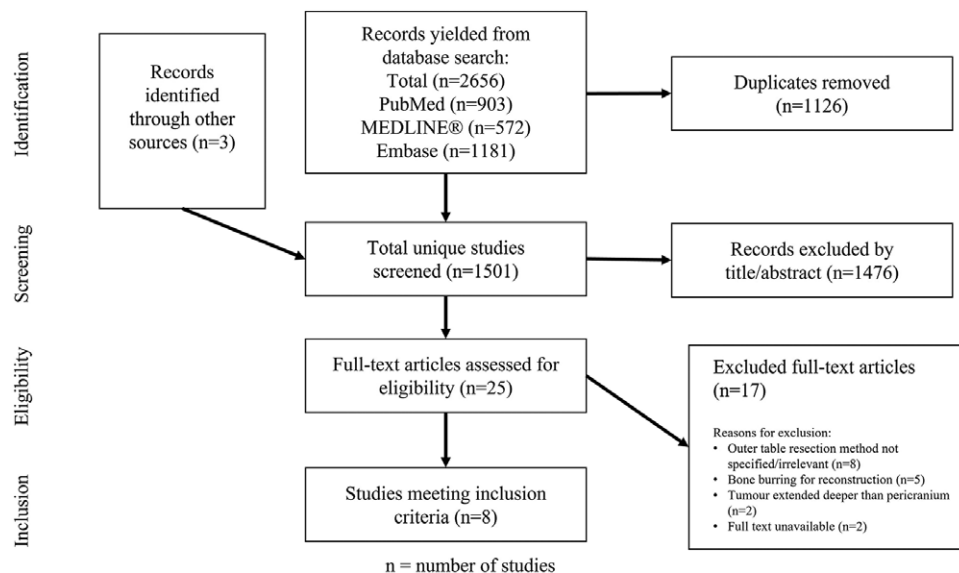


Fig. 1. PRISMA Flowchart illustrating the identification and screening process of studies for inclusion.

and rationale available in the published literature for this approach is sparse. The conducted search identified eight relevant studies in the form of case reports and case series. Several articles^{14–21} detailing the clinical management and outcomes of patients with scalp malignancy mention the use of bone burring but provide no explanation as to why this technique was implemented in these cases over alternatives such as outer table splitting,^{10,21,22} outer table curettage,²³ or high-dose radiotherapy as a sole treatment.^{24,25}

It was determined that a scoping review would be more appropriate than a systematic review for this research question due to the anticipated heterogeneity and low evidence level of the available studies on this topic. There still remains a great deal of uncertainty about how these review types differ from each other but there are distinct guidelines available for each.^{11,26} Generally speaking, scoping reviews are based in broader research questions, and as a result, they typically summarize and remark on the evidence in a narrative sense. Moreover, they are also more fluid and adaptive with regard to their methodology and the manner in which the results are presented.

Bone Burring Technique

A myriad of methods can be used for the cutting/removal of bony tissue. Traditionally, surgeons use an array of tools, including surgical saws, drills/burrs, mills, and osteotomes depending on the circumstance.²⁷ Their various drawbacks, including thermal and physical damages to the bone or surrounding structures, combined with their limited precision have driven the development of novel tools such as piezoelectric saws.²⁸

Surgical burrs are small metal instruments attached to a rotating handpiece and are mainly used to meticulously shape and contour bone. With respect to the burring of bone during the resection of scalp tumors, the level of technical detail frequently reported is lacking in terms of the types and size of burrs used and rotational speed. Pineapple and rose-head burr were some of the types reported.^{10,22} Customarily, surgeons report drilling the outer cortex down to the level of diploic space, which, while consistent with the removal of an entire anatomic plane to err on the side of caution, could in theory be causing unnecessary morbidity to the calvaria especially in the absence of bony tumor involvement. The study by Chou et al,¹⁴ which was the only study analyzed that did not report drilling the entire outer cortex, reported a local recurrence rate of 37.5%, which is on the lower end of estimated recurrence rates of angiosarcoma of the scalp (35%–86% despite intensive measures).^{29–33} It might be worth investigating the utility of partial outer cortical drilling for tumors concealed to the pericranium compared with the frequently reported burring down to the diploic space.

Malignant scalp neoplasms that invade the calvarial bone routinely involve full-thickness craniectomy during their resection.^{17,21,34} Outer table resection procedures can be upgraded to full-thickness craniectomy in the case of positive frozen section analysis of the outer cortex, which signifies bony tumor involvement.²¹

Benefits

Unfortunately, based on the presented evidence, it is not possible to ascertain the effectiveness of bone burring in the establishment of local control and minimizing tumor recurrence. The low disease-related mortality rates observed is reassuring, but further investigation is required to enable firm conclusions to be made. Nonetheless additionally, the low complication rate observed attributable to burring possibly signifies the relative safety of this method. Compared with the more invasive full-thickness craniectomy, which could also be used in locally advanced scalp tumor cases and is associated with a number of complications,³⁵ burring seems to offer minimal morbidity.¹⁶

Other benefits can be attributed to bone burring in this context. The use of a burr in these cases may potentially present a simpler and less time-consuming means of decortication when compared with the use of other sharp cutting tools.

Additionally, the drilling of the cortex down to the diploic space aids reconstruction efforts. Scalp defects arising as a result of tumor resection that are devoid of vascular periosteum present a reconstructive challenge: the diploic bleeding that burring provides combats this, allowing for the placement of a split-thickness graft.^{36–38} Coverage of the defects caused by burring should be tailored for each case, with consideration given to individual patient factors as well as the preference of those operating.^{10,21} Smaller defects can often be reconstructed with local flaps, dermal regeneration templates, and skin grafts, or a combination of these.^{10,18–20,22} Larger defects usually call for more involved measures most commonly the anterolateral thigh flap and latissimus dorsi musculocutaneous free flap.^{14,15,17,22} This is in contrast to the reconstruction of full-thickness craniectomies, which almost always require cranioplasty for the skull defect and free flaps for coverage.^{17,21,34}

Drawbacks

The lack of reported secondary outcomes such as infection rates and damage to surrounding structures especially the superior sagittal sinus is rather remarkable. (See table, **Supplemental Digital Content 1**, <http://links.lww.com/PRSGO/C721>.) Although some studies reported complications regarding reconstruction, the study by Sleiwah et al¹⁷ was the only article reporting a complication attributable to burring: one patient had an infection. Although this may be a testament to the skill of the surgeons operating, it is not possible to exclude reporting bias. Although the risks of these events are low, adverse events are intrinsic to surgical interventions and should be reported when they occur.³⁹

Although not dwelled upon in the literature, other drawbacks of bone burring must be considered. One major disadvantage is that the resultant fragments of bone are not ideal for histopathological analysis²¹; it is more advantageous to send an intact outer table segment for analysis.³¹ On the other hand, Kusanale and Akare⁴⁰ in their 2019 abstract concluded that the bone dust obtained from burring at a lower rotation speed is viable for pathological

analysis. Further investigation into the diagnostic accuracy of bone dust as opposed to outer cortical segments is needed.

Another risk worth considering is the theoretical prospect of tumor seeding as a result of high-speed drilling if there is inconspicuous bony involvement. An animal study by Wang et al⁴¹ demonstrated the spraying of bony tissue up to 20 cm from the drill site, which, if extrapolated to bone burring, could lead to tumor recurrence or local spread intraoperatively. However, these disadvantages do not seem to outweigh the benefits this technique offers, providing some context as to why this method is so widely used.

Future Insights/Limitations of This Study

This study was not without limitations. Firstly, the literature search was primarily devised and conducted by a single author, which may have limited the breadth of evidence collected. Further, the articles that were included are of a low level of evidence, which undermines the generalizability of the conclusion drawn. Ideally, the most effective manner by which the utility of bone burring in this context can be evaluated would be through a formal systematic review comparing the technique with alternatives such as outer cortical splitting and curative radiotherapy.

Nonetheless, the glaring lack of studies published reporting sufficient technical details and comprehensive outcome measures combined with the ethical inability to conduct controlled trials with interventions of this nature renders this prospect hardly worthwhile.

CONCLUSIONS

Eight studies were identified incorporating the burring of cortical cranial bone in the excision of various scalp malignancies. These articles were limited by both study design and sample size, and as a result, although they demonstrate some utility of this technique in obtaining local control, a definitive conclusion about the extent of this remains beyond reach. Bone burring seems to be a relatively safe and effective means of ensuring clear deep margins in the resection of scalp tumors. However, further robust investigation into the oncological benefits and its favorability against alternatives is still required. Future studies should aim to provide more detailed information about the technical aspects of the burring technique, as well as comprehensive data on its outcomes. It is also worth establishing an evidence base on the drawbacks such as less ideal pathological analysis and tumor seeding due to bony tissue spray intraoperatively.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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