Surgical management of malignant eyelid tumours: a retrospective analysis over 10 years of surgical treatment in 1443 consecutive cases

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Surgical Management of Malignant Eyelid Tumors: A Retrospective Analysis over 10 Years of Surgical Treatment in 1443 Consecutive Cases

Operatives Management von malignen Lidtumoren: eine retrospektive Analyse der chirurgischen Behandlung von 1443 konsekutiven Patienten über einen Zeitraum von 10 Jahren

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ABSTRACT

Background Malignant eyelid tumors are the most frequent malignant tumors in ophthalmology. They threaten the patients' vision and, if not treated adequately, even the patients' life. Complete resection of the tumor is the standard of care, but poses unique surgical challenges, due to the anatomical and functional importance of the eyelid region.

Material and Methods We retrospectively analyzed data of 1,443 consecutive patients with malignant eyelid tumors who were treated at the Eye Center, Medical Center – University of Freiburg between 2009 and 2019. Data were collected on tumor type, post-excisional size of the lid defect, frequency of re-excisions and reconstructive effort regarding surgical duration and complexity. Reconstructive duration was categorized by the time required for eyelid reconstruction and the complexity of the reconstructive procedures, as based on the operation and procedure codes (OPS).

Results The largest mean defect size (MDS) was seen in cases of malignant melanoma (MDS: 560 mm^2 (95% CI: 290–992 mm^2). Re-excisions were most common in SGC (71%), then SCC and LM (both 53%). Regarding reconstruction duration, most patients (74%) required 30–90 minutes, with a minority needing less than 30 minutes (21%) or more than 90 minutes (5%). Reconstructive complexity was predominantly intermediate (54%), with 22% requiring low and 24% high reconstructive complexity.

Conclusions The majority of malignant eyelid tumor reconstructions can be managed with surgical procedures that typically last between 30 and 90 minutes and have intermediate complexity, but surgeons must maintain expertise in complex reconstruction techniques for challenging cases.

ZUSAMMENFASSUNG

Hintergrund Maligne Lidtumoren sind die häufigsten bösartigen Tumoren in der Ophthalmologie. Sie bedrohen das Sehvermögen der Patienten und bei unzureichender Behandlung auch deren Leben. Die vollständige Tumorresektion stellt den Therapiestandard dar, birgt jedoch aufgrund der anatomischen und funktionellen Bedeutung der Lidregion besondere chirurgische Herausforderungen.

Material und Methoden Wir analysierten retrospektiv die Daten von 1443 konsekutiven Patienten mit malignen Lidtumoren, die zwischen 2009 und 2019 an der Klinik für

Augenheilkunde des Universitätsklinikums Freiburg behandelt wurden. Erfasst wurden Tumortyp, postoperative Defektgröße, Frequenz von Nachresektionen sowie der rekonstruktive Aufwand hinsichtlich Operationsdauer und -komplexität. Die Rekonstruktionsdauer wurde anhand der für die Lidrekonstruktion benötigten Zeit kategorisiert; die Komplexität der rekonstruktiven Verfahren wurde basierend auf den Operationen- und Prozedurenschlüsseln (OPS) klassifiziert.

Ergebnisse Die größte mittlere Defektgröße (MDS) zeigte sich beim malignen Melanom (MDS: 560 mm^2 [95%-KI: 290–992 mm^2]). Nachresektionen waren beim Talgdrüsenkarzinom (SGC; 71%) am häufigsten, gefolgt vom Plattenepithelkarzinom (SCC) und Lentigo maligna (LM) (beide 53%). Bezüglich der Rekonstruktionsdauer benötigte die Mehrheit der Patienten (74%) 30–90 min, während eine Minderheit weniger als 30 min (21%) oder mehr als 90 min (5%) erforderte. Die rekonstruktive Komplexität war überwiegend intermediär (54%), wobei 22% eine geringe und 24% eine hohe Komplexität aufwiesen.

Schlussfolgerung Die Mehrheit der Rekonstruktionen maligner Lidtumoren kann durch chirurgische Eingriffe versorgt werden, die in der Regel zwischen 30 und 90 min dauern und eine intermediäre Komplexität aufweisen. Dennoch müssen Chirurgen ihre Expertise in komplexen Rekonstruktionstechniken für anspruchsvolle Fälle aufrechterhalten.

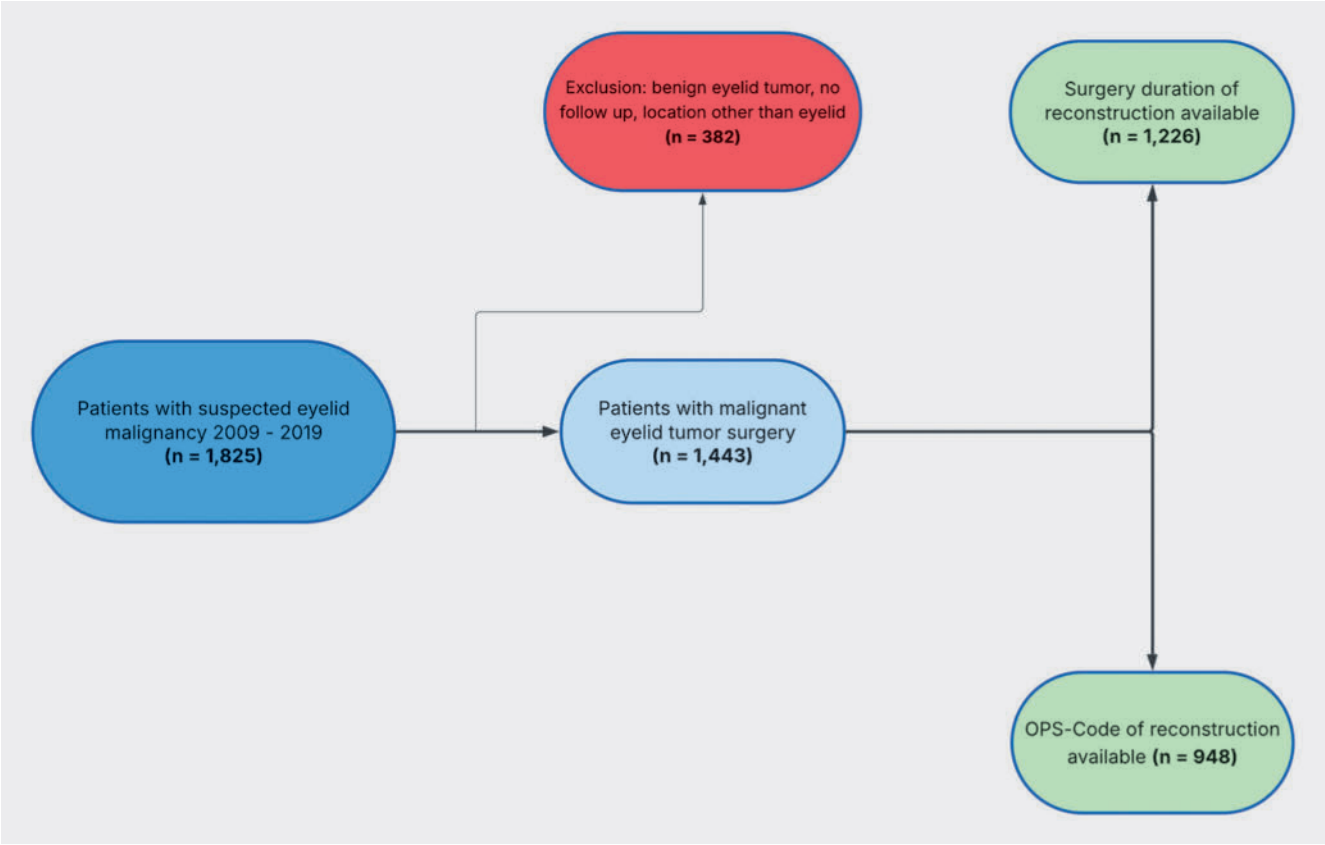
Introduction

The incidence of all malignant eyelid tumors, such as basal cell carcinoma (BCC), squamous cell carcinoma (SCC), malignant melanoma (MM) and sebaceous gland carcinoma (SGC), has been rising steadily, reflecting broader trends in skin cancer epidemiology [1]. Non-melanocytic skin cancers BCC and SCC account for the majority of malignant skin tumors of the Caucasian population (BCC81–86%, SCC7–8%) overall. All malignant lid tumors necessitate different surgical approaches based on their growth patterns and metastatic potential [2–7]. Micrographic controlled surgery is the gold standard for treating malignant tumors of the eyelid [8–10]. However, in the case of MM, the safety margin is determined by tumor thickness, with an adjusted safety margin in the eyelid region if maintaining the recommended width would compromise surrounding structures [11]. Resection of malignant eyelid tumors and reconstruction of the periocular structures is of critical importance due to the potential impairment of lid function, protection of the globe and consequent loss of vision [2, 12]. Post-excisional defect size and localization are critical factors in determining the complexity and type of reconstructive surgery. Larger defects often result from more extensive tumors, tumors with higher invasive potential, or those located at critical anatomical sites [12]. Reconstruction techniques range from primary closure for smaller defects to complex flap surgery or tissue transplantation procedures for larger or more anatomically challenging defects. These procedures may require a high level of surgical expertise and in complex situations an interdisciplinary approach [12]. This study aims to analyze the tumor-specific size of surgical defects as well as the reconstructive workload and complexity involved in managing malignant eyelid tumors.

Material and Methods

We retrospectively analyzed consecutive patients who underwent surgical excision for suspected malignant eyelid tumors and subsequent reconstructive procedures at the Eye Center at Medical Center, University of Freiburg, between September 2009 and July 2019. Patient records were initially cross-referenced with our institutional histological laboratory database to confirm malignancy and collect detailed tumor characteristics. Subsequently, the clinical treatment pathway for each patient was reviewed by examining surgical reports and the digital patient records to gather comprehensive data on the procedures performed and postoperative follow-up. Patients were eligible for inclusion in this retrospective analysis if the initial clinical suspicion was for a malignant eyelid tumor or a tumor of unknown dignity, and this was subsequently confirmed by histological examination as a malignant eyelid tumor, classified according to the World Health Organization International Classification of Diseases (WHO-ICD). Inclusion required complete medical records, including all operative reports and postoperative histological confirmation of malignancy. Patients were excluded from the study if they presented with benign eyelid lesions, if the tumor was located in a region other than the eyelid, if medical records were incomplete, or if they had not completed their full course of treatment at our institution. After applying these criteria, 1,443 consecutive patients were included in the final analysis (▶ **Fig. 1**).

The study was approved by the local ethics committee and adhered to the tenets of the Declaration of Helsinki. Data were collected on tumor type, post-excisional defect size and the number of resections required to achieve R0 status (complete resection with no microscopic residual tumor). Defect size was measured intraoperatively in two perpendicular dimensions and recorded in the surgical protocol. In our clinic, when a malignant eyelid tumor was suspected, we typically adhere to a two-step surgical approach. A biopsy may be performed prior to excision if deemed necessary for diagnostic confirmation. The first surgical step involves excising the tumor without primary closure of the defect, aiming for microscopically clear margins. After receiving histological confirmation of the diagnosis and assessment of resection status from our specialized laboratory, reconstruction is performed in the second step. If clear margins are not achieved, re-excision is carried out, effectively repeating the first and second steps until complete tumor removal is histologically confirmed. The procedures were performed by specialized ophthalmologists experienced in plastic-reconstructive eyelid surgery, supported by an in-house, highly specialized histopathological laboratory. The reconstructive duration was categorized based on the operative time specifically required for the reconstructive procedure: < 30 minutes, 30–90 minutes, and > 90 minutes. The complexity of reconstruction was categorized based on the "Operations- und



▶ **Fig. 1** Data Collection of surgery duration and OPS-Code of reconstruction.

Prozedurenschlüssel" (OPS), which is the official German national coding system for medical procedures (https://www.bfarm.de/EN/Code-systems/Classifications/OPS-ICHI/OPS/_node.html).
The OPS provides a detailed and standardized classification of surgical and medical interventions, and its codes are a fundamental component for case grouping within the German Diagnosis-Related Groups (G-DRG) system, used for hospital reimbursement and healthcare resource management. For the purposes of this study, the OPS allowed for a systematic and reproducible classification of the reconstructive techniques performed (detailed in ▶ **Table 1**). Based on these codes and the nature of the procedures, complexity was graded as follows. Simple defect closures using sliding flaps that required no follow-up procedures were classified as low complexity. Defect closures with sliding flaps and skin grafts, extended healing periods, secondary interventions like eyelid openings, or prolonged follow-up care, were considered intermediate complexity (e.g. Hughes procedure, Mustardé flap, free skin grafts). Highly complex procedures as well as those associated with delayed wound healing and significant morbidity, were classified as high complexity (e.g. free tarsomarginal grafts, large cheek advancement flaps, and Cutler-Beard procedure).

Descriptive statistics were used to summarize tumor characteristics and surgical details. The correlation between defect size and the localization of the tumor was analyzed using Pearson's correlation coefficient. Comparisons between different reconstructive techniques were made using Chi-square tests for categorical variables and t-tests for continuous variables. Statistical significance was set at $p < 0.05$.

Results

We initially conducted data research within our institutional histological laboratory databank and identified 1,825 patients who had undergone tumor surgery related to malignant eyelid tumors within the specified study period (September 2009 to July 2019). Following a review of these records and application of the predefined exclusion criteria (benign eyelid tumors, incomplete follow-up data, or tumor locations other than the eyelid), 1,443 patients met the inclusion criteria and were included in the final analysis.

Patient Demographics and Tumor Characteristics

Of the 1,443 included patients, 949 (66%) were female. The mean age at diagnosis was 74 years (95% CI: 66–81). The most common tumor type was basal cell carcinoma (BCC), accounting for 86.0% (1,241 cases). Less common tumor types included squamous cell carcinoma (SCC; 5.2%, n = 75), actinic keratosis (AK; 5.1%, n = 74), sebaceous gland carcinoma (SGC; 1.2%, n = 17), lentigo maligna (LM; 1.0%, n = 15), Bowen's disease (BD; 0.6%, n = 9), and malignant melanoma (MM; 0.5%, n = 7). While these common malig-

▶ **Table 1** OPS Codes used for classification of the defect closure.

Eyelid defect closure	OPS Code	Group
Lateral Shift	5–096.1 x	Low complexity
Other Procedures	5–096.4 x	
Tenzel Procedure	5–096.11	
Eyelid Margin	5–095.11	
Rotation Flap	5–095.41	
Upper Eyelid Margin	5–095.10	
Rotational Flap	5–096.41	
Reconstruction of Medial Canthus	5–096.50	
Reconstruction of Lateral Canthus	5–096.51	
Tarsorrhaphy without Involvement of Eyelid Margin	5–092.00	
Tarsorrhaphy with Involvement of Eyelid Margin	5–092.01	
Cheek	5–096.40	Intermediate complexity
Tarsoconjunctival Pedicled Transposition	5–096.30	
Tarsoconjunctival Free Transposition	5–096.31	
Tarsomarginal Procedure	5–096.32	
Full-Thickness Skin Graft from Scalp	5–901.14 large	
5–902.24 small		
Upper Eyelid Reconstruction from Lower Eyelid	5–096.42	High complexity
Full-Thickness Skin Graft	5–902.64 large	
Full-Thickness Skin Graft from Upper Arm	5–901.17	
Full-Thickness Skin Graft from Scalp	5–901.14	

OPS: Operations- und Prozedurenschlüssel

nant eyelid tumors predominated, several rarer entities were also identified, each with a single documented case: mucoepidermoid carcinoma, porocarcinoma, cystadenocarcinoma, lymphoma, and Merkel cell carcinoma.

The mean defect size (MDS) was available for 1,426 patients (surgical protocols were missing MDS data for 17 patients). Detailed MDS by tumor type and localization are presented in ▶ **Table 2**.

Malignant melanoma (MM) exhibited the largest MDS at 560 mm^2 (95% CI: 290–992 mm^2). Sebaceous gland carcinoma (SGC) followed with an MDS of 187 mm^2 (95% CI: 119–324 mm^2). Lentigo maligna (LM) and squamous cell carcinoma (SCC) showed similar MDS values of 136 mm^2 (95% CI: 56–456 mm^2) and 135 mm^2 (95% CI: 55–218 mm^2), respectively. BCC had a slightly smaller MDS of 120 mm^2 (95% CI: 72–120 mm^2), while AK and BD had the smallest MDS at 90 mm^2 (95% CI: 28–136 mm^2).

By location, the largest MDS was observed at the temporal canthus (200 mm^2, 95% CI: 109–497 mm^2), followed by the nasal canthus (140 mm^2, 95% CI: 84–288 mm^2), upper eyelid (120 mm^2, 95% CI: 59–275 mm^2), and lower eyelid (112 mm^2, 95% CI: 64–183 mm^2).

Re-excision Rates

The number of re-excisions performed until achieving microscopically clear tumor margins for the treated malignant eyelid tumors is shown in ▶ **Table 3**. Re-excisions were needed most frequently for SGC patients (71%), followed by cases of SCC (53%) and LM (53%). Orbital exenteration was required due to large tumor growth in two patients: one with MM and one with SGC.

Among 1,443 patients with confirmed malignant eyelid tumors, detailed information on the duration of surgical reconstruction was available for 1,226 patients. For these patients, the duration of reconstructive procedures was recorded intraoperatively and categorized as follows (shown in ▶ **Fig. 2**):

- Up to 30 minutes: 256 patients (21%)
- Between 30 and 90 minutes: 907 patients (74%)
- More than 90 minutes: 63 patients (5%)

OPS codes, which are used to classify surgical procedures (as described in the Methods section), were obtained for 948 patients. These OPS codes were used to estimate the complexity of the reconstructive surgeries performed.

Based on the OPS codes (see ▶ **Table 1**), reconstructive complexity was classified into three categories (shown in ▶ **Fig. 2**):

- Low complexity: 206 patients (22%)
- Intermediate complexity: 511 patients (54%)
- High complexity: 231 patients (24%)

This classification reflects the technical demands and extent of the reconstructive techniques utilized.

When pooling all patients, the majority underwent reconstruction lasting between 30 to 90 minutes, representing 64–76% of cases depending on localization. The highest proportion of procedures within this time frame was observed for tumors located at the lower eyelid (76%), the most common tumor site, followed by the nasal canthus (72%), the temporal canthus (65%), and the upper eyelid (64%). Shorter reconstructive times (< 30 minutes) were most seen in the upper eyelid and temporal canthus (30% each), followed by the nasal canthus (22%) and the lower eyelid (19%). Longer reconstructive durations exceeding 90 minutes were required in only 5–6% of cases and, like shorter surgery times, did not differ significantly across tumor localizations ($p = 0.091$). ▶ **Table 4** shows both the distribution of reconstructive duration across different tumor localizations and the association between MDS and reconstructive duration. While tumor localizations did not show significant differences in reconstructive duration, larger MDS was associated with significantly longer reconstructive duration ($p < 0.001$).

In terms of surgical complexity, 54% of patients required procedures of intermediate complexity, while 22% underwent low-complexity reconstructions and 24% high-complexity procedures.

▶ **Table 2** Mean defect size and localization in relation to different tumor entities.

	BCC n = 1241 (86.0%)	SCC n = 75 (5.2%)	AK & BD n = 83 (5.7%)	SGC n = 17 (1.2%)	LM n = 15 (1.0%)	MM n = 7 (0.5%)	MDS in mm²
Lower Eyelid n = 980 (67.9%)	849 (68.4%)	48 (64.0%)	55 (66.2%)	8 (47.0%)	15 (100%)	4 (57.1%)	112 (95% CI: 64–183)
Upper Eyelid n = 135 (9.4%)	99 (8.0%)	13 (17.3%)	14 (16.9%)	8 (47.0%)	0	0	120 (95% CI: 59–275)
Nasal Canthus n = 277 (19.2%)	253 (20.4%)	9 (12.0%)	13 (15.7%)	0	0	2 (28.5%)	140 (95% CI: 84–288)
Temporal Canthus n = 51 (3.5%)	40 (3.2%)	5 (6.7%)	1 (1.2%)	1 (6.0%)	0	1 (14.3%)	200 (95% CI: 109–497)
MDS in mm²	120 (95% CI: 72–120)	135 (95% CI: 55–218)	90 (95% CI: 28–136)	187 (95% CI: 119–324)	136 (95% CI: 56–456)	560 (95% CI: 290–992)	

BCC: Basal cell carcinoma, SCC: Squamous cell carcinoma, AK: Actinic keratosis, BD: Bowen's Disease, SGC: Sebaceous gland carcinoma, LM: Lentigo Maligna, MM: Malignant melanoma, MDS: Mean defect size

▶ **Table 3** Number of re-excisions.

Number of re-excisions	SGC n = 17	SCC n = 75	LM n = 15	MM n = 7	BCC n = 1241	AK & BD n = 83
None	29% (5)	46% (34)	47% (7)	57% (4)	59% (732)	67% (56)
1	47% (8)	41% (31)	40% (6)	43% (3)	34% (422)	21% (17)
≥ 2	24% (4)	13% (10)	13% (2)	–	7% (87)	12% (10)

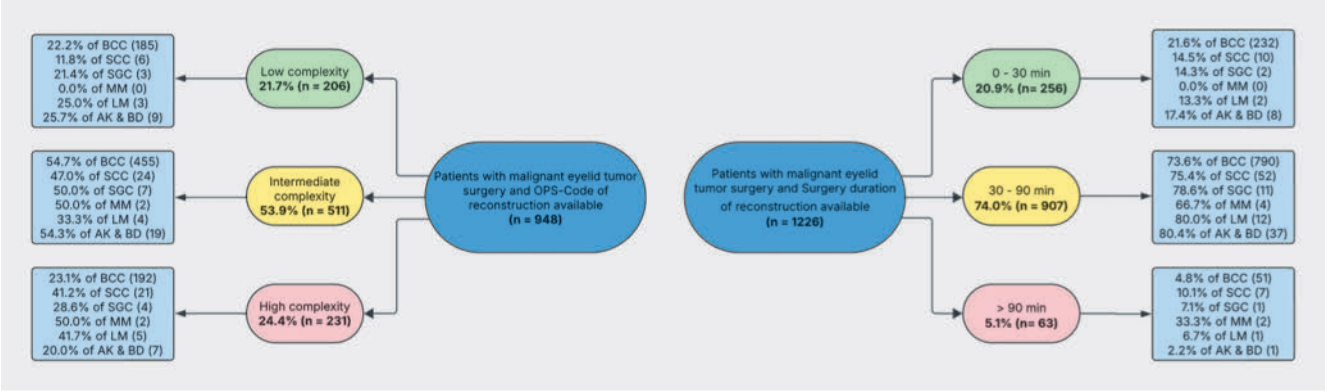
SGC: Sebaceous gland carcinoma, SCC: Squamous cell carcinoma, LM: Lentigo Maligna, MM: Malignant melanoma, BCC: Basal cell carcinoma, AK: Actinic keratosis, BD: Bowen's Disease

High-complexity interventions were primarily associated with malignant melanoma, lentigo maligna, and squamous cell carcinoma. Notably, no melanoma cases were managed with low-complexity procedures.

To evaluate chronological trends in tumor incidence, the study population was subdivided into two five-year cohorts. During the first period (2009–2013), 669 patients were treated. In the subsequent period (2014–2018), the number increased to 774. In addition to the rise in patient volume, the interval between excision and closure served as an additional indicator of disease severity. Whereas lesions such as BCC required an average of 4 days, more aggressive entities, including SCC (8 days), MM (10 days), and SGC (16 days), required substantially longer intervals due to the need for extensive margin control.

Discussion

This large retrospective analysis of consecutive 1,443 malignant eyelid tumor cases provide valuable insights into the relationship between tumor types, defect sizes, and reconstructive duration and complexity in eyelid surgery. Beyond its clinical relevance, the study highlights the substantial effort and resources required for the treatment of malignant eyelid tumors. These data are crucial for restructuring appropriate cost reimbursement strategies, particularly considering ongoing discussions around the increasing shift toward outpatient surgical care in Germany. Although the two-step surgical approach is utilized at this institution, alternative modalities for intraoperative margin control such as frozen section analysis, Mohs micrographic surgery, and reflectance confocal microscopy (e.g., Vivascope) are valid alternatives. The two-step procedure was favored because intraoperative techniques often necessitated time-consuming tissue processing, which resulted in substantial delays within the operating theater workflow [13]. Furthermore, these alternatives require the immediate and synchronized availability of specialized histopathologists or specifically trained surgeons, presenting significant logistical challenges for routine clinical management [14, 15]. From a diagnostic perspective, formal paraffin-embedded sections with hematoxylin and eosin (HE) staining remain the established gold standard for ensuring complete tumor removal [16]. Unlike frozen sections, the two-step approach facilitates complex immunohistochemical staining, which is essential for the accurate characterization and



▶ **Fig. 2** Classification of the reconstructive duration and reconstructive complexity.

▶ **Table 4** Reconstructive duration in relation to the localization and mean defect size.

	Lower Eyelid n = 831	Upper Eyelid n = 107	Nasal Canthus n = 245	Temporal Canthus n = 43	Mean defect size in mm^2
0–30 min	19% (157)	30% (32)	22% (54)	30% (13)	72 (95% CI: 49–120)
30–90 min	76% (634)	64% (69)	72% (176)	65% (28)	132 (95% CI: 88–216)
> 90 min	5% (40)	6% (6)	6% (15)	5% (2)	329 (95% CI: 216–612.5)

safety margin assessment of aggressive entities like sebaceous gland carcinoma or malignant melanoma [17, 18]. Notably, comparable large-scale data are lacking in the international literature, underscoring the importance of this study in both medical and health policy contexts. Tumors with a high risk of metastasis and recurrence, as well as those that are clinically less well-defined, require larger safety margins and consequently result in larger tumor defects [11]. This is reflected in the measured MDS values. Our findings demonstrate that MM led to the largest mean defect size (560 mm^2), followed by SGC with 187 mm^2, while more common tumors such as BCC typically resulted in smaller defects averaging 120 mm^2. These variations in defect sizes not only illustrate the differing biological behaviors of the tumor types but also correspond to the surgical principles applied in their treatment, especially in terms of ensuring adequate safety margins [10, 11].

Tumors whose etiology, malignancy, and extent are clinically and sometimes even histologically difficult to assess often require multiple surgical interventions to achieve complete tumor removal with adequate safety margins (R0 status). These factors are important parameters that impact both the complexity and cost of treatment. For example, the high re-excision rate observed for SGC at 71% likely arises from initial diagnostic challenges, as SGC frequently mimics inflammatory conditions or other tumor types [19]. Additionally, its pagetoid growth pattern hampers macroscopic delineation of tumor margins and often necessitates mapping biopsies to ensure complete excision [20]. BCC required re-excisions in 41% of cases, a notably lower rate than both SGC and SCC. This lower rate may be explained by the predominance of nodular BCC subtypes in our patient population, although this remains speculative without subtype-specific data. In contrast, the morpheaform BCC subtype typically exhibits an infiltrative growth pattern with irregular extensions, often necessitating multiple re-excisions to achieve clear margins [21]. The rise in patient volume reflects a global trend consistent with the increasing incidence of malignant eyelid tumors over the past decade [22, 23]. The severity of these malignancies is further highlighted by the prolonged intervals required for definitive reconstruction, particularly in cases of MM and SGC. The periocular region presents unique therapeutic challenges compared to other cutaneous sites. While AK and BD can typically be managed with topical agents such as 5-fluorouracil, imiquimod or diclofenac, with laser therapy or with cryotherapy in other anatomical locations, these treatment modalities are relatively contraindicated in the eyelid region due to the risk of ocular complications [24]. This anatomical limitation necessitates surgical excision for lesions that would otherwise be treated non-surgically elsewhere on the body. This surgical approach explains the relatively high re-excision rate of 33% for AK and BD in our study, a rate that would be unusual for AK in other anatomical locations where topical therapies or laser treatment would be the preferred first-line approach. However, for extensive AK or BD periocular lesions, topical treatment may be considered as an alternative therapeutic option. Several case series have demonstrated the efficacy of this approach, reporting that ocular side effects were temporary and manageable [25]. Nevertheless, careful patient selection and close monitoring remain essential when considering topical therapy in the periocular region.

The predominant localization of malignant eyelid tumors to the lower eyelid (68%) in our cohort is consistent with existing lit-

erature [26]. Notably, we found that temporal canthal lesions, despite being less common (4%), resulted in the largest mean defect sizes (200 mm^2). This is likely because most tumors of the upper and lower eyelids occur at the lid margin. Consequently, maintaining a 3 mm safety margin towards the lid margin is not feasible. At the medial canthus, a situation similar to that at the lateral canthus might be expected. However, due to the concave shape of the medial canthus compared to the convex shape of the lateral canthus, the required measurement may differ slightly, or a more extensive resection may be performed.

Our analysis of reconstructive duration reveals that most procedures (74%) can be completed within 30–90 minutes, with only 5% requiring more than 90 minutes. This finding has important implications for surgical planning and resource allocation for the reconstructive surgery. The correlation between defect size and reconstructive duration ($p < 0.001$) provides a practical metric for estimating surgical time requirements based on initial tumor assessment. The classification of reconstructive complexity showed that intermediate complexity procedures predominated (54%), suggesting that most eyelid reconstructions can be managed with established techniques like the Hughes procedure or Mustardé flap. However, the significant proportion of high-complexity cases (24%) highlights the importance of specialized surgical expertise in demanding eyelid reconstruction.

A notable strength of our study is its large sample size of 1,443 consecutive patients treated for malignant eyelid tumors, along with comprehensive documentation of surgical parameters. However, several limitations should be considered. First, the retrospective nature of the study inherently carries potential biases. Future prospective studies are warranted to further investigate the associations between tumor characteristics, surgical techniques, and long-term functional and aesthetic outcomes. Second, results regarding re-excision rates especially for the most frequent malignant eyelid tumor (BCC) are limited because we did not differentiate between tumor subtypes. This distinction is particularly relevant, as growth patterns vary significantly among subtypes [21, 27–29]. Third, our analysis includes only surgically treated cases, creating a selection bias towards operable tumors. Patients with locally advanced or metastatic disease, who may not be candidates for surgery, were not included in this analysis. These cases typically undergo interdisciplinary evaluation to consider alternative treatment approaches, such as systemic therapy (e.g., Cemiplimab for SCC, Hedgehog inhibitors for BCC) or radiation therapy [30–32]. However, such cases were rare in our clinical experience, with fewer than 10 patients requiring these alternative approaches during the study period. The use of the OPS system is associated with certain inherent limitations. The OPS nomenclature occasionally lacks the necessary granularity to describe complex periocular interventions with absolute precision, as multiple surgical sub-steps are frequently subsumed under a single, broader code. Consequently, subtle variations in surgical technique may not have been fully captured. However, this system was deliberately chosen to facilitate a standardized and reproducible categorization into broad complexity groups, thereby preventing excessive fragmentation of the data and maintaining the statistical validity of the analysis.

Conclusion

Our findings have several practical implications for surgical planning and patient counseling. First, data on tumor-specific defect size can help surgeons better predict reconstructive requirements. Second, the predominance of intermediate-duration procedures suggests that most cases can be managed within standard operating time slots. Finally, the complexity distribution supports the current practice of treating these cases in specialized centers capable of handling the full spectrum of reconstructive challenges.

CONCLUSION BOX

Already known:

- Malignant eyelid tumors are the most frequent malignancies in ophthalmology and require complete surgical excision with functional reconstruction. Reconstruction techniques vary widely, depending especially on postoperative defect size and tumor localization.

Newly described:

- Our large cohort shows that most eyelid reconstructions after tumor excision were of intermediate complexity and lasted 30–90 minutes, whereas ~ 25% required highly complex procedures.
- Potentially metastatic tumors such as melanoma and sebaceous gland carcinoma produced the largest defects and highest re-excision rates, reflecting their aggressive growth pattern and both clinical and histopathological diagnostic challenges.
- Detailed data on tumor-specific defect sizes and reconstructive workload improve preoperative planning and support individualized management of malignant eyelid tumors.

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