Oftalmologi: Jurnal Kesehatan Mata Indonesia 2026, Volume 8, Number 1.
P-ISSN. 2723-6935, E-ISSN. 2541-4283
Received: 25 November 2025; Revised: 29 April 2026; Accepted: 30 April 2026

# Innovation Meets Restoration: A Narrative Review of Recent Reconstructive Techniques in Oculoplastic Surgery

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How to Cite:
Widianty, R. S. (2026). Innovation Meets Restoration: A Narrative Review of Recent Reconstructive Techniques in Oculoplastic Surgery. *Oftalmologi: Jurnal Kesehatan Mata Indonesia*, *8*(1), 7–13. https://doi.org/10.11594/ojkmi.v8i1.98

**ABSTRACT**

**Introduction**: Oculoplastic surgery continues to evolve, yet current literature remains fragmented and lacks focused synthesis of innovation-driven periocular reconstruction. This narrative review aims to critically evaluate modern reconstructive techniques and their clinical applications.

**Methods:** A literature review was conducted using Google Scholar, PubMed, and ScienceDirect with defined search terms targeting oculoplastic reconstruction and innovation. Inclusion criteria focused on freely accessible English-language studies from 2020-2025 reporting clinical outcomes of surgical techniques. Twelve studies were selected and synthesized based on surgical approach and postoperative results.

**Results:** Reconstructive techniques were categorized into flap-based, graft-based, and technology-assisted approaches. Flap-based techniques remain the primary choice for large defects, with high success rates. Graft-based and minimally invasive techniques offer greater aesthetic flexibility. Innovations such as minced fat grafting and dermal matrix grafts demonstrated promising outcomes with low complication rates

**Conclusion:** Modern oculoplastic surgery balances restoration and aesthetics through patient-specific, technique-driven planning. Emerging technologies, biologically engineered materials, and refined flap designs continue to expand options in eyelid and periorbital reconstruction. These developments mark a clear shift toward biocompatible, minimally invasive, outcome-driven care.

**Keywords:** eyelid repair, flap design, oculoplastic surgery, periocular reconstruction, reconstructive techniques

**ABSTRAK**

**Pendahuluan:** Bedah okuloplastik terus berkembang melalui berbagai inovasi, namun literatur yang ada masih terfragmentasi dan belum secara spesifik mensintesis pendekatan rekonstruksi periokular berbasis inovasi terkini. Ulasan naratif ini bertujuan mengevaluasi secara kritis teknik rekonstruksi modern serta aplikasinya dalam praktik klinis.

**Metode:** Pencarian literatur dilakukan melalui Google Scholar, PubMed, dan ScienceDirect dengan kata kunci terkait rekonstruksi okuloplastik dan inovasi. Kriteria inklusi meliputi, studi berbahasa Inggris, akses bebas, terbit 2020–2025, dan melaporkan luaran klinis dimasukkan. Sebanyak 12 studi dianalisis berdasarkan teknik operasi dan hasil pascaoperasi.

**Hasil:** Teknik rekonstruksi meliputi flap-based, graft-based, dan teknologi. Teknik flap tetap menjadi pilihan utama pada defek besar dengan tingkat keberhasilan tinggi. Pendekatan dengan graft dan teknik minimal invasif memberikan hasil estetika yang lebih fleksibel. Inovasi seperti minced fat grafting dan dermal matrix menunjukkan hasil menjanjikan dengan komplikasi rendah.

**Kesimpulan:** Bedah okuloplastik modern mengutamakan perbaikan fungsi dan penampilan melalui perencanaan yang disesuaikan dengan pasien. Kemajuan teknologi, biomaterial, dan desain flap terus memperluas pilihan rekonstruksi, menandai pergeseran menuju teknik yang lebih aman, minimal invasif, dan berfokus pada hasil.

**Kata kunci:** bedah okuloplastik, desain flap, perbaikan kelopak mata, rekonstruksi periokular, teknik rekonstruksi

## INTRODUCTION

One of the earlier, yet significant source contributors to ophthalmology is Georg Bartisch in his work titled "Ophthalmodouleia" which includes detailed anatomical descriptions and surgical tools that, in turn, laid the basis for future development in eye surgery, despite the limitations and prejudice in his time regarding religious and magical beliefs.[1]

Since then, oculoplastic surgery has seen many innovations, such as biopolymers and functional biomaterials, have enhanced compatibility and outcomes, particularly in lacrimal system repair and orbital socket reconstruction.[2] The integration of 3D printing has further improved surgical planning, precision, and training.[3] Robotic systems like the Da Vinci Surgical System have introduced new standards of accuracy and safety, though adaptation remains limited by cost and logistical constraints.[4]

Traditional reconstructive techniques, including the Tenzel rotational flap, Hughes flap, Mustardé lid switch, and periosteal flaps, remain essential for managing large eyelid defects.[4,5] Yet, the field continues to evolve, with emerging materials, technologies, and surgical strategies redefining oculoplastic possibilities.

Given this ongoing transformation, a focused and critical synthesis of recent advancements is needed, as existing literature often lacks a dedicated analysis of innovation-driven reconstructive techniques in oculoplastic surgery. This review compiles key literature published between 2020 and 2025 to evaluate its clinical and aesthetic outcomes while highlighting emerging trends and future directions in periocular reconstruction.

## METHODS

This study was conducted as a narrative review with a structured literature search to summarize recent innovation-driven reconstructive techniques in oculoplastic surgery. Relevant literature was identified from 3 databases (Google Scholar, Science Direct and Pubmed) using the search query:

1. **Google Scholar**
   ("oculoplastic surgery" OR "periocular reconstruction") AND ("reconstructive techniques" OR "flap techniques" OR "grafting" OR "eyelid repair" OR "periorbital reconstruction") AND (innovation OR advances OR novel OR techniques)
2. **Science Direct**
   TITLE-ABSTR-KEY ("oculoplastic surgery" OR "periocular reconstruction") AND TITLE-ABSTR-KEY ("reconstructive techniques" OR "eyelid reconstruction" OR "flap techniques" OR "grafting") AND TITLE-ABSTR-KEY (innovation OR advances OR novel)
3. **Pubmed**
   ("oculoplastic surgery" [Title/Abstract] OR "periocular reconstruction" [Title/Abstract] AND ("reconstructive techniques [Title/Abstract] OR "flap surgery [Title/Abstract] OR "eyelid reconstruction" [Title/Abstract] OR "grafting" [Title/Abstract]) AND (innovation [Title/Abstract] OR novel [Title/Abstract] OR advanced [Title/Abstract])

Articles included are,

- **Inclusion**
  1. Articles in English.
  2. Articles that can be accessed freely.
  3. Articles that emphasize the usage and survival rate of certain types of oculoplastic surgery.
  4. Articles ranging from 2020-2025
- **Exclusion**
  1. Articles not in English.
  2. Articles which full text cannot be accessed freely.

3. Literature Review, Systematic Review, Meta-Analyses, and other types of non-research articles.
4. Articles that emphasize non-surgical approaches to ocular problems and theoretical breakthroughs.

The initial search identified approximately 85 articles. After removing duplicates, the articles were screened based on their titles and abstracts, followed by a full-text assessment to confirm eligibility according to the inclusion and exclusion criteria. A total of 12 studies were included in the final synthesis.

Data from the included studies were synthesized descriptively and grouped according to the reconstructive approach, including flap-based techniques, graft-based techniques, and technology-assisted interventions.

As this study is a narrative review, formal systematic review frameworks such as PRISMA, risk of bias assessment, and meta-analysis were not applied, and the findings are presented as a qualitative synthesis of current evidence.

## RESULT

Based on the search criteria, 12 articles were deemed suitable. Those articles are presented in the table below, highlighting the surgical technique involved, technique type and the outcomes of those techniques.

A total of 12 studies were included in this review, representing a range of reconstructive approaches in oculoplastic surgery. These techniques were categorized into flap-based, graft-based, and technology-assisted interventions, as summarized in Table 1. Overall, most studies reported favorable functional and aesthetic outcomes, with high success rates and low complication profiles across different reconstructive strategies.

**Table 1. Study Synthesis**

| Author & Year | Title | Surgical Technique | Technique Type | Treatment Outcome |
|---|---|---|---|---|
| McDonald et al., 2024 | Free Bilamellar Autograft (FBA) | Full-thickness eyelid graft without vascular supply | Flap-based | Anatomical and cosmetic success in large eyelid defects |
| Mori et al., 2020 | Myocutaneous Flap for Upper Lid Reconstruction | Lower eyelid orbicularis oculi flap | Flap-based | High aesthetic-functional outcome, with no recurrence after 12 months |
| Ang et al., 2022 | Paramedian Forehead Flap in Periocular Reconstruction | Rotational PMFF | Flap-based | Reliable coverage of complex defects, with minor complications |
| Kubo, 2024 | Modified Transconjunctival Blepharoplasty | Fat repositioning via transconjunctival approach | Graft-based | Improved lid contour and symmetry |
| Chen et al., 2020 | Modified Hughes Flap Above Tarsus | Flap reconstruction above tarsus for retraction repair | Flap-based | Effective in refractory cicatricial lower lid retraction |
| Balchev et al., 2022 | V-Y Glabellar Advancement Flap | V-Y rotation flap ± skin graft | Flap-based | Successful repair of medial periorbital defects |

| | | | | |
|---|---|---|---|---|
| Karimi et al., 2024 | Fat Flap vs Minced Graft in Blepharoplasty | Pedicle fat flap vs minced fat graft under TCLB | Graft-based | Both effective; the minced graft offers easier shaping and volume control |
| Zhong et al., 2023 | Propeller Flap for Eyelid Defect | Subcutaneous pedicled propeller flap | Flap-based | High flap survival and aesthetic satisfaction |
| Chaiyasate et al., 2024 | RFFF for Complex Periorbital Defects | Radial Forearm Free Flap (RFFF) | Flap-based | Customizable, reliable, complete eyelid closure with minimal complications |
| Barbi et al., 2020 | Scalpel vs Wavetronic in Blepharoplasty | Conventional scalpel vs radiofrequency incision | Technology -assisted | Wavetronic led to thinner scars at 30 days; both were equal in pigmentation & vascularity |
| Blumenthal et al., 2023 | Periosteal Flap in MMS Reconstruction | Periosteal flap after Mohs surgery | Flap-based | Good cosmetic results and low complication rates in tumor-related eyelid defects |
| Custer & Maamari, 2020 | Porcine Dermal Matrix Sandwich Graft | Acellular dermal matrix between skin & conjunctival flap | Graft-based | Stable contour with minimal complications |

Flap-based techniques were the most frequently reported approach, particularly for large or full-thickness periocular defects. The majority of studies demonstrated high flap survival rates and reliable functional outcomes. Techniques such as Free Bilamellar Autograft (FBA), Hughes flap modification, V-Y glabellar advancement flap, propeller flap, radial forearm free flap (RFFF), and periosteal flap provided strong structural support and adequate vascularization. For example, FBA offered a robust solution for full-thickness eyelid defects without the need for vascular pedicles. Similarly, the lower eyelid orbicularis oculi myocutaneous flap for upper eyelid reconstruction.[7,8] Aditionally, PMFF and RFFF were especially effective in complex reconstructions, including traumatic and oncologic cases.[9,10] Similarly, modified Hughes flap techniques showed effectiveness in managing cicatricial lid retraction with reduced recurrence. However, some studies noted potential limitations, including donor-site morbidity and contour irregularities in certain cases.[11,12]

Graft-based approaches, including fat grafting and dermal matrix applications, were associated with improved contour adaptability and aesthetic refinement. Several studies have reported that minced fat grafting provides greater flexibility and ease of placement compared with pedicled fat flaps in volume restoration procedures.[13,14] Additionally, the use of acellular dermal matrix in sandwich graft techniques demonstrated favorable structural integrity and a stable postoperative eyelid contour with minimal complications. These approaches were particularly useful for correcting volume deficiencies and enhancing periocular symmetry, although they may offer less structural support in extensive defects.

Technology-assisted techniques demonstrated promising outcomes in improving surgical precision and postoperative healing. Comparative

studies between conventional scalpel methods and radiofrequency-assisted incisions showed reduced scar thickness with comparable pigmentation and vascular outcomes. These findings highlight the potential role of advanced surgical tools in optimizing periocular reconstruction while minimizing tissue trauma.[15-17]

Collectively, the included studies demonstrate a shift toward biocompatibility, minimally invasive approaches, and individualized surgical planning in oculoplastic reconstruction. Flap-based techniques remain the foundation for structurally demanding cases, while graft-based and technology-assisted methods serve as valuable adjuncts in enhancing aesthetic outcomes and surgical flexibility. These innovations are particularly relevant in the periocular region, where functional restoration and cosmetic considerations are closely interconnected.

## DISCUSSION

This review of twelve reconstructive techniques in oculoplastic surgery highlights the evolution of periocular reconstruction, emphasizing the balance between function, aesthetics, and innovation. Overall, the reviewed methods demonstrated high flap survival, satisfactory anatomical outcomes, and improved contour restoration, though key limitations remain in standardization and accessibility.

From a clinical perspective, the selection of a reconstructive technique should be guided by defect characteristics and patient-specific factors. For large or full-thickness eyelid defects, techniques such as the FBA and PMFF provide reliable structural support but may be associated with contour irregularities or donor-site morbidity. In contrast, less invasive approaches such as transconjunctival blepharoplasty or minced fat grafting offer excellent cosmetic outcomes for smaller corrections, although they provide limited structural support. This highlights a fundamental trade-off between structural reliability and aesthetic flexibility in oculoplastic reconstruction.

Another important consideration is the balance between innovation and accessibility. Techniques involving advanced equipment, such as radiofrequency-assisted incisions or porcine dermal matrix grafts, offer improved healing and tissue integration but may be limited to high-resource settings. In contrast, traditional techniques such as the Hughes flap or glabellar advancement remain dependable and widely applicable, particularly in resource-limited environments.

The current literature also reveals a significant evidence gap. Most included studies were case series or retrospective in design, with subjective outcome measures and limited long-term follow-up. The absence of standardized functional and aesthetic scoring systems limits the ability to directly compare outcomes across different techniques. Therefore, prospective, multicenter studies with standardized evaluation tools are needed to strengthen the evidence base in oculoplastic reconstruction.

Looking forward, three major innovations, such as 3D bioprinting, artificial intelligence (AI), and augmented/virtual reality (AR/VR), are poised to redefine oculoplastic surgery. 3D bioprinting technologies, such as those described by Wu et al., offer patient-specific orbital implants and tissue scaffolds with high anatomical precision.[18,19] While current applications are mostly experimental, future improvements in vascularization, mechanical fidelity, and in vivo integration could allow personalized, biocompatible eyelid reconstruction with reduced donor-site morbidity.

In parallel, AI-driven tools are emerging for periocular diagnostics and surgical planning. Neural network-based systems have shown high accuracy in eyelid contour measurement and morphological analysis, with future applications extending into flap design optimization and intraoperative guidance.[20] However, challenges remain in training these models on diverse datasets and ensuring transparency and safety in clinical use.

AR and VR are also gaining attention for their role in surgical simulation and anatomical mapping. Ong et al. reported promising applications of extended reality in ophthalmology, particularly in educational and preoperative planning contexts. Their adoption in oculoplastics could support better visualization of complex defect geometry and flap orientation during surgery, though clinical evidence remains early-stage.[21]

Despite these opportunities, equitable integration remains a challenge. Access to advanced technologies is often limited by cost and infrastructure, particularly in low-to-middle-income settings. Ethical concerns regarding AI transparency, patient data use, and animal-derived biomaterials (e.g., porcine matrices) must also be addressed to ensure responsible innovation.

### Clinical Implications

In clinical practice, reconstructive planning should be individualized based on defect size, location, tissue availability, and patient expectations. Flap-based techniques remain essential for achieving structural integrity in extensive defects, while graft-based and minimally invasive approaches are valuable for optimizing aesthetic outcomes in selected cases.

### Limitations

This narrative review has several limitations, including a relatively small number of included studies and the heterogeneity of study designs. Additionally, as a narrative review, formal systematic evaluation methods such as risk of bias assessment were not performed, which may introduce selection bias.

## CONCLUSION

In summary, while current reconstructive techniques continue to offer reliable outcomes, the field is moving toward a future defined by patient-specific design, technology-enhanced precision, and biocompatible materials. Careful validation, multidisciplinary collaboration, and ethical implementation will be key to ensuring these innovations translate into meaningful improvements in oculoplastic care.

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