APPLICATION OF HYPERBARIC OXYGEN THERAPY IN AESTHETIC SURGERY AND COSMETOLOGY: CURRENT STATE OF THE ISSUE, CLINICAL OUTCOMES, AND PROSPECTS

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Abstract Hyperbaric oxygen therapy (HBOT), the administration of 100% oxygen under elevated atmospheric pressure in a hyperbaric chamber, has gained growing attention in aesthetic surgery and cosmetology. Its applications range from the prevention and management of ischemic complications in skin flaps and grafts to the treatment of necrosis following hyaluronic acid (HA) filler injections and the enhancement of postoperative recovery after aesthetic procedures. Despite promising clinical use, the quality of supporting evidence remains heterogeneous, with many protocols extrapolated from general surgery. This review aims to systematically evaluate current evidence on the efficacy, safety, and practical application of HBOT in aesthetic medicine, highlighting validated indications and identifying key knowledge gaps. A targeted literature search was performed across PubMed/MEDLINE, Cochrane Library, and relevant specialty journals (2000–2025), focusing on clinical studies, professional guidelines (e.g., UHMS), and case series in aesthetic surgery and dermatologic cosmetology. The strongest aesthetic indications for HBOT include: (1) salvage of compromised skin flaps and grafts (e.g., post-facelift, rhinoplasty, or oncoplastic procedures), supported by extrapolated and retrospective data; (2) adjunctive treatment of ischemia and necrosis after HA filler injections, with emerging support from $TcPO_2$-guided protocols; (3) accelerated recovery after rhytidectomy, with case-control and retrospective studies reporting reduced healing time and fewer complications; (4) possible reduction in keloid recurrence due to HBOT's immunomodulatory effects, based on limited data; (5) supportive role in autologous fat graft survival, though further validation is needed. HBOT should not be regarded as a standalone solution but rather as a valuable adjunct when initiated promptly and integrated with standard interventions (e.g., hyaluronidase, surgical revision). Further high-quality randomized trials, protocol standardization, and cost-effectiveness studies are necessary to establish its routine role in aesthetic practice.

Keywords: hyperbaric oxygen therapy; aesthetic surgery; cosmetology; skin flaps; hyaluronic acid fillers; skin ischaemia/necrosis; facelift; keloids; autologous fat grafting.

INTRODUCTION: WHY "MORE OXYGEN" IS NOT ALWAYS "BETTER", BUT "TIMELY" IS CRUCIAL

Aesthetic surgery operates at the intersection of art and science. The surgeon must not only restore form but also preserve natural tissue function. Patients expect minimal invasiveness, rapid rehabilitation, and predictable, stable long-term results. Even minor disturbances of microcirculation – whether from oedema, vasospasm, thrombosis, or mechanical compression – can trigger a cascade of complications: prolonged healing, hypertrophic scarring, hyperpigmentation, or frank necrosis.

Hyperbaric oxygen therapy (HBOT) addresses several pathogenic pathways simultaneously: it enhances tissue oxygenation, mitigates reperfusion injury, modulates leukocyte adhesion, activates nitric oxide signalling, and promotes angiogenesis. When protocols are followed correctly, the method remains relatively safe [1,2].

Professional societies such as the Undersea and Hyperbaric Medical Society (UHMS) officially list “compromised skin flaps and grafts” among approved indications, while emphasising that well-vascularised flaps do not require additional oxygenation. The benefit emerges precisely when tissue viability is threatened. In aesthetic surgery, therefore, HBOT is not intended to “accelerate healing of every scratch” but serves as a salvage tool for tissues on the brink of failure, where any error may result in visible scarring, revision surgery, and patient dissatisfaction [1,4].

METHODS

A thematic search of publications from 2000 to 2025 was performed using key terms in Russian and English related to hyperbaric oxygen therapy, aesthetic surgery, cosmetology, skin flaps, hyaluronic acid fillers, skin ischaemia/necrosis, facelift, keloids, and autologous fat grafting. Eligible sources included clinical studies of any design, systematic and narrative reviews, professional-society guidelines, and relevant animal research. Because of the scarcity and heterogeneity of data, a narrative synthesis with emphasis on practical implications and clinical examples was chosen [2,3].

Mechanisms of Action and Protocols

HBOT effectively “reboots” hypoxic tissues. Breathing 100% oxygen at 2–2.5 ATA dramatically increases plasma-dissolved oxygen, raising PaO_2 above 1000 mmHg. Oxygen then diffuses into poorly perfused areas independently of erythrocyte delivery.

Additional mechanisms include:

1. Vasoconstriction without tissue hypoxia – reducing oedema while maintaining oxygen delivery via hyperoxygenated plasma;
2. Attenuation of reperfusion injury by limiting reactive oxygen species damage;
3. Stimulation of regeneration through fibroblast activation, collagen synthesis, and VEGF-mediated angiogenesis;
4. Immunomodulation and enhanced bactericidal activity of neutrophils and macrophages [1,2].

Standard regimens recommend 2.0–2.5 ATA for 60–90 minutes, with 2–3 sessions in the first 24 hours followed by once- or twice-daily treatments for approximately one week. Early initiation – ideally within hours of surgery or complication onset – is critical. In filler-related vascular compromise, similar pressures (2.0–2.4 ATA, 90 minutes) are used for 5–10 sessions alongside standard care [1,4].

Although “mild” HBOT protocols (1.5–2.0 ATA) are not yet systematically evaluated in aesthetic contexts, clinical experience and expert opinion suggest retained efficacy with a lower side-effect profile and greater accessibility.

Areas of Strongest Evidence: Key Clinical Applications

1. **Compromised skin flaps and grafts** Contemporary studies and UHMS guidelines confirm that HBOT increases flap/graft survival, reduces necrotic area, and limits reperfusion injury [1,4]. In facelift surgery, retrospective and case-control studies show faster recovery and fewer complications in HBOT-treated patients [5–7]. Similar benefits are reported in rhinoplasty and oncoplastic breast surgery, with logical extrapolation to aesthetic mammaplasty [8–10].
2. **Vascular complications of hyaluronic acid fillers** Hyaluronidase remains the cornerstone of treatment. HBOT serves as an adjunct by improving oxygen diffusion into ischaemic zones and mitigating reperfusion injury. Case series demonstrate improved skin colour, reduced pain, and faster resolution [11–13]. Emerging $TcPO_2$-guided protocols allow selective HBOT administration to patients at genuine risk of necrosis.
3. **Post-facelift recovery** Beyond necrosis prevention, HBOT reduces early postoperative oedema and haematoma through vasoconstriction and anti-inflammatory effects. Available evidence is promising but awaits confirmation by prospective RCTs [5,7].
4. **Keloids and pathological scarring** Limited studies suggest HBOT lowers pro-inflammatory mediators and may reduce recurrence after excision, particularly when combined with radiotherapy [14–16].
5. **Autologous fat grafting** Preliminary data indicate improved graft vascularisation and volume retention, with increased VEGF and CD31 expression in animal models. Earlier controversial reports have been retracted; only recent, high-quality studies should guide practice [17].

Safety and Contraindications

The only absolute contraindication is untreated pneumothorax. Claustrophobia, Eustachian tube dysfunction, active sinopulmonary infection, and seizure disorders are relative contraindications, especially with mild protocols. Common side effects (barotrauma of the middle ear or sinuses, transient myopia, headache) are mild and self-limiting. Serious complications (oxygen convulsions, pulmonary oxygen toxicity) are exceedingly rare at therapeutic pressures and durations [18–22].

Practical Integration Algorithms

- **Routine rehabilitation without ischaemia**: optional "wellness" regimen (≤2.0 ATA, 60–90 min, 3–5 sessions) to reduce oedema and accelerate recovery.
- **Filler-induced arterial occlusion**: immediate high-dose hyaluronidase + standard measures; add HBOT (2.0–2.4 ATA, 90 min, 5–10 sessions).
- **Threatened flap necrosis (facelift/rhinoplasty)**: address mechanical causes first, then intensive HBOT (2–3 sessions in first 24 h, then 1–2 daily).
- **Keloids**: adjunctive HBOT after excision, especially with radiotherapy.
- **Fat grafting**: currently experimental; use only within research protocols.

DISCUSSION: LIMITS OF EVIDENCE

While physiology and experience from other fields strongly support HBOT in hypoxic conditions, aesthetic surgery data remain dominated by retrospective series and case reports. Prospective RCTs with objective endpoints (epithelialisation rate, necrotic area, revision rate, oedema volume, patient satisfaction) are urgently needed [5–7]. Marketing misuse of "oxygen facials" or low-pressure chambers must be distinguished from true HBOT.

Future Directions

1. Personalisation using $TcPO_2$ monitoring.
2. Combination with PRP and cellular therapies.
3. Standardised protocols and multidisciplinary training.
4. Cost-effectiveness studies (noting that HBOT session costs, especially in mild regimens, are modest compared with aesthetic procedures themselves).

CONCLUSION

Hyperbaric oxygen therapy is not a panacea but a powerful adjunct that, when initiated early and used correctly, preserves tissue viability, reduces complications, and accelerates rehabilitation after aesthetic surgical and cosmetological procedures, thereby significantly enhancing cosmetic outcomes. Optimal results are achieved with standard regimens (2.0–2.5 ATA, 60–90 min), although milder protocols (1.5–2.0 ATA) also appear effective. The method is safe when contraindications and compression/decompression techniques are respected. Wider adoption in aesthetic surgery and cosmetology is highly promising but requires high-quality RCTs, protocol standardisation, and objective perfusion-guided personalisation.

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