Review Article

Advanced on Minimally Invasive Techniques in Facial Rejuvenation: A Comprehensive Review

Amir Hossein Alaviyan[1*]

1. Department of General Surgery, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran

ABSTRACT

Contemporary cosmetic surgical approaches to facial rejuvenation have undergone a significant transformation due to the integration of new technologies aimed at addressing age-related facial changes. Among the most commonly used minimally invasive techniques are neuromuscular blocking agents and injectable fillers. The scope of minimally invasive procedures encompasses a broad range of modalities, including nutritional and hormonal interventions, light- and laser-based therapies, minimal-incision surgeries, as well as botulinum toxin and dermal filler injections. This study specifically focuses on injectable techniques for facial rejuvenation. Botulinum toxin type A has demonstrated efficacy in softening hyper functional lines in both the upper and lower face, with notable improvements observed in areas such as the glabella, forehead, periorbital region, lips, and platysma muscle. More recently, hyaluronic acid and other injectable fillers have gained widespread use. These temporary fillers effectively diminish wrinkles and creases, enhance deep nasolabial folds, augment thin lips, and correct volume loss in periorbital hollows and other facial depressions or contour irregularities. A major paradigm shift has occurred in facial rejuvenation, with injectable, minimally invasive methods now offering solutions for age-related and acquired deformities of the head and neck—providing temporary yet effective corrections that were historically managed through more invasive surgical approaches.

KEYWORDS

Plastic surgery: Minimally Invasion: Facial rejuvenation: Injection procedure

Please cite this paper as:
Alaviyan AH. Advanced on Minimally Invasive Techniques in Facial Rejuvenation: A Comprehensive Review. World J Plast Surg. 2025;14(3):1-6.
doi: 10.61186/wjps.14.3.**

***Corresponding Author:**

Dr. Amirhossein Alaviyan,

Department of General Surgery, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran

Email:
amirhosseinalavian41@gmail.com
dralaviyan@gmail.com

Received: ***
Accepted: ***

INTRODUCTION

Facial aging has become an increasing concern in modern society. This complex process involves two primary factors: progressive loss of facial volume and repetitive muscular contractions that lead to the formation of wrinkles and folds[1].

Historically, facial rejuvenation relied heavily on dermatologic procedures such as CO_2 laser resurfacing, microdermabrasion, and electrical stimulation to stimulate collagen production in dermal fibroblasts. The traditional approach centered on modifying the dermal layers to counteract aging effects [2]. Conventional surgical techniques typically involved tissue excision and two-dimensional

repositioning—tightening the skin primarily in horizontal and vertical planes—without adequately addressing underlying volume loss. Consequently, skin tightening alone could sometimes result in an unnatural or aged appearance.

The ideal outcome now emphasizes smooth, firm, and well-hydrated skin, achieved through the injection of fully absorbable, biocompatible substances into the superficial dermis [3]. Mesotherapy injections promote skin rejuvenation by enhancing both hydration and fibroblast activity. Additionally, it is well established that antioxidants can mitigate signs of aging. One of the most widely studied theories posits that aging results from oxidative stress, which damages proteins, DNA, and lipids. In recent years, plastic surgery has experienced a transformative evolution, marked by a decisive shift toward minimally invasive techniques [4]. These innovations have revolutionized aesthetic practice by offering patients safer, more efficient, and less invasive alternatives to achieve their cosmetic goals. Minimally invasive procedures have surged in popularity due to their ability to reduce scarring, minimize postoperative discomfort, and accelerate recovery[5]. In contrast to traditional open surgeries—which often require large incisions, extensive tissue manipulation, and prolonged healing—minimally invasive methods utilize smaller access points, specialized instruments, and advanced technologies to deliver optimal aesthetic results with minimal disruption to natural anatomy[5].

This study aimed to explore recent advancements in minimally invasive techniques for facial rejuvenation.

Injectables (Botulinum Toxin and Dermal Fillers)

Injectable treatments—primarily botulinum toxin and dermal fillers such as hyaluronic acid (HA), calcium hydroxyapatite (CaHA), and poly-L-lactic acid (PLLA)—continue to serve as cornerstones of non-surgical facial rejuvenation. Botulinum toxin has consistently demonstrated short-term efficacy in softening dynamic wrinkles and expression lines. Experts have also highlighted its utility in refining facial pore appearance and managing conditions like masseter muscle hypertrophy and gummy smile [6].

In addition, newer filler materials—including PLLA, polycaprolactone (PCL), and polymethylmethacrylate (PMMA) formulated as hydrogels—have attracted interest for their capacity to restore volume, stimulate collagen production through bioactive matrices, and achieve high patient satisfaction. However, their long-term safety and effectiveness warrant further clinical investigation[7]. In contrast, combining HA with CaHA has yielded encouraging outcomes in facial rejuvenation, offering both immediate sustained collagen stimulation, along with favorable tolerability, high patient satisfaction, and only minor adverse effects such as pain, swelling, nodules, or localized inflammation [8].

Notably, the synergistic application of botulinum toxin alongside dermal fillers appears to enhance overall results, particularly in addressing dynamic wrinkles and masseteric hypertrophy, with improved patient satisfaction. When used in conjunction with Profhilo—a stabilized HA-based gel—evidence suggests superior and safer outcomes in neck rejuvenation. However, caution is advised in patients with pre-existing conditions such as muscular weakness, joint instability, or spinal curvature, as these may be exacerbated [9]. Despite its advantages, this combined approach remains temporary, carries risks of asymmetry, bruising (ecchymosis), ptosis, or headache, and can be costly. Rare but serious complications—including dysphagia, facial nerve paralysis, systemic botulism, and even death—have been documented, underscoring the critical need for ongoing research to refine techniques and enhance patient safety [10].

When choosing a filler, clinicians must evaluate key factors such as rheological properties, target tissue depth, and individual anatomical variations. HA fillers offer distinct benefits, particularly their reversibility with hyaluronidase, making them a safer option for less experienced injectors. Non-HA fillers, while associated with higher risks, may be preferred when longer-lasting results are desired [11]. Differentiating between biphasic HA fillers—which provide robust volumizing effects but are less moldable—and monophasic HA fillers—which exhibit greater cohesiveness, softness, and adaptability—along with assessing viscoelastic characteristics, enables more precise, individualized treatment planning [12].

Clinically, HA fillers have proven highly effective for midface volumization, tear trough correction, and lip augmentation. Additionally, HA-based "skin boosters" have gained popularity for improving

skin hydration and elasticity, meeting the growing demand for subtle, natural-looking enhancements. Nevertheless, serious complications—including vascular occlusion, vision loss, and immune-mediated reactions—have been reported, emphasizing the necessity of thorough patient assessment and in-depth anatomical knowledge [12].

Currently, HA fillers remain the most widely utilized injectables, especially for correcting nasolabial folds. Their favorable safety profile is further supported by the availability of hyaluronidase for prompt reversal of complications. Common, self-limiting side effects include pain, redness (erythema), swelling (edema), and transient nodules. However, moderate to severe adverse events—such as infection, filler migration, and vascular compromise—can occur. Treatment outcomes are influenced by multiple variables, including injector expertise, product characteristics, injection technique, and patient-specific factors [13]. Furthermore, a dual-plane injection technique using HA has been described for acne scar revision, targeting both dermal and subdermal scar components to achieve structural remodeling [14].

To support standardized clinical practice, a panel of experts has developed a consensus framework simplifying the use of the Restylane family of HA fillers. This guidance aligns product selection with specific facial regions, outlines exceptions, and recommends optimal injection techniques—aiming to harmonize clinical approaches, enhance reproducibility, and improve decision-making in aesthetic practice [15].

Bio-Stimulatory and Regenerative Therapies

Bio-stimulatory fillers—including calcium hydroxyapatite (CaHA), poly-L-lactic acid (PLLA), and polymethylmethacrylate (PMMA)—deliver longer-lasting aesthetic improvements by promoting endogenous collagen synthesis. CaHA, in particular, serves a dual function: offering immediate volumetric correction and delayed regenerative benefits through neocollagenesis[16]

Biostimulatory agents such as PLLA, CaHA, platelet-rich plasma (PRP), and platelet-rich fibrin (PRF) have demonstrated positive effects in localized facial rejuvenation by enhancing collagen production. Their clinical outcomes depend on factors including the specific agent subtype, delivery technique, and use of adjunctive therapies. However, current evidence remains inconsistent, with no standardized protocols for preparation, administration, or objective assessment of results—highlighting the need for further validation through rigorous studies[17].

In facial rejuvenation, PLLA has emerged as a safe alternative—comparable to hyaluronic acid (HA) and collagen-based fillers—with proven efficacy in improving skin texture, firmness, and elasticity, and consistently high patient satisfaction rates. To mitigate potential adverse effects, various strategies have been proposed, including optimized dilution protocols, adequate hydration periods prior to injection, and refined administration techniques. Despite these advances, the heterogeneity of existing studies underscores the necessity for long-term clinical trials to confirm safety, assess durability, and explore novel formulations [18].

CaHA also holds specific utility in hand rejuvenation, where innovative dilution or hyperdilution techniques have yielded favorable aesthetic outcomes. Furthermore, combining biostimulators with botulinum toxin, dermal fillers, and energy-based devices appears to produce synergistic enhancements in skin laxity and wrinkle reduction. At the cellular level, these combinations are thought to amplify fibroblast activity through distinct mechanisms: CaHA activates transforming growth factor-beta (TGF-β) and macrophages; PLLA stimulates collagen via lactic acid degradation; and HA fillers engage CD44-MAPK signaling pathways, further potentiated by hydration. These regenerative processes are augmented when paired with controlled thermal or mechanical injury induced by energy-based modalities such as high-intensity focused ultrasound (HIFU), radiofrequency (RF) microneedling, and intense pulsed light (IPL). Additionally, botulinum toxin type A contributes by reducing dermal tension and stabilizing collagen remodeling. Despite the promise of these multimodal approaches, robust clinical evidence is still needed to validate efficacy, standardize treatment protocols, and establish long-term safety profiles [19].

Although common side effects like erythema and localized edema are typically transient, experts caution that rare but significant complications—such as granulomatous inflammation and nodule formation—can occur with biostimulatory agents. Standardized management guidelines for such adverse events remain essential [12].

Meanwhile, polynucleotides (PNs) and PRP have garnered increasing interest for their ability to enhance skin elasticity, tone, and texture, particularly in sensitive regions like the periorbital area, where they effectively reduce fine lines[20].

Polynucleotides stand out as naturally derived agents that promote tissue regeneration, hydration, collagen synthesis, and overall skin quality with sustained effects. Their safety profile appears superior to that of HA fillers and collagen-stimulating products. Compared to PRP or PRF, PNs also offer practical advantages, including lower cost, shorter procedural time, and reduced dependence on operator technique [20].

Similarly, PRP therapy has shown encouraging results in treating female hair loss conditions such as androgenetic alopecia, telogen effluvium, and female pattern hair loss. Its mechanism involves the release of growth factors—including platelet-derived growth factor (PDGF) and vascular endothelial growth factor (VEGF)—which activate stem cells and promote angiogenesis. As an autologous, biocompatible treatment, PRP carries a favorable safety record. However, significant variability exists in preparation methods, centrifugation protocols, and external influencing factors. Therefore, further long-term studies are needed to clarify its efficacy, durability, and potential synergies with other therapies. Among available preparation techniques, the single-spin centrifugation method has demonstrated superior clinical outcomes[21].

Mechanical Lifting (Thread Lifting)

Thread lifting using biodegradable materials such as PLLA, PCL, or polydioxanone (PDO) offers a minimally invasive approach to correct surface irregularities, fine lines, and volume loss. Beyond lifting, these threads also enhance skin texture and firmness, granting clinicians improved precision in tissue repositioning and contouring [22].

PDO threads, in particular, are regarded as a promising technique in non-surgical facial rejuvenation. However, robust clinical data remain limited regarding their performance across diverse populations, skin types (Fitzpatrick phototypes), and comparative safety and efficacy profiles among different thread variants—including spiculated versus monofilament designs and materials such as PDO, PLLA, and PCL [22].

Complication rates associated with thread lifting are influenced by multiple factors: thread material, fixation mechanism, surface texture, and anatomical placement. In terms of material, PCL has been linked to increased tissue sensitivity and bruising (ecchymosis), whereas PDO tends to provoke less inflammatory response but carries a relatively higher risk of infection. PLLA demonstrates an intermediate safety profile between the two. Regarding thread design, barbed threads—most commonly made of PDO—are associated with higher incidences of erythema, ecchymosis, tenderness, and infection compared to smooth threads. Conversely, smooth threads, due to their greater mobility within tissue, are more frequently linked to inflammation, redness, and bruising. Anatomical location further modulates risk: placement in the midface—characterized by thinner skin and rich vascularization—often results in more pronounced inflammation, ecchymosis, and sensitivity. In contrast, use along the jawline, in proximity to branches of the trigeminal nerve and dense salivary gland tissue, increases the likelihood of paresthesia and infection. Collectively, these risks emphasize the critical importance of operator expertise, thorough anatomical knowledge, and diligent post-procedural monitoring [23].

Laser Treatments

Recent advancements in laser technology have significantly expanded the repertoire of minimally invasive options available to plastic surgeons. Lasers have demonstrated high efficacy in addressing a variety of aesthetic concerns, including skin rejuvenation, scar revision, and hair removal [24]. For example, fractional laser resurfacing promotes collagen remodeling and enhances skin texture, effectively diminishing the appearance of wrinkles and scars. The precision and adaptability of laser systems make them indispensable in modern aesthetic practice [25]. By fine-tuning parameters such as wavelength and energy intensity, clinicians can selectively target specific tissues while sparing surrounding structures. Another widely used application, laser lipolysis, employs laser energy to melt and eliminate localized fat deposits, enabling refined body contouring with minimal scarring. Importantly, laser platforms can be customized to accommodate different skin types and clinical conditions, broadening their applicability across diverse patient populations [2].

Fat Transfer

Fat transfer—also referred to as fat grafting or lipofilling—involves the extraction of adipose tissue from a donor site on the patient's body and its subsequent reinjection into areas requiring volume restoration or contour enhancement[26]. This technique has undergone substantial refinement in recent years, with optimized protocols for fat harvesting, processing, and delivery [27]. Innovations such as microfat and nanofat grafting enable more accurate placement of adipocytes, leading to improved graft take, enhanced tissue integration, and more durable outcomes. Fat transfer is now routinely employed in facial rejuvenation, as well as in augmentation procedures for the breasts and buttocks [28].

Scarless Surgery

Progress in minimally invasive surgical approaches has paved the way for scarless or nearly scarless interventions. A notable example is transoral endoscopic surgery, which grants surgeons access to internal anatomical structures through the oral cavity, thereby avoiding external incisions and eliminating visible scarring [29]. These scarless techniques not only deliver excellent functional results but also offer superior cosmetic outcomes, helping patients avoid the psychological burden often associated with postoperative scars [30].

CONCLUSION

As aesthetic medicine continues to evolve, this comprehensive review underscores the increasing clinical relevance of nonsurgical and minimally invasive techniques in facial rejuvenation. The transition from conventional surgical methods to less invasive modalities mirrors a wider trend shaped by patient preferences for safer procedures, shorter recovery periods, and outcomes that appear natural. Nevertheless, these approaches are not devoid of limitations. The review highlights a range of potential adverse events and stresses the critical role of thorough anatomical understanding and individualized risk assessment in clinical decision-making. Furthermore, the evidence supports the strategic combination of therapies to achieve comprehensive, multidimensional rejuvenation. Consequently, future research should prioritize well-structured randomized controlled trials and long-term longitudinal studies that assess not only treatment efficacy but also sustained safety profiles, patient-reported satisfaction, and cost-effectiveness across diverse populations and skin types.

ACKNOWLEDGMENTS

No financial support was revived for this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

REFERENCES

1. Swift A, Liew S, Weinkle S, Garcia JK, Silberberg MB. The Facial Aging Process From the "Inside Out". *Aesthet Surg J* 2021 Sep 14;**41**(10):1107-19.
2. Loesch MM, Somani AK, Kingsley MM, Travers JB, Spandau DF. Skin resurfacing procedures: new and emerging options. *Clin Cosmet Investig Dermatol* 2014;**7**:231-41.
3. Firat M. Endoscopic Deep Plane Facelift: A Classified Approach. *Aesthet Surg J* 2025 Sep 16;**45**(10):989-1001.
4. El-Domyati M, El-Ammawi TS, Moawad O, et al. Efficacy of mesotherapy in facial rejuvenation: a histological and immunohistochemical evaluation. *Int J Dermatol* 2012 Aug;**51**(8):913-9.
5. Shridharani SM, Palm MD, Jarmuz T, et al. Optimizing Aesthetic Facial Surgery Outcomes Following Minimally Invasive Treatments: Guidelines for Perioperative Management. *Aesthet Surg J Open Forum* 2025;**7**:ojaf087.
6. Lorenc ZP, Daro-Kaftan E. Optimizing facial rejuvenation outcomes by combining poly-L-lactic acid, hyaluronic acid, calcium hydroxylapatite, and neurotoxins: two case studies. *J Drugs Dermatol* 2014 Feb;**13**(2):191-5.
7. Ouyang R, Su X, Liang Y, et al. Advances in Poly-l-lactic Acid Injections for Facial and Neck Rejuvenation. *Plast Reconstr Surg Glob Open* 2025 Aug;**13**(8):e7029.
8. Ruiz-de-León G, Cortés-Eslava D, Hernández-Pacheco E, Serrera-Figallo M-Á, Torres-Lagares D, Baus-Domínguez M. Biopolymers in Facial Aesthetics: Gel-Based Applications, Safety, Effectiveness, and Future Prospects—A Systematic Review of the Literature. *Gels* 2025;**11**(6):455.
9. Kundu N, Kothari R, Shah N, et al. Efficacy of botulinum toxin in masseter muscle hypertrophy

for lower face contouring. *J Cosmet Dermatol* 2022 May;**21**(5):1849-56.
10. Bessar H, Nassar A, Saad Eldin RM, Anis N. The synergistic effect of combining botulinum toxin with polydioxanone threads on the upper face static wrinkles. *Arch Dermatol Res* 2024 Dec 14;**317**(1):123.
11. Hong GW, Wan J, Yoon SE, Wong S, Yi KH. Conditions to Consider When Choosing Fillers. *J Cosmet Dermatol* 2025 Mar;**24**(3):e70075.
12. Rashid Y, Estela-Fernandez C, Sardar A, et al. Advances in Anti-aging Procedures: A Comprehensive Review of Surgical and Non-surgical Rejuvenation Techniques. *Cureus* 2025 Sep;**17**(9):e92666.
13. Kim BR, Shin JW, Kim DW, et al. Efficacy and Safety of New Hyaluronic Acid Filler for Nasolabial Fold Correction: A Double-Blind, Randomized Trial. *Plast Reconstr Surg* 2025 Jul 21.
14. Artzi O, Cohen S, Koren A, Niv R, Friedman O. Dual-plane hyaluronic acid treatment for atrophic acne scars. *J Cosmet Dermatol* 2020 Jan;**19**(1):69-74.
15. van Loghem J, Sattler S, Casabona G, et al. Consensus on the Use of Hyaluronic Acid Fillers from the Cohesive Polydensified Matrix Range: Best Practice in Specific Facial Indications. *Clin Cosmet Investig Dermatol* 2021;**14**:1175-99.
16. McCarthy AD, Hartmann C, Durkin A, Shahriar S, Khalifian S, Xie J. A morphological analysis of calcium hydroxylapatite and poly-l-lactic acid biostimulator particles. *Skin Res Technol* 2024 Jun;**30**(6):e13764.
17. Qin N, Kochheiser M, Akosman I, et al. Systematic Review of Platelet-Rich Plasma and Platelet-Rich Fibrin in Facial Rejuvenation. *Ann Plast Surg* 2025 Apr 1;**94**(4S Suppl 2):S376-s89.
18. Ao YJ, Yi Y, Wu GH. Application of PLLA (Poly-L-Lactic acid) for rejuvenation and reproduction of facial cutaneous tissue in aesthetics: A review. *Medicine (Baltimore)* 2024 Mar 15;**103**(11):e37506.
19. Suh DH, Choi JH, Lee SJ, Jeong KH, Song KY, Shin MK. Comparative histometric analysis of the effects of high-intensity focused ultrasound and radiofrequency on skin. *J Cosmet Laser Ther* 2015;**17**(5):230-6.
20. Haddad A, Menezes A, Guarnieri C, et al. Recommendations on the use of injectable poly-L-lactic acid for skin laxity in off-face areas. *J Drugs Dermatol: JDD* 2019;**18**(9):929-35.
21. Garg S, Manchanda S. Platelet-rich plasma-an 'Elixir' for treatment of alopecia: personal experience on 117 patients with review of literature. *Stem Cell Investig* 2017;**4**:64.
22. Aliyeva A. Synergistic facial rejuvenation with PDO threads and Botulinum Toxin A for aging skin. *Case Reports in Plastic Surgery and Hand Surgery* 2025;**12**(1):2546528.
23. Hong GW, Kim SB, Park SY, Wan J, Yi KH. Thread Lifting Materials: A Review of Its Difference in Terms of Technical and Mechanical Perspective. *Clin Cosmet Investig Dermatol* 2024;**17**:999-1006.
24. Haykal D, Cartier H, Goldberg D, Gold M. Advancements in laser technologies for skin rejuvenation: A comprehensive review of efficacy and safety. *J Cosmet Dermatol* 2024 Oct;**23**(10):3078-89.
25. Borges J, Araújo L, Cuzzi T, Martinez L, Gonzales Y, Manela-Azulay M. Fractional Laser Resurfacing Treats Photoaging by Promoting Neocollegenesis and Cutaneous Edema. *J Clin Aesthet Dermatol* 2020 Jan;**13**(1):22-7.
26. Simonacci F, Bertozzi N, Grieco MP, Grignaffini E, Raposio E. Procedure, applications, and outcomes of autologous fat grafting. *Ann Med Surg (Lond)* 2017 Aug;**20**:49-60.
27. Costanzo D, Romeo A, Marena F. Autologous Fat Grafting in Plastic and Reconstructive Surgery: An Historical Perspective. *Eplasty* 2022;**22**:e4.
28. Bellini E, Grieco MP, Raposio E. The science behind autologous fat grafting. *Ann Med Surg (Lond)* 2017 Dec;**24**:65-73.
29. Fanelli CA, Vera LC, Ahn DY, McCain JP. A review of endoscopic surgical applications in oral and maxillofacial surgery. *Frontiers of Oral and Maxillofacial Medicine* 2021;**5**.
30. San José Estépar R, Stylopoulos N, Ellis RE, et al. Towards scarless surgery: an endoscopic-ultrasound navigation system for transgastric access procedures. *Med Image Comput Comput Assist Interv* 2006;**9**(Pt 1):445-53