Regenerative Medicine in Dermatology

Kanthi Bommareddy, MD,[1] Saranya Wyles, MD PhD,[2] Shino Bay Aguilera, DO,[3] and Kachiu Lee, MD MPH[4]

[1]Department of Dermatology, Larkin Health System, South Miami, FL
[2]Department of Dermatology, Mayo Clinic Department of Dermatology, Rochester, MN
[3]Shino Bay Cosmetic Dermatology & Laser Institute, Fort Lauderdale, FL
[4]Department of Dermatology, Temple University, Philadelphia, PA

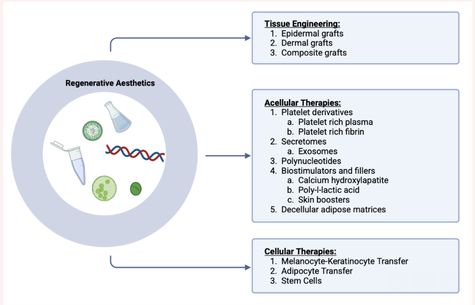
BACKGROUND

Definition & Purpose: Regenerative medicine harnesses the body's innate reparative mechanisms to restore tissue function following injury, disease, trauma, congenital defects, and aging.

Historical Use: Sanskrit texts describe skin grafting techniques in ancient India around 600 BCE. Maharishi Sushruta, regarded as a pioneer in surgery, detailed methods of skin transplantation for reconstructive procedures such as rhinoplasty, otoplasty, and lobuloplasty. In the early 19th century, "stem cells" was coined to describe progenitor cells capable of generating the germline. Extracellular vesicles (EVs) were first identified as distinct biological entities with enzymatic and functional activity during the 1980s and 1990s.

Categorization of treatment modalities:
Regenerative medicine incorporates several treatment modalities—including tissue engineering, cellular, and acellular therapies—for medical, surgical and cosmetic utility.

Clinical Relevance: Knowledge of regenerative medicine tools is useful for maximizing benefits and minimizing risks in treating medical, surgical, ad aesthetic dermatology patients.



Tissue Engineering

Engineered skin scaffolds: Tissue engineering restores or replaces diseased skin using epidermal, dermal, or composite extracellular matrices embedded with recognition sequences, growth factors, and customized physical properties (e.g., defined shape and pore size) to support cell infiltration, proliferation, and angiogenesis.

Epidermal substitutes: These consist of keratinocytes seeded onto natural or synthetic scaffolds; however, clinical outcomes remain limited, likely because they lack a supportive dermal component.

Dermal and composite substitutes: Dermal substitutes include fibroblasts from adult or fetal sources, while composite substitutes pair epidermal keratinocytes with fibroblast-containing dermal layers.

Acellular Therapies

Platelet Derivatives (PRP, PRF)
Skin & Pigment: PRP/PRF promote collagen, elastin, and HA production, improving fine lines, texture, and melasma; evidence is promising but heterogeneous, with strongest results in periorbital rejuvenation and when combined with microneedling, lasers, or chemexfoliation.
Hair, Wounds & Inflammation: PRP improves hair density in AGA and AA (with mixed results vs. steroids), accelerates healing in chronic wounds, and enhances outcomes in post-acne scarring, though robust randomized trials remain limited.

Acellular Therapies

Secretomes (Exosomes & EVs)
Mechanisms & Challenges: Secretomes exert anti-inflammatory, pro-angiogenic, and regenerative effects but face major challenges in sourcing, isolation, stability, and lack of standardization, leaving most evidence preclinical.
Potential Applications: Exosomes may boost collagen via PI3K/Akt signaling, promote anagen initiation in hair models, and enhance wound healing and immune modulation, but clinical validation is needed.

Polynucleotides (PNs)
Mechanisms & Evidence: PNs may promote collagen synthesis, ECM support, and anti-inflammatory effects via A2A receptors and ERK/MAPK activation, but current data are largely mechanistic with no robust trials.
Clinical Signals: Early reports show improvements in hydration, elasticity, wrinkles, erythema, scars, and possibly hair growth, yet PNs remain investigational without FDA approval.

Biostimulators & HA Fillers
Calcium Hydroxylapatite (CaHA)
Mechanisms & Uses: CaHA stimulates collagen, elastin, and neovascularization, improving dermal thickness and texture; FDA-approved for facial volume loss and lipoatrophy.
Combinations: CaHA combined with micronutrients or HA fillers enhances skin quality, laxity, pigmentation, and dermal viscoelasticity; more trials needed.
Poly-L-Lactic Acid (PLLA)
Mechanisms & Timing: PLLA induces collagen via controlled inflammation, with peak activity at 6 months and effects lasting up to 2 years; FDA-approved for HIV lipoatrophy.
Applications: Improves skin thickness, elasticity, and wrinkles; increasingly used off-label for body rejuvenation (gluteal, arms, thighs, abdomen).
Skin Boosters (HA-based)
Mechanisms & Skin Effects: Low or non–cross-linked HA hydrates dermis and mildly stimulates collagen, improving fine lines, texture, and elasticity but without true volumization.
Enhanced Formulations: Additives such as glycerol, growth factors, or botulinum toxin enhance hydration and barrier function, though large-scale trials are lacking.

Decellularized Adipose Matrices (DAMs)
Structure & Function: DAMs preserve native adipose architecture, supporting adipogenesis and angiogenesis for soft-tissue augmentation and improved skin quality.
Clinical Outcomes: Studies show improved contour, texture, and long-term volume retention (up to 8 years), with expert endorsement as a safe alternative to fat grafting and fillers.

Acellular therapy	Description	Source
Platelet-rich plasma (PRP)	Platelet concentrate from blood containing platelet-derived growth factor (PDGF), transforming growth-factor beta (TGFβ), fibroblast growth factor (FGF), insulin-like growth factor (EGF), vascular endothelial growth factor (VEGF).[47]	Autologous whole blood
Platelet-rich fibrin (PRF)	Platelet concentrate containing fibrin clot and entrapped cells with growth factors and cytokines.[49]	Autologous whole blood without an anticoagulant (108)
Exosomes	Nano-sized (30-150 nm) lipid bilayer extracellular vesicles for therapeutics.[101]	Varied
Polynucleotides	Biopolymers of polydeoxyribonucleic acid or polyribonucleic acid, possibly functioning as a donor or nucleotide bases or through enhancing salvage pathway, angiogenesis, collagen production via binding A2A receptors.[6,113]	Sperm cells of Oncorhynchus mykiss (rainbow/steelhead trout) or Oncorhynchus keta (chum salmon).
Skin boosters	Non-cross linked or low-cross linked hyaluronic acid filler (typically 12-20 mg/mL). Often formulated with other active ingredients—including vitamins, minerals, amino acids, cytokines, co-enzymes, nucleic acids, and trace elements.[146,147]	Streptococcus bacteria
Calcium hydroxylapatite	Bioceramic injectable that stimulates collagen, elastin, proteoglycan, tissue, and vasculature production.[129]	Synthetically derived
Poly-L-Lactic Acid	Synthetic biocompatible polymer that stimulates a subclinical inflammatory response that produces collagen.[136,152]	Synthetically derived
Decellular adipose matrices	Decellularized adipose tissue matrix from lipoaspirates.[152]	Cadaveric human adipose tissue

Cellular Therapies

Melanocyte-Keratinocyte Transfer:
Effectiveness & Challenges: MKTP offers durable, physiologic repigmentation for pigmentary disorders but is limited by technical challenges in melanocyte culture and amplification.

Clinical Outcomes & Enhancers: Epidermal cell suspensions outperform suction blister grafting, with higher melanocyte concentrations improving outcomes; in vitiligo, 13–86% of patients achieve near-complete repigmentation, especially in segmental and head/neck or trunk disease. Combination therapies (growth factors, platelet-derived products) and skin-prep techniques (dermabrasion, microneedling) further enhance graft survival.

Future Needs: Standardized grading systems, consistent preparation methods, and patient stratification based on comorbidities are required for broader clinical adoption.

Adipose Transfer:
Composition & Regenerative Potential: Adipose tissue contains adipocytes and a regenerative SVF rich in MSCs and other cells, offering a biocompatible, non-immunogenic source for tissue repair; advances in harvesting/processing have improved outcomes, though large-volume transfers still yield inconsistent results and longer recovery.

Aesthetic & Structural Skin Benefits: Nanofat grafting—preserving regenerative elements without mature adipocytes—can improve scars, discoloration, and fine wrinkles, with SVF or PRF combinations enhancing texture and elasticity; however, some studies report minimal phenotypic change. SVF-enriched grafts can increase dermal density and elastic fiber content.

Hair & Inflammatory Disease Applications: Adipose-derived products promote hair growth via Wnt/β-catenin–mediated MSC activation, improving density and diameter in nonscarring alopecia; they also show variable benefit in inflammatory dermatoses, including reductions in acne lesions and improvement of hypertrophic acne scars through cytokine modulation.

Stem Cells:
Immunomodulation & Inflammation: MSCs—key adult stem cells with self-renewal and regenerative capacity—can attenuate pro-inflammatory cytokine signaling; in a trial of moderate-to-severe AD, subcutaneous MSCs significantly reduced disease severity, IgE levels, and eosinophil counts through suppression of Th2-driven inflammation.

Dermatologic & Cosmetic Applications: MSCs enhance healing in acute/chronic wounds and hypertrophic scars and are being explored for rejuvenation and pigment disorders; umbilical cord–derived MSC topical applications improved melasma, and hair-follicle–derived stem cell injections increased hair density in androgenetic alopecia.

Limitations & Future Needs: Clinical impact is constrained by inadequate progenitor cell numbers, disease-related impairment, and ECM fibrosis limiting engraftment; widespread adoption requires standardized protocols, optimized delivery methods, and evidence of durable outcomes.

Ethical and Regulatory Considerations

Ethical Considerations:
Standardization & Evidence: Lack of standardized manufacturing, protocols, and product characterization limits trial quality and makes clinical efficacy difficult to assess, requiring clear informed consent about variability.
Benefit, Cost & Electiveness: Patients must understand the balance between expected benefit, cost, and potential side effects, especially since most regenerative treatments are elective rather than medically necessary.
Provider Responsibility: Clinicians must uphold beneficence and non-maleficence by offering therapies only when reasonable benefit is expected and by minimizing risk in elective interventions.

Regulatory Considerations:
Product Oversight & Classification: Purity, sourcing, and formulation variability hinder clinical adoption; regenerative products are regulated as biologics under PHS Act sections 351 and 361, with most aesthetic applications requiring biologics license approval.
Standards & Pathways: Regulatory agencies must develop flexible frameworks for diverse emerging therapies; expedited pathways like RMAT exist for serious conditions but generally do not apply to aesthetic uses.
Compliance & Transparency: Marketing and patient consent must align with regulatory requirements to avoid misleading claims and ensure accurate representation of product capabilities and limitations.

REFERENCES:

1. Wyles SP, Lynch MD. Introduction. Dermatologic Surgery. 2024;50(11S):S127-S127. doi:10.1097/DSS.0000000000004445

2. Berthiaume F, Maguire TJ, Yarmush ML. Tissue engineering and regenerative medicine: History, progress, and challenges. Annu Rev Chem Biomol Eng. 2011;2. doi:10.1146/annurev-chembioeng-061010-114257

3. Gandhi MA, Patil BK. Sushruta: The Father of Surgery and Ancient Medical Innovations. Cureus. 2024;16(9):e70577. doi:10.7759/cureus.70577

4. Champaneria MC, Workman AD, Gupta SC. Sushruta: Father of plastic surgery. Ann Plast Surg. 2014;73(1). doi:10.1097/SAP.0b013e31827ae9f5

5. Hashemi DA, Tao J, Wang J V., Munavalli G, Geronemus RG. Dermal Microcoring for Skin Laxity, Rhytides, and Scars. Dermatologic Surgery. 2024;50(11S):S135-S138. doi:10.1097/DSS.0000000000004432

6. Charitos IA, Ballini A, Cantore S, et al. Stem Cells: A Historical Review about Biological, Religious, and Ethical Issues. Stem Cells Int. 2021;2021. doi:10.1155/2021/9978837

7. Couch Y, Buzás EI, Vizio D Di, et al. A brief history of nearly EV-erything – The rise and rise of extracellular vesicles. J Extracell Vesicles. 2021;10(14). doi:10.1002/jev2.12144

8. Dieckmann C, Renner R, Milkova L, Simon JC. Regenerative medicine in dermatology: Biomaterials, tissue engineering, stem cells, gene transfer and beyond. Exp Dermatol. 2010;19(8). doi:10.1111/j.1600-0625.2010.01087.x

9. Lynch MD, Wyles SP. Regenerative Medicine: On the Vanguard of Dermatology. Dermatologic Surgery. 2024;50(11S):S128-S130. doi:10.1097/DSS.0000000000004388

10. Birlea SA, Costin GE, Roop DR, Norris DA. Trends in Regenerative Medicine: Repigmentation in Vitiligo Through Melanocyte Stem Cell Mobilization. Med Res Rev. 2017;37(4). doi:10.1002/med.21426

11. Tegta GR, Parsad D, Majumdar S, Kumar B. Efficacy of autologous transplantation of noncultured epidermal suspension in two different dilutions in the treatment of vitiligo. Int J Dermatol. 2006;45(2). doi:10.1111/j.1365-4632.2004.02403.x

12. Budania A, Parsad D, Kanwar AJ, Dogra S. Comparison between autologous noncultured epidermal cell suspension and suction blister epidermal grafting in stable vitiligo: A randomized study. British Journal of Dermatology. 2012;167(6). doi:10.1111/bjd.12007

13. Huggins RH, Henderson MD, Mulekar S V., et al. Melanocyte-keratinocyte transplantation procedure in the treatment of vitiligo: The experience of an academic medical center in the United States. J Am Acad Dermatol. 2012;66(5). doi:10.1016/j.jaad.2011.05.002

14. Mulekar S V. Stable vitiligo treated by a combination of low-dose oral pulse betamethasone and autologous, noncultured melanocyte-keratinocyte cell transplantation. Dermatologic Surgery. 2006;32(4). doi:10.1111/j.1524-4725.2006.32109.x

15. Vakharia PP, Lee DE, Khachemoune A. Efficacy and safety of noncultured melanocyte-keratinocyte transplant procedure for vitiligo and other leukodermas: a critical analysis of the evidence. Int J Dermatol. 2018;57(7). doi:10.1111/ijd.13895

16. Parambath N, Sharma VK, Parihar AS, Sahni K, Gupta S. Use of platelet-rich plasma to suspend noncultured epidermal cell suspension improves repigmentation after autologous transplantation in stable vitiligo: a double-blind randomized controlled trial. Int J Dermatol. 2019;58(4). doi:10.1111/ijd.14286

17. Jafarzadeh A, Pour Mohammad A, Keramati H, Zeinali R, Khosravi M, Goodarzi A. Regenerative medicine in the treatment of specific dermatologic disorders: a systematic review of randomized controlled clinical trials. Stem Cell Res Ther. 2024;15(1):176. doi:10.1186/s13287-024-03800-6

18. Hajimortezayi Z, Daei N, Gholizadeh N, et al. Fat transplant: Amazing growth and regeneration of cells and rebirth with the miracle of fat cells. J Cosmet Dermatol. 2024;23(4). doi:10.1111/jocd.16103

19. Suh A, Pham A, Cress MJ, et al. Adipose-derived cellular and cell-derived regenerative therapies in dermatology and aesthetic rejuvenation. Ageing Res Rev. 2019;54. doi:10.1016/j.arr.2019.100933

20. Charles-De-Sá L, Gontijo-De-Amorim NF, Maeda Takiya C, et al. Antiaging treatment of the facial skin by fat graft and adipose-derived stem cells. Plast Reconstr Surg. 2015;135(4). doi:10.1097/PRS.0000000000001123

21. Uyulmaz S, Sanchez Macedo N, Rezaeian F, Giovanoli P, Lindenblatt N. Nanofat Grafting for Scar Treatment and Skin Quality Improvement. Aesthet Surg J. 2018;38(4). doi:10.1093/asj/sjx183

22. Wei H, Gu SX, Liang YD, et al. Nanofat-derived stem cells with platelet-rich fibrin improve facial contour remodeling and skin rejuvenation after autologous structural fat transplantation. Oncotarget. 2017;8(40). doi:10.18632/oncotarget.19721

23. Yoshimura K, Sato K, Aoi N, Kurita M, Hirohi T, Harii K. Cell-assisted lipotransfer for cosmetic breast augmentation: Supportive use of adipose-derived stem/stromal cells. Aesthetic Plast Surg. 2008;32(1). doi:10.1007/s00266-007-9019-4

24. Amirkhani MA, Shoae-Hassani A, Soleimani M, Hejazi S, Ghalichi L, Nilforoushzadeh MA. Rejuvenation of facial skin and improvement in the dermal architecture by transplantation of autologous stromal vascular fraction: A clinical study. BioImpacts. 2016;6(3). doi:10.15171/bi.2016.21

25. Perez-Meza D, Ziering C, Sforza M, Krishnan G, Ball E, Daniels E. Hair follicle growth by stromal vascular fractionenhanced adipose transplantation in baldness. Stem Cells Cloning. 2017;10. doi:10.2147/SCCAA.S131431

26. Anderi R, Makdissy N, Azar A, Rizk F, Hamade A. Cellular therapy with human autologous adipose-derived adult cells of stromal vascular fraction for alopecia areata. Stem Cell Res Ther. 2018;9(1). doi:10.1186/s13287-018-0889-y

27. Kim SJ, Kim MJ, Lee YJ, et al. Innovative method of alopecia treatment by autologous adipose-derived SVF. Stem Cell Res Ther. 2021;12(1). doi:10.1186/s13287-021-02557-6

28. Shin H, Ryu HH, Kwon O, Park BS, Jo SJ. Clinical use of conditioned media of adipose tissue-derived stem cells in female pattern hair loss: A retrospective case series study. Int J Dermatol. 2015;54(6). doi:10.1111/ijd.12650

29. Fukuoka H, Narita K, Suga H. Hair Regeneration Therapy: Application of Adipose-Derived Stem Cells. Curr Stem Cell Res Ther. 2017;12(7). doi:10.2174/1574888x12666170522114307

30. Zhao H, Hao L, Chen X, Bai R, Luo S. An Efficacy Study of a New Radical Treatment for Acne Vulgaris Using Fat Injection. Aesthet Surg J. 2021;41(8). doi:10.1093/asj/sjab162

31. Nilforoushzadeh MA, Heidari-Kharaji M, Alavi S, et al. Transplantation of autologous fat, stromal vascular fraction (SVF) cell, and platelet-rich plasma (PRP) for cell therapy of atrophic acne scars: Clinical evaluation and biometric assessment. J Cosmet Dermatol. 2022;21(5). doi:10.1111/jocd.14333

32. Shan X, Choi JH, Kim KJ, et al. Adipose Stem Cells with Conditioned Media for Treatment of Acne Vulgaris Scar. Tissue Eng Regen Med. 2018;15(1). doi:10.1007/s13770-017-0105-7

33. Kwon HH, Yang SH, Lee J, et al. Combination treatment with human adipose tissue stem cellderived exosomes and fractional co2 laser for acne scars: A 12-week prospective, double-blind, randomized, split-face study. Acta Derm Venereol. 2020;100(18). doi:10.2340/00015555-3666

34. Menon S, Monteleon C, Rhodes ASJ, Sebastiano V, Hsia E. Transient Epigenetic Reprogramming: The Future of Skin Rejuvenation. Dermatologic Surgery. 2024;50(11S):S145-S148. doi:10.1097/DSS.0000000000004433

35. Ogliari KS, Marinowic D, Brum DE, Loth F. Stem cells in dermatology. An Bras Dermatol. 2014;89(2):286-291. doi:10.1590/abd1806-4841.20142530

36. Kim HS, Lee JH, Roh KH, Jun HJ, Kang KS, Kim TY. Clinical Trial of Human Umbilical Cord Blood-Derived Stem Cells for the Treatment of Moderate-to-Severe Atopic Dermatitis: Phase I/IIa Studies. Stem Cells. 2017;35(1). doi:10.1002/stem.2401

37. Bellei B, Migliano E, Picardo M. Therapeutic potential of adipose tissue-derivatives in modern dermatology. Exp Dermatol. 2022;31(12). doi:10.1111/exd.14532

38. Lee HC, An SG, Lee HW, et al. Safety and effect of adipose tissue-derived stem cell implantation in patients with critical limb ischemia: - A pilot study -. Circulation Journal. 2012;76(7). doi:10.1253/circj.CJ-11-1135

39. Rasulov MF, Vasil'chenkov A V., Onishchenko NA, et al. First experience of the use bone marrow mesenchymal stem cells for the treatment of a patient with deep skin burns. Bull Exp Biol Med. 2005;139(1). doi:10.1007/s10517-005-0232-3

40. Vojtaššák J, Danišovič L, Kubeš M, et al. Autologous biograft and mesenchymal stem cells in treatment of the diabetic foot. In: Neuroendocrinology Letters. Vol 27. 2006.

41. Yoshikawa T, Mitsuno H, Nonaka I, et al. Wound therapy by marrow mesenchymal cell transplantation. Plast Reconstr Surg. 2008;121(3). doi:10.1097/01.prs.0000299922.96006.24

42. Falanga V, Iwamoto S, Chartier M, et al. Autologous bone marrow-derived cultured mesenchymal stem cells delivered in a fibrin spray accelerate healing in murine and human cutaneous wounds. Tissue Eng. 2007;13(6). doi:10.1089/ten.2006.0278

43. Badiavas E V., Falanga V. Treatment of chronic wounds with bone marrow-derived cells. Arch Dermatol. 2003;139(4). doi:10.1001/archderm.139.4.510

44. Mazini L, Rochette L, Admou B, Amal S, Malka G. Hopes and limits of adipose-derived stem cells (ADSCs) and mesenchymal stem cells (MSCs) in wound healing. Int J Mol Sci. 2020;21(4). doi:10.3390/ijms21041306

45. Adelipour M, Sorkheh H, Kiani Z, et al. Umbilical cord as a source of mesenchymal stem cells improves melasma in parturients: a clinical randomized trial. Physiology and Pharmacology (Iran). 2023;27(1). doi:10.52547/phypha.27.1.7

46. Gentile P, Scioli MG, Bielli A, Orlandi A, Cervelli V. Stem cells from human hair follicles: first mechanical isolation for immediate autologous clinical use in androgenetic alopecia and hair loss. Stem Cell Investig. 2017;4(7). doi:10.21037/sci.2017.06.04

Merchán WH, Gómez LA, Chasoy ME, Alfonso-Rodríguez CA, Muñoz AL. Platelet-rich plasma, a powerful tool in dermatology. J Tissue Eng Regen Med. 2019;13(5). doi:10.1002/term.2832

48. Proffer SL, Wyles SP, Hausauer AK. Update on Platelet-Rich Plasma and Platelet-Rich Fibrin for Dermatologic Surgery: Addressing Knowns and Unknowns. Dermatologic Surgery. 2024;50(11S):S149-S159. doi:10.1097/DSS.0000000000004421

49. Acebes-Huerta A, Arias-Fernández T, Bernardo Á, et al. Platelet-derived bio-products: Classification update, applications, concerns and new perspectives. Transfusion and Apheresis Science. 2020;59(1). doi:10.1016/j.transci.2019.102716

50. Alam M, Hughart R, Champlain A, et al. Effect of Platelet-Rich Plasma Injection for Rejuvenation of Photoaged Facial Skin: A Randomized Clinical Trial. JAMA Dermatol. 2018;154(12). doi:10.1001/jamadermatol.2018.3977

51. Shen J, Yu X, Zhuang Y, Kong Y, Zhao J, Yao Z. Clinical efficacy and safety of targeted injection of PRP with skin booster in the treatment of aging face. Biotechnol Genet Eng Rev. Published online 2023. doi:10.1080/02648725.2023.2199233

52. Ulusal BG. Platelet-rich plasma and hyaluronic acid – an efficient biostimulation method for face rejuvenation. J Cosmet Dermatol. 2017;16(1). doi:10.1111/jocd.12271

53. Everts PA, Pinto PC, Girão L. Autologous pure platelet-rich plasma injections for facial skin rejuvenation: Biometric instrumental evaluations and patient-reported outcomes to support antiaging effects. J Cosmet Dermatol. 2019;18(4). doi:10.1111/jocd.12802

54. Cameli N, Mariano M, Cordone I, Abril E, Masi S, Foddai ML. Autologous Pure Platelet-Rich Plasma Dermal Injections for Facial Skin Rejuvenation: Clinical, Instrumental, and Flow Cytometry Assessment. Dermatologic Surgery. 2017;43(6). doi:10.1097/DSS.0000000000001083

55. Elnehrawy NY, Ibrahim ZA, Eltoukhy AM, Nagy HM. Assessment of the efficacy and safety of single platelet-rich plasma injection on different types and grades of facial wrinkles. J Cosmet Dermatol. 2017;16(1). doi:10.1111/jocd.12258

56. Redaelli A, Romano D, Marcianò A. Face and neck revitalization with Platelet-rich Plasma (PRP): Clinical outcome in a series of 23 consecutively treated patients. Journal of Drugs in Dermatology. 2010;9(5).

57. Mehryan P, Zartab H, Rajabi A, Pazhoohi N, Firoozi A. Assessment of efficacy of platelet-rich plasma (PRP) on infraorbital dark circles and crow's feet wrinkles. J Cosmet Dermatol. 2014;13(1). doi:10.1111/jocd.12072

58. Kang BK, Shin MK, Lee JH, Kim NI. Effects of platelet-rich plasma on wrinkles and skin tone in Asian lower eyelid skin: Preliminary results from a prospective, randomised, split-face trial. European Journal of Dermatology. 2014;24(1). doi:10.1684/ejd.2014.2267

59. González-Ojeda A, Cervantes-Guevara G, Chejfec-Ciociano JM, et al. Treatment of melasma with platelet-rich plasma: A self-controlled clinical trial. Dermatol Ther. 2022;35(9). doi:10.1111/dth.15703

60. Çayirli M, Çaliskan E, Açikgöz G, Erbil AH, Ertürk G. Regression of melasma with platelet-rich plasma treatment. Ann Dermatol. 2014;26(3). doi:10.5021/ad.2014.26.3.401

61. Sirithanabadeekul P, Dannarongchai A, Suwanchinda A. Platelet-rich plasma treatment for melasma: A pilot study. J Cosmet Dermatol. 2020;19(6). doi:10.1111/jocd.13157

62. Patil NK, Bubna AK. A comparative evaluation of the efficacy of intralesional tranexamic acid versus platelet rich plasma in the treatment of melasma. Dermatol Ther. 2022;35(7). doi:10.1111/dth.15534

63. Ramadan WM, Hassan AM, Ismail MA, El Attar YA. Evaluation of adding platelet-rich plasma to combined medical therapy in androgenetic alopecia. J Cosmet Dermatol. 2021;20(5). doi:10.1111/jocd.13935

64. Tawfik AA, Osman MAR. The effect of autologous activated platelet-rich plasma injection on female pattern hair loss: A randomized placebo-controlled study. J Cosmet Dermatol. 2018;17(1). doi:10.1111/jocd.12357

65. Siah TW, Guo H, Chu T, et al. Growth factor concentrations in platelet-rich plasma for androgenetic alopecia: An intra-subject, randomized, blinded, placebo-controlled, pilot study. Exp Dermatol. 2020;29(3). doi:10.1111/exd.14074

66. Chuah SY, Tan CH, Wang ECE, et al. Efficacy of platelet-rich plasma in Asians with androgenetic alopecia: A randomized controlled trial. Indian J Dermatol Venereol Leprol. 2023;89(1). doi:10.25259/IJDVL_512_2021

67. Dubin DP, Lin MJ, Leight HM, et al. The effect of platelet-rich plasma on female androgenetic alopecia: A randomized controlled trial. J Am Acad Dermatol. 2020;83(5). doi:10.1016/j.jaad.2020.06.1021

68. Rodrigues BL, Montalvão SAL, Cancela RBB, et al. Treatment of male pattern alopecia with platelet-rich plasma: A double-blind controlled study with analysis of platelet number and growth factor levels. J Am Acad Dermatol. 2019;80(3). doi:10.1016/j.jaad.2018.09.033

69. Butt G, Hussain I, Ahmed FJ, Choudhery MS. Efficacy of platelet-rich plasma in androgenetic alopecia patients. J Cosmet Dermatol. 2019;18(4). doi:10.1111/jocd.12810

70. Gentile P, Garcovich S, Scioli MG, Bielli A, Orlandi A, Cervelli V. Mechanical and controlled PRP injections in patients affected by androgenetic alopecia. Journal of Visualized Experiments. 2018;2018(131). doi:10.3791/56406

71. Alves R, Grimalt R. Randomized placebo-controlled, double-blind, half-head study to assess the efficacy of platelet-rich plasma on the treatment of androgenetic alopecia. Dermatologic Surgery. 2016;42(4). doi:10.1097/DSS.0000000000000665

72. Gentile P, Garcovich S, Bielli A, Scioli MG, Orlandi A, Cervelli V. The Effect of Platelet-Rich Plasma in Hair Regrowth: A Randomized Placebo-Controlled Trial. Stem Cells Transl Med. 2015;4(11). doi:10.5966/sctm.2015-0107

73. Singhal P, Agarwal S, Dhot PS, Sayal SK. Efficacy of platelet-rich plasma in treatment of androgenic alopecia. Asian J Transfus Sci. 2015;9(2). doi:10.4103/0973-6247.162713

74. Ho A, Sukhdeo K, Lo Sicco K, Shapiro J. Trichologic response of platelet-rich plasma in androgenetic alopecia is maintained during combination therapy. J Am Acad Dermatol. 2020;82(2). doi:10.1016/j.jaad.2018.03.022

75. Gkini MA, Kouskoukis AE, Tripsianis G, Rigopoulos D, Kouskoukis K. Study of platelet-rich plasma injections in the treatment of androgenetic alopecia through an one-year period. J Cutan Aesthet Surg. 2014;7(4). doi:10.4103/0974-2077.150743

76. Moftah NH, Taha NEE, Alhabibi AM, Hamdino M. Different platelet-rich plasma preparation protocols in Female pattern hair loss: Does it affect the outcome? A pilot study. J Cosmet Dermatol. 2022;21(8). doi:10.1111/jocd.14648

77. Ozcan KN, Sener S, Altunisik N, Turkmen D. Platelet rich plasma application by dermapen microneedling and intradermal point-by-point injection methods, and their comparison with clinical findings and trichoscan in patients with androgenetic alopecia. Dermatol Ther. 2022;35(1). doi:10.1111/dth.15182

78. Muhammad A, Iftikhar N, Mashhood A, et al. Comparison of Efficacy of Platelet-Rich Plasma (PRP) With PRP Microneedling in Androgenetic Alopecia. Cureus. Published online 2022. doi:10.7759/cureus.30418

79. Pensato R, Al-Amer R, La Padula S. Platelet-Rich Plasma for Treating Androgenic Alopecia: A Systematic Review. Aesthetic Plast Surg. 2024;48(1). doi:10.1007/s00266-023-03482-0

80. Trink A, Sorbellini E, Bezzola P, et al. A randomized, double-blind, placebo- and active-controlled, half-head study to evaluate the effects of platelet-rich plasma on alopecia areata. British Journal of Dermatology. 2013;169(3). doi:10.1111/bjd.12397

81. Hegde P, Relhan V, Sahoo B, Garg VK. A randomized, placebo and active controlled, split scalp study to evaluate the efficacy of platelet-rich plasma in patchy alopecia areata of the scalp. Dermatol Ther. 2020;33(6). doi:10.1111/dth.14388

82. Khan FA, Hussain M, Khan BM, et al. COMPARATIVE STUDY BETWEEN INTRALESIONAL INJECTION OF PLATELET RICH PLASMA AND INTRA LESIONAL TRIAMCINOLONE FOR THE TREATMENT OF ALOPECIA AREATA. Journal of Ayub Medical College. 2022;34(4). doi:10.55519/JAMC-04-10933

83. Sarvajnamurthy S, Suryanarayan S, Budamakuntala L, Suresh D. Autologous platelet rich plasma in chronic venous ulcers: Study of 17 cases. J Cutan Aesthet Surg. 2013;6(2). doi:10.4103/0974-2077.112671

84. Suthar M, Gupta S, Bukhari S, Ponemone V. Treatment of chronic non-healing ulcers using autologous platelet rich plasma: a case series. J Biomed Sci. 2017;24(1). doi:10.1186/s12929-017-0324-1

85. Ahmed M, Reffat SA, Hassan A, Eskander F. Platelet-Rich Plasma for the Treatment of Clean Diabetic Foot Ulcers. Ann Vasc Surg. 2017;38. doi:10.1016/j.avsg.2016.04.023

86. Anitua E, Aguirre JJ, Algorta J, et al. Effectiveness of autologous preparation rich in growth factors for the treatment of chronic cutaneous ulcers. J Biomed Mater Res B Appl Biomater. 2008;84(2). doi:10.1002/jbm.b.30886

87. Marck RE, Gardien KLM, Stekelenburg CM, et al. The application of platelet-rich plasma in the treatment of deep dermal burns: A randomized, double-blind, intra-patient controlled study. Wound Repair and Regeneration. 2016;24(4). doi:10.1111/wrr.12443

88. Gómez LA, Romero VC, Rubiano WHM. The use of platelet-rich plasma in the treatment of acne and its scars: a pilot study. Surgical & Cosmetic Dermatology. 2017;9(2). doi:10.5935/scd1984-8773.201792932

89. Guo R, Xuan W, He X, Xu K. Safety and efficacy of CO2 dot matrix laser combined with platelet-rich plasma on depressed scar after acne vulgaris and influencing factors of its repair effect: A retrospective analysis. J Cosmet Dermatol. 2023;22(3). doi:10.1111/jocd.15501

90. Chawla S. Split face comparative study of microneedling with PRP versus microneedling with vitamin C in treating atrophic post acne scars. J Cutan Aesthet Surg. 2014;7(4). doi:10.4103/0974-2077.150742

91. Asif M, Kanodia S, Singh K. Combined autologous platelet-rich plasma with microneedling verses microneedling with distilled water in the treatment of atrophic acne scars: a concurrent split-face study. J Cosmet Dermatol. 2016;15(4). doi:10.1111/jocd.12207

92. Abuaf OK, Yildiz H, Baloglu H, Bilgili ME, Simsek HA, Dogan B. Histologic evidence of new collagen formulation using platelet rich plasma in skin rejuvenation: A prospective controlled clinical study. Ann Dermatol. 2016;28(6). doi:10.5021/ad.2016.28.6.718

93. Abdel Aal AM, Ibrahim IM, Sami NA, Abdel Kareem IM. Evaluation of autologous platelet-rich plasma plus ablative carbon dioxide fractional laser in the treatment of acne scars. Journal of Cosmetic and Laser Therapy. 2018;20(2). doi:10.1080/14764172.2017.1368667

94. Min S, Yoon JY, Park SY, Moon J, Kwon HH, Suh DH. Combination of platelet rich plasma in fractional carbon dioxide laser treatment increased clinical efficacy of for acne scar by enhancement of collagen production and modulation of laser-induced inflammation. Lasers Surg Med. 2018;50(4). doi:10.1002/lsm.22776

95. Gawdat HI, Hegazy RA, Fawzy MM, Fathy M. Autologous platelet rich plasma: Topical versus intradermal after fractional ablative carbon dioxide laser treatment of atrophic acne scars. Dermatologic Surgery. 2014;40(2). doi:10.1111/dsu.12392

96. Lee JH, Kim J, Lee YN, et al. The efficacy of intradermal hyaluronic acid filler as a skin quality booster: A prospective, single-center, single-arm pilot study. J Cosmet Dermatol. 2024;23(2). doi:10.1111/jocd.15944

97. El-Domyati M, Abdel-Wahab H, Hossam A. Microneedling combined with platelet-rich plasma or trichloroacetic acid peeling for management of acne scarring: A split-face clinical and histologic comparison. J Cosmet Dermatol. 2018;17(1). doi:10.1111/jocd.12459

98. Faghihi G, Keyvan S, Asilian A, Nouraei S, Behfar S, Nilforoushzadeh M. Efficacy of autologous platelet-rich plasma combined with fractional ablative carbon dioxide resurfacing laser in treatment of facial atrophic acne scars: A split-face randomized clinical trial. Indian J Dermatol Venereol Leprol. 2016;82(2). doi:10.4103/0378-6323.174378

99. Ibrahim ZA, El-Ashmawy AA, Shora OA. Therapeutic effect of microneedling and autologous platelet-rich plasma in the treatment of atrophic scars: A randomized study. J Cosmet Dermatol. 2017;16(3). doi:10.1111/jocd.12356

100. Hani R, Khayat L, Rahman AA, Alaaeddine N. Effect of stem cell secretome in skin rejuvenation: a narrative review. Mol Biol Rep. 2023;50(9). doi:10.1007/s11033-023-08622-y

101. Wu D, Zhao X, Xie J, et al. Physical modulation of mesenchymal stem cell exosomes: A new perspective for regenerative medicine. Cell Prolif. 2024;57(8). doi:10.1111/cpr.13630

102. Wyles SP, Yu GT, Gold M, Behfar A. Topical Platelet Exosomes Reduce Senescence Signaling in Human Skin: An Exploratory Prospective Trial. Dermatologic Surgery. 2024;50(11S):S160-S165. doi:10.1097/DSS.0000000000004426

103. Cheng T, Naughton GK, Makino ET, Kadoya K, Maitra P. Regenerative Skincare Technologies Derived From Human Fibroblasts: Growth Factors and Exosomes for Transformative Outcomes. Dermatologic Surgery. 2024;50(11S):S139-S144. doi:10.1097/DSS.0000000000004436

104. Beer L, Mildner M, Ankersmit HJ. Cell secretome based drug substances in regenerative medicine: When regulatory affairs meet basic science. Ann Transl Med. 2017;5(7). doi:10.21037/atm.2017.03.50

105. Miron RJ, Estrin NE, Sculean A, Zhang Y. Understanding exosomes: Part 2-Emerging leaders in regenerative medicine. Periodontol 2000. 2024;94(1):257-414. doi:10.1111/prd.12561

106. Zhang W, Bai X, Zhao B, et al. Cell-free therapy based on adipose tissue stem cell-derived exosomes promotes wound healing via the PI3K/Akt signaling pathway. Exp Cell Res. 2018;370(2). doi:10.1016/j.yexcr.2018.06.035

107. Xiong M, Zhang Q, Hu W, et al. The novel mechanisms and applications of exosomes in dermatology and cutaneous medical aesthetics. Pharmacol Res. 2021;166. doi:10.1016/j.phrs.2021.105490

108. Kost Y, Muskat A, Mhaimeed N, Nazarian RS, Kobets K. Exosome therapy in hair regeneration: A literature review of the evidence, challenges, and future opportunities. J Cosmet Dermatol. 2022;21(8). doi:10.1111/jocd.15008

109. Zhou L, Wang H, Jing J, Yu L, Wu X, Lu Z. Regulation of hair follicle development by exosomes derived from dermal papilla cells. Biochem Biophys Res Commun. 2018;500(2). doi:10.1016/j.bbrc.2018.04.067

110. Matsuzaki T, Yoshizato K. Role of hair papilla cells on induction and regeneration processes of hair follicles. In: Wound Repair and Regeneration. Vol 6. 1998. doi:10.1046/j.1524-475X.1998.60605.x

111. Bailey AJM, Li H, Kirkham AM, et al. MSC-Derived Extracellular Vesicles to Heal Diabetic Wounds: a Systematic Review and Meta-Analysis of Preclinical Animal Studies. Stem Cell Rev Rep. 2022;18(3). doi:10.1007/s12015-021-10164-4

112. Guo L, Lai P, Wang Y, et al. Extracellular vesicles from mesenchymal stem cells prevent contact hypersensitivity through the suppression of Tc1 and Th1 cells and expansion of regulatory T cells. Int Immunopharmacol. 2019;74. doi:10.1016/j.intimp.2019.05.048

113. Urso Pitassi LH, Pearson K, Antônio de Assis L, et al. Polynucleotides in Skin Regeneration: Targeting the Adenosine A2A Receptor and Salvage Pathway. Dermatol Surg. 2024;50(11S):S131-S134. doi:10.1097/DSS.0000000000004438

114. Shin SM, Baek EJ, Kim KH, Kim KJ, Park EJ. Polydeoxyribonucleotide exerts opposing effects on ERK activity in human skin keratinocytes and fibroblasts. Mol Med Rep. 2023;28(2). doi:10.3892/mmr.2023.13035

115. Lee KWA, Chan KWL, Lee A, et al. Polynucleotides in Aesthetic Medicine: A Review of Current Practices and Perceived Effectiveness. Int J Mol Sci. 2024;25(15). doi:10.3390/ijms25158224

116. Park KY, Seok J, Rho NK, Kim BJ, Kim MN. Long-chain polynucleotide filler for skin rejuvenation: Efficacy and complications in five patients. Dermatol Ther. 2016;29(1). doi:10.1111/dth.12299

117. Lis A, Kawałkiewicz W, Kubisz L. A comparison of the efficacy of reducing the signs of ageing in the neck skin after polynucleotides injections in regimens with different dosing intervals – a case study. Journal of Face Aesthetics. 2023;6(1). doi:10.20883/jofa.68

118. Brandi C, Cuomo R, Nisi G, Grimaldi L, D'Aniello C. Face rejuvenation: A new combinated protocol for biorevitalization. Acta Biomedica. 2018;89(3). doi:10.23750/abm.v89i3.6162

119. Lim TS, Liew S, Tee XJ, et al. Polynucleotides HPT for Asian Skin Regeneration and Rejuvenation. Clin Cosmet Investig Dermatol. 2024;17. doi:10.2147/CCID.S437942

120. Kim JH, Kim ES, Kim SW, Hong SP, Kim J. Effects of Polynucleotide Dermal Filler in the Correction of Crow's Feet Using an Antera Three-Dimensional Camera. Aesthetic Plast Surg. 2022;46(4). doi:10.1007/s00266-022-02832-8

121. Jeong GJ, Ahn GR, Park SJ, Hong JY, Kim BJ. A randomized, patient/evaluator-blinded, split-face study to compare the efficacy and safety of polycaprolactone and polynucleotide fillers in the correction of crow's feet: The latest biostimulatory dermal filler for crow's feet. J Cosmet Dermatol. 2020;19(7). doi:10.1111/jocd.13199

122. Park KY, Kwon HJ, Youn CS, Seo SJ, Kim MN. Treatments of infra-orbital dark circles by various etiologies. Ann Dermatol. 2018;30(5). doi:10.5021/ad.2018.30.5.522

123. Yogya Y, Wanitphakdeedecha R, Wongdama S, Nanchaipruek Y, Yan C, Rakchart S. Efficacy and Safety of Using Noninsulated Microneedle Radiofrequency Alone versus in Combination with Polynucleotides for Treatment of Periorbital Wrinkles. Dermatol Ther (Heidelb). 2022;12(5):1133-1145. doi:10.1007/s13555-022-00729-7

124. Lee YJ, Kim HT, Lee YJ, et al. Comparison of the effects of polynucleotide and hyaluronic acid fillers on periocular rejuvenation: a randomized, double-blind, split-face trial. Journal of Dermatological Treatment. 2022;33(1). doi:10.1080/09546634.2020.1748857

125. Lee D, Kim MJ, Park HJ, et al. Current practices and perceived effectiveness of polynucleotides for treatment of facial erythema by cosmetic physicians. Skin Research and Technology. 2023;29(9). doi:10.1111/srt.13466

126. Kim JH, Jeong JJ, Lee YI, et al. Preventive effect of polynucleotide on post-thyroidectomy scars: A randomized, double-blinded, controlled trial. Lasers Surg Med. Published online March 25, 2018. doi:10.1002/lsm.22812

127. Araco A, Araco F. Preliminary Prospective and Randomized Study of Highly Purified Polynucleotide vs Placebo in Treatment of Moderate to Severe Acne Scars. Aesthet Surg J. 2021;41(7). doi:10.1093/asj/sjab125

128. Samadi A, Ayatollahi A, Kashani MN, Zamani S, Firooz A. Efficacy and tolerability assessment of a polynucleotide-based gel for improvement of pattern hair loss. Arch Dermatol Res. 2024;316(6):331. doi:10.1007/s00403-024-03088-9

129. Aguilera SB, McCarthy A, Khalifian S, Lorenc ZP, Goldie K, Chernoff WG. The Role of Calcium Hydroxylapatite (Radiesse) as a Regenerative Aesthetic Treatment: A Narrative Review. Aesthet Surg J. 2023;43(10). doi:10.1093/asj/sjad173

130. Goldie K, Chernoff G, Corduff N, Davies O, van Loghem J, Viscomi B. Consensus Agreements on Regenerative Aesthetics: A Focus on Regenerative Biostimulation With Calcium Hydroxylapatite. Dermatologic Surgery. 2024;50(11S):S172-S176. doi:10.1097/DSS.0000000000004437

131. De Almeida AT, Figueredo V, Da Cunha ALG, et al. Consensus Recommendations for the Use of Hyperdiluted Calcium Hydroxyapatite (Radiesse) as a Face and Body Biostimulatory Agent. Plast Reconstr Surg Glob Open. 2019;7(3). doi:10.1097/GOX.0000000000002160

132. Theodorakopoulou E, McCarthy A, Perico V, Aguilera SB. Optimizing Skin Regenerative Response to Calcium Hydroxylapatite Microspheres Via Poly-Micronutrient Priming. J Drugs Dermatol. 2023;22(9). doi:10.36849/JDD.7405

133. Urdiales-Gálvez F, Braz A, Cavallini M. Facial rejuvenation with the new hybrid filler HArmonyCaTM: Clinical and aesthetic outcomes assessed by 2D and 3D photographs, ultrasound, and elastography. J Cosmet Dermatol. 2023;22(8). doi:10.1111/jocd.15706

134. Bravo BSF, Almeida TSC De, Carvalho RDM, Machado CJ, Bravo LG, Elias MC. Dermal Thickness Increase and Aesthetic Improvement with Hybrid Product Combining Hyaluronic Acid and Calcium Hydroxyapatite: A Clinical and Sonographic Analysis. Plast Reconstr Surg Glob Open. 2023;11(6). doi:10.1097/GOX.0000000000005055

135. Fitzgerald R, Bass LM, Goldberg DJ, Graivier MH, Lorenc ZP. Physiochemical Characteristics of Poly-L-Lactic Acid (PLLA). Aesthet Surg J. 2018;38. doi:10.1093/asj/sjy012

136. 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 (United States). 2024;103(11). doi:10.1097/MD.0000000000037506

137. Waibel J, Ziegler M, Nguyen TQ, et al. Comparative Bulk RNA-Seq Analysis of Poly-l-Lactic Acid Versus Calcium Hydroxylapatite Reveals a Novel, Adipocyte-Mediated Regenerative Mechanism of Action Unique to PLLA. Dermatol Surg. 2024;50(11S):S166-S171. doi:10.1097/DSS.0000000000004425

138. Bohnert K, Dorizas A, Lorenc P, Sadick NS. Randomized, Controlled, Multicentered, Double-Blind Investigation of Injectable Poly-L-Lactic Acid for Improving Skin Quality. Dermatol Surg. 2019;45(5):718-724. doi:10.1097/DSS.0000000000001772

139. Wilkerson EC, Goldberg DJ. Poly-L-lactic acid for the Improvement of photodamage and rhytids of the décolletage. J Cosmet Dermatol. 2018;17(4). doi:10.1111/jocd.12447

140. Baroni E do RV, Biondo-Simões M de LP, Auersvald A, et al. Influence of aging on the quality of the skin of white women: the role of collagen. Acta Cir Bras. 2012;27(10). doi:10.1590/s0102-86502012001000012

141. Jabbar A, Arruda S, Sadick N. Off face usage of poly-L-lactic acid for body rejuvenation. Journal of Drugs in Dermatology. 2017;16(5).

142. Mazzuco R, Evangelista C, Gobbato DO, de Almeida LM. Clinical and histological comparative outcomes after injections of poly-L-lactic acid and calcium hydroxyapatite in arms: A split side study. J Cosmet Dermatol. 2022;21(12). doi:10.1111/jocd.15356

143. Shridharani SM, Tisch GM, Ebersole TG, Moak TN, Edwartz C. Clinical experience of poly-L-lactic acid injections for body contouring treatment. J Cosmet Dermatol. 2021;20(6). doi:10.1111/jocd.14141

144. Durairaj KK, Devgan L, Lee A, et al. Poly-L-Lactic Acid for Gluteal Augmentation found to be Safe and Effective in Retrospective Clinical Review of 60 Patients. Dermatol Surg. 2020;46. doi:10.1097/DSS.0000000000002598

145. Lin MJ, Dubin DP, Khorasani H. Poly-L-Lactic Acid for Minimally Invasive Gluteal Augmentation. Dermatologic Surgery. 2020;46(3). doi:10.1097/DSS.0000000000001967

146. Yi KH, Winayanuwattikun W, Kim SY, et al. Skin boosters: Definitions and varied classifications. Skin Research and Technology. 2024;30(3). doi:10.1111/srt.13627

147. Arora G, Arora S, Sadoughifar R, Batra N. Biorevitalization of the skin with skin boosters: Concepts, variables, and limitations. J Cosmet Dermatol. 2021;20(8). doi:10.1111/jocd.13871

148. Wang F, Garza LA, Kang S, et al. In vivo stimulation of de novo collagen production caused by cross-linked hyaluronic acid dermal filler injections in photodamaged human skin. Arch Dermatol. 2007;143(2). doi:10.1001/archderm.143.2.155

149. Ayatollahi A, Firooz A, Samadi A. Evaluation of safety and efficacy of booster injections of hyaluronic acid in improving the facial skin quality. J Cosmet Dermatol. 2020;19(9). doi:10.1111/jocd.13493

150. Kim JS. Clinical effects on skin texture and hydration of the face using microbotox and microhyaluronicacid. Plast Reconstr Surg Glob Open. 2018;6(11). doi:10.1097/GOX.0000000000001935

151. Adem S, Abbas DB, Lavin C V., et al. Decellularized Adipose Matrices Can Alleviate Radiation-Induced Skin Fibrosis. Adv Wound Care (New Rochelle). 2022;11(10). doi:10.1089/wound.2021.0008

152. Zhang S, Lu Q, Cao T, Toh WS. Adipose tissue and extracellular matrix development by injectable decellularized adipose matrix loaded with basic fibroblast growth factor. Plast Reconstr Surg. 2016;137(4). doi:10.1097/PRS.0000000000002019

153. Gold MH, Numani AS, Dasgupta A, Wyles SP. Allograft Adipose Matrix: A New Natural Approach With Evidence for 8-Year Longevity of Soft Tissue Augmentation. Dermatol Surg. 2024;50(11S):S177-S179. doi:10.1097/DSS.0000000000004427

154. Gold MH, Kinney BM, Kaminer MS, Rohrich RJ, D'Amico RA. A multi-center, open-label, pilot study of allograft adipose matrix for the correction of atrophic temples. J Cosmet Dermatol. 2020;19(5). doi:10.1111/jocd.13363

155. Gold M, Biesman B, Cohen J, et al. Real-World Clinical Experience With an Allograft Adipose Matrix for Replacing Volume Loss in Face, Hands, and Body. J Cosmet Dermatol. 2024;23 Suppl 4:1-9. doi:10.1111/jocd.16579

156. Beetler DJ, Di Florio DN, Law EW, et al. The evolving regulatory landscape in regenerative medicine. Mol Aspects Med. 2023;91. doi:10.1016/j.mam.2022.101138