Autologous Fat Grafting: Evaluation of Efficacy in Pain Relief

Kara Klomparens, BA*
Richard Simman, MD, FACS, FACCWS†‡

Introduction: Autologous fat grafting (AFG) has been used in reconstructive plastic surgery for over a century. Although it has obvious benefits to the aesthetic appearance of many reconstructive surgeries, less appreciated advantages of fat grafting have also been shown in potential pain reduction. This can be seen across the board from head to toe with examples ranging from facial nerve injury to pedal atrophy and foot ulcers. The purpose of this literature review is to evaluate the efficacy of AFG for pain relief in various indications and serve as a reference for clinicians to gain insight on potentially beneficial therapies for their patients.

Methods: A broad literature review was performed to analyze the various uses of AFG for pain management by various indications including postmastectomy pain syndrome, scar pain, neuromas, chronic wounds, and many more. The PubMed, Science Direct, and Scopus online databases were searched using keywords such as “autologous fat grafting,” “reconstruction,” “pain,” and “therapy.”

Results: At this point, there is decent evidence to support AFG’s role in pain resolution in postmastectomy pain syndrome, neuropathic scar pain, and pedal injury. There is also ample low-level evidence for pain efficacy in autoimmune diseases, neuromas, vulvar lichen sclerosis, burns, and radiation-induced wounds.

Conclusions: While there is a clear lack of higher-level evidence based studies conducted on AFG for all indications, the existing literature shows a definite trend of reconstructive efficacy and pain management that can be clearly appreciated. With the increasing popularity of this procedure for reconstruction, higher-level studies are beginning to take place pertaining to AFG’s efficacy not only in reconstruction, but pain management as well. (Plast Reconstr Surg Glob Open 2022;10:e4543; doi: 10.1097/GOX.0000000000004543; Published online 1 November 2022.)
or “radiation”) to ensure all adequate studies would be included in this review. After removing duplicate and non-relevant articles, these additional searches yielded eight more articles to be included making our total number of included articles 35.

RESULTS BY INDICATION

Postmastectomy Pain Syndrome

Breast cancer affects one in eight women in the United States, many times leading to breast conserving therapy or total mastectomy. Unfortunately, the treatment of breast cancer is very commonly associated with persistent pain in 24%–52% of patients. Postmastectomy pain syndrome (PMPS) can be defined as chronic pain located in the chest, axilla, and/or upper arm that lasts for over 3 months postoperatively that has been noted to afflict up to 65% of patients. This pain is typically neuropathic with features such as tingling, burning, and aching. PMPS significantly affects the quality of life in these women who are already dealing with a cancer diagnosis and potentially...
the loss of one or both breasts. There have been many proposed treatments for PMPS including analgesics, antidepressants, anticonvulsants, topical medications, physical therapy, nerve blocks, and AFG.  

Six total trials, as detailed in Figure 2, from 2011 to 2022 were found that investigate the role of AFG in PMPS. All but one trial support this procedure and its efficacy in diminishing pain for this patient population. However, the most recent publication by Sollie et al denies its efficacy. This study involved a sample size of only 36 participants, 18 of whom received AFG (compared to other studies three times this size), and was the only study to not include the visual analog scale (VAS) as the measurable pain outcome. However, it was the only study to date to compare the fat grafting group with a double blinded sham operation group. With these limitations and benefits in mind and while looking at all 505 patients across these six trials, there is still strong evidence to accept fat grafting as a safe and potentially effective treatment for PMPS.

### Table: Studies pertaining to AFG in PMPS

| Study               | Design                      | Size                          | Results                                      | Conclusion                      |
|---------------------|-----------------------------|-------------------------------|----------------------------------------------|---------------------------------|
| Caviggioli et al 2011<sup>1</sup> | Controlled prospective trial | 113 patients, 63 with AFG   | Significant decrease in pain with using the VAS | AFG considered a safe and effective treatment |
| Maione et al 2014<sup>2</sup> | Controlled prospective trial | 96 patients, 69 with AFG     | Significant decrease in pain using the VAS   | AFG considered useful for pain treatment in this setting |
| Juhl et al 2016<sup>3</sup> | Randomized clinical trial   | 15 patients, 8 with AFG       | Significant improvement of VAS and other measures | In support of the use of AFG     |
| Caviggioli et al 2016<sup>4</sup> | Controlled prospective trial | 209 patients, 131 with AFG   | Significant difference in VAS reduction between treatment and control groups | Supports the role of AFG in treating neuropathic pain in women with PMPS |
| Lisa et al 2020<sup>4</sup> | Prospective multicenter study | 37 patients, all with AFG   | Significant reduction in VAS at 1 and 3 months post operatively | Confirms efficacy of AFG for this patient population |
| Sollie et al 2022<sup>7</sup> | Single center, double blind and randomized | 35 patients, 18 with AFG | No statistically significant change in pain using the NRS | Does not support the efficacy of AFG in these patients |

Fig. 2. Studies pertaining to AFG in PMPS.

Fat grafting in these patients is many times used as a great tool for reconstruction, allowing the surgeon to create a more natural aesthetic breast. However, its potential to reduce pain in this patient population should not be overlooked. Although the exact mechanism is yet to be determined, physical components such as padding around an entrapped or inflamed nerve are very possible as well as fat tissue-provided substrates promoting the healing process and reducing inflammation.

### Scar Pain

Left over scars from traumatic or minor injuries can inflict a large amount of pain and greatly decrease a patient’s quality of life. Pain from scar tissue is generally described as neuropathic and has proven to be difficult for clinicians to effectively treat. Furthermore, scars create a diverse range of adverse symptoms in affected patients such as pruritus, discomfort, discoloration, stiffness, and contraction.

Injecting fat into scar tissue can loosen retractile skin, decreasing the stiffness and contracture characteristics that can contribute to pain. Furthermore, adipose tissue-containing mesenchymal stem cells have potential for propa-gating the healing process and decreasing inflammation. The use of AFG in the treatment of neuropathic scar pain...
has been very widely researched. And as such, there have been many studies on this treatment modality leading to systematic reviews and meta-analyses. For the purposes of this article, we decided to only include these previously conducted larger view projects as a means of gaining a fuller understanding of AFG in this patient population.

Systemic reviews by both To and Negenborn reported positive results in regard to both pain reduction and aesthetic outcome when treating scars with AFG. These studies included 288 and 905 patients, respectively, giving a significant generalizability of these results. Furthermore, a recent significant systemic review and meta-analysis done by Krastev et al in 2020 included 45 studies with 3000+ patients with scar pain being included. Their results showed a statistically significant decrease in VAS score with the use of AFG for this condition. These larger-based, higher-level analyses show the credibility of AFG in pain relief for these patients and are highlighted in Figure 3.

Two of three of these reviews highlighted the therapeutic level of their included studies ranging from level I to level V with the average being III–IV. This points to the larger limitation of most studies surrounding AFG lacking larger-based randomized controlled trials. However, having multiple systematic reviews and meta-analyses pointing toward the same conclusion does show strength in the use of this technique and justifies future research and practice of AFG in scar therapy.

Painful End Neuromas and Other Neuropathic Pain

A neuroma is a benign nerve growth commonly characterized by severe debilitating pain. As with many difficult to treat conditions, there are a multitude of therapy modalities in use by clinicians with none remaining as the gold standard of care. To this point, there is only low-level evidence, including studies of limited patient size and largely from one center, to support the role of AFG in this population.

| Study                | Design                | Size          | Results                              | Conclusion                                      |
|----------------------|-----------------------|---------------|--------------------------------------|------------------------------------------------|
| Negenborn 2016       | Systematic review     | 26 articles: 905 patients | Statistically significant improvement of scar appearance, skin characteristics and pain | Supports AFG’s role in scar treatment for both aesthetics and pain |
| To et al 2019        | Systematic review     | 18 studies: 288 patients | 233 patients responded with a reduction in pain | AFG is a promising and safe treatment of painful scars |
| Krastev et al 2020   | Systematic review and meta-analysis | 45 studies: 3033 patients | Statistically significant improvement in VAS score | AFG appears to be an effective treatment for fibrosis and scar related conditions |

![Fig. 3. Studies pertaining to AFG in scar treatment.](image)

![Fig. 4. Studies pertaining to AFG in painful end neuromas and other neuropathic pain.](image)
Five publications, as described in Figure 4, were found pertaining to the use of AFG mainly in neuromas and also neuropathic pain from herpes zoster virus. All articles spoke to the effectiveness of this technique. Although this is a mix of lower- and medium-level evidence, it does suggest that more research is needed to fully determine the usefulness of AFG in painful neuromas. The suggested most likely mechanism for reduction of pain includes fat acting as a protective barrier around the sensitive nerve endings.

Pedal Injury
Foot pain can be very debilitating for patients for obvious reasons including impaired ambulation and decreased ability to care for oneself. This can be due to various reasons such as pedal fat pad atrophy and chronic wounds on the base of the foot. Recently, work has been done, as detailed in Figure 5, to attempt to relieve this pain with AFG. It is reasonable to assume there would be some pain management with increased padding on the weight bearing areas on the sole of the foot. However, these studies are even finding adequate pain relief once the thickness of the foot has returned to preprocedure baseline. This continued pain relief suggests an additional mechanism contributing to analgesia and validates the use of AFG over a simple shoe pad for more significant results.

Autoimmune Conditions
Autoimmune diseases, specifically systemic scleroderma, are life altering conditions commonly associated with pain and minimal treatment options. Scleroderma consists of malfunction of connective tissue causing stiffness and thickening of the skin as well as manifestations in other organ systems. Skin involvement of the facial region can cause significant distress to patients by way of both disfigurement and loss of function including eating, drinking and speaking. The hands can also become very affected by scleroderma causing great pain and digital ulcers. The rationale behind the use of AFG in these patients lies in its potential for decreasing collagen depositions and increasing elasticity and vascularization. As seems to be the case throughout AFG research, there have been multiple low-level studies performed that are

| Study                        | Design                | Size   | Results                                                                 | Conclusion                                      |
|------------------------------|-----------------------|--------|------------------------------------------------------------------------|------------------------------------------------|
| James et al 2021             | Prospective randomized | 13 patients | Foot pain, function and appearance all significantly improved with controls at 6 and 12 months | In support of AFG for rejuvenation of heel       |
| Maione et al 2019            | Case series           | 7 patients | Resolved pain in all patients                                          | Supports AFG for treatment of calcaneal post-surgical chronic ulcer |
| Minter et al 2019            | Prospective, randomized, crossover, single center | 18 patients | Pain improved immediately following fat grafting in both groups and lasted through follow-up | Supports AFG due to long lasting improvements in pain and function |
| Raposio and Calderazzi 2017 | Prospective study     | 8 patients | Statistically significant decrease in pain scales at 6 months post-op   | Promotes AFG for the relief of weight bearing foot pain |

Fig. 5. Studies pertaining to AFG in pedal injury.
making way for larger randomized control trials. We have included two smaller based retrospective analyses as well as the first higher evidence-based trial of this kind investigating the role of AFG in burn patients, as can be seen in Figure 7.

Although the work by Ahmed did not include any specific outcome measure pertaining to pain, a great increase in quality of life can be seen. Furthermore, an impressive and significant difference in opioid use is a very strong indication of pain relief in these patients. Not only is decreased need for pain medications and decreased hospital stay beneficial for quality of life but it also is a decreased financial burden on the patient and family.

### Radiation Injury

Radiation injury and its various treatment modalities are another well-debated topic among clinicians. Once again, we see a large amount of case studies and retrospective studies pointing towards the efficacy of AFG in this pathology. One comprehensive systematic review pulls all these studies together and advocates for the future trials that need to take place. The details of these included studies can be seen in Figure 8.

Although the available literature is not fully robust yet, a great potential can be seen with AFG in radiated tissue. Improvements can be seen in tissue quality pertaining to liability and vascularization after grafting. Furthermore, pain seems to be reduced across the board, regardless of radiation injury location, removing some of the disability from these patients.

### Vulvar Lichen Sclerosus

Vulvar lichen sclerosus (VLS) presents with very painful fibrosis and scarring of the vulvar area. In severe cases, this can greatly decrease quality of life by fibrosis impairing the anatomy of the vagina. Studies on the treatment of VLS with AFG have shown significant increases in relief of itching, pain, soreness and burning as well as improved sexual function and less distress. Currently, there are not many studies dedicated to this treatment modality, but the two included articles shown in Figure 9 are promising for the future direction of this treatment.

### DISCUSSION

Pain is a notoriously difficult to treat and potentially debilitating condition even with whole fields of medicine dedicated towards treating it. The prospect of AFG in the treatment of pain has been a promising development in plastic and reconstructive surgery. Another benefit of this treatment modality is a low complication rate; AFG is generally considered a very safe procedure.

AFG has been greatly developed over the course of a century. Starting in 1899 for the treatment of scars, the process has been refined immensely, leading to the start of the Coleman method in 1994. The Coleman method includes aspiration of the fat tissue by means of a blunt cannula under low negative pressure suction to avoid unnecessary trauma to the cells. The lipoaspirate is then centrifuged to obtain the purest form of the fat.

---

**Table 1. Studies pertaining to AFG in autoimmune conditions.**

| Study            | Design            | Size               | Results                                                                 | Conclusions                                      |
|------------------|-------------------|--------------------|-------------------------------------------------------------------------|--------------------------------------------------|
| Strong et al 2021 | Retrospective analysis | 10 patients | Subjectively and qualitatively improved perioral skin quality, facial animation, hand ROM and hand pain | Supports AFG in patients with systemic scleroderma |
| Bene et al 2014  | Prospective       | 9 patients with 15 treated ulcers | Complete healing in 10 ulcers, 6 patients with reduced pain | Supports treatment with AFG in systemic sclerosis |
| Del Papa 2019    | Randomized Controlled trial | 38 patients | Significant reduction in pain intensity after 4 and 8 weeks | Strongly supports AFG’s effectiveness in treating scleroderma induced digital ulcers |
| Pignatti et al 2020 | Prospective | 25 patients | Pain reduced while perception of disability improved | Supports treatment of AFG in systemic sclerosis |

**Fig. 6.** Studies pertaining to AFG in autoimmune conditions.
There are many proposed therapeutic mechanisms for the efficacy of fat grafting. Although a simple physical padding of the area seems to have obvious benefits, more complex mechanisms of the components in adipose tissue may reveal the true analgesic effects. Fat contains many elements that have potential to benefit the wound healing process such as extracellular matrix, collagens, laminin, fibronectin, adipocytes, and stem cells. Adipose-derived stem cells have the capability to differentiate into multiple cell lineages including all three germ cell layers. They also serve to secrete multiple restorative growth factors and chemicals that suppress inflammation. These properties in the presence of damaged tissue seem to give way to an environment prone to healing. Potentially, these mechanisms are more effective in certain areas of the body which could be why there is more complete evidence for PMPS, whereas it is lacking for other indications such as autoimmune diseases.

Histological studies have given a basis of evidence for the healing effects of fat grafting by showing neovessel formation and improved hydration within the treatment of radiation injury. They also serve to secrete multiple restorative growth factors and chemicals that suppress inflammation. These properties in the presence of damaged tissue seem to give way to an environment prone to healing. Potentially, these mechanisms are more effective in certain areas of the body which could be why there is more complete evidence for PMPS, whereas it is lacking for other indications such as autoimmune diseases.

Without uniformity throughout the studies it is difficult to give a conclusive answer; however, the current data do show a trend toward more adequate pain relief in indications related to neuropathic pain as seen in PMPS, scars, and neuromas.

Histological studies have given a basis of evidence for the healing effects of fat grafting by showing neovessel formation and improved hydration within the treatment of radiation injury. Further studies have even shown new collagen formation, dermal hyperplasia, and local hypervascularity. Increasing blood flow to a damaged area greatly increases its likelihood to heal and thereby decrease pain. One of the included studies on scleroderma also gave evidence of this in showing newly formed capillary beds in patients with debilitating digital ulcers treated by AFG using nailfold video capillaroscopy to visualize the capillaries in addition to histology. Another proposed mechanism lies within AFG decreasing the inflammatory response. Keyser’s work found inhibition of NK cell proliferation and T cell activation by fat grafting. The inhibition of T cell activation could be explained by Huang’s work showing adipose cells secreting interleukin-10 which adamantly inhibits both CD4 and CD8 found on T cells. Furthermore, mesenchymal stem cells also found in adipose tissue are known to decrease inflammation by inhibiting the generation and release of inflammatory cytokines.

**LIMITATIONS**

As was continually noted, there is a clear lack of higher-level evidence-based studies conducted on AFG for all indications. The available nonrandomized and nonblind data leave many opportunities for bias, namely selection and measurement biases. However, in the existing case studies and series, retrospective reviews and prospective investigations, a definite trend of reconstructive efficacy and pain management can be clearly appreciated.

To gain an encompassing view of the level of evidence available at this point in research, the included studies were evaluated using the GRADE tool. The number of studies found to be in each category can be seen below in Figure 10.
Although the average of all studies was between low and moderate, it is important to note that this varied greatly by section. For instance, more established categories such as PMPS, scar pain, and pedal injury had averages between moderate to high, while the indications for treatment earlier in the research stages such as VLS and painful end neuromas ranged from low to very low.

**FUTURE DIRECTIONS**

With the limitations in mind, it is imperative that continued research be done on AFG to help us unlock its full potential. Although much of this work has yielded promising results, future studies should be performed in a uniform manner to gain higher-level evidence for AFG in pain relief.

One study improvement could include scales for pain severity such as the VAS and other standardized measures for pain symptoms. The use of objective outcomes in this way will allow researchers and clinicians to analyze and compare the efficacy of pain relief throughout all of the proposed indications. The authors hope to see future studies moving away from case reports and series and toward high-level controlled trials.
CONCLUSIONS

Although there is a clear lack of higher-level evidence-based studies conducted on AFG for all indications, the existing case studies and series, retrospective reviews, and prospective investigations show a definite trend of reconstructive efficacy and pain management that can be clearly appreciated. With the increasing popularity of this procedure for reconstruction, higher-level studies are beginning to take place pertaining to AFG’s efficacy not only in reconstruction, but pain management as well.

At this point, there is decent evidence to support its role in pain resolution in PMPS, neuropathic scar pain and pedal injury. Although more higher-level studies need to be conducted for every indication, we can see ample low-level evidence for pain efficacy also in autoimmune diseases, neuromas, vulvar lichen sclerosis, burns, and radiation-induced wounds.

There are many proposed reasons for why this relief may come with AFG. For instance, the introduction of multipotent mesenchymal stromal cells found in adipose tissue may increase vascularity and promote healing. Additionally, the increased volume alone could act as a protective barrier against noxious stimuli. Perhaps, the combination of this and other factors is the source of pain relief that can be seen throughout various indications and across all areas of the body.

Richard Simman, MD, FACS, FACCWS
Department of Surgery
Plastic and Reconstructive Surgery
University of Toledo
2109 Hughes Drive, Suite 400
Toledo, OH 43606
E-mail: Richard.simmanmd@promedica.org

REFERENCES

1. Costanzo D, Romeo A, Marena F. Autologous fat grafting in plastic and reconstructive surgery: an historical perspective. Eplasty. 2022;22:e4.
2. Maione L, Vinci V, Caviggioni F, et al. Autologous fat grafting in post-mastectomy pain syndrome, following breast conservative surgery and radiotherapy. *Aesthetic Plast Surg* 2014;38:529–532.

3. Juhl AA, Karlsson P, Damsgaard TF. Fat grafting for alleviating persistent pain after breast cancer treatment: a randomized controlled trial. *J Plast Reconstr Aesthet Surg* 2016;69:1192–1202.

4. Lisa AVE, Murolo M, Maione L, et al. Autologous fat grafting efficacy in treating Post-Mastectomy pain syndrome: a prospective multicenter trial of two Senonetolle Italia breast centers. *Breast J* 2020;26:1652–1658.

5. Caviggioni F, Maione L, Forcellini D, et al. Autologous fat graft in post mastectomy pain syndrome. *Plast Reconstr Surg* 2011;128:349–352.

6. Caviggioni F, Maione L, Klinger F, et al. Autologous fat grafting reduces pain in irradiated breast: a review of our experience. *Stem Cells Int* 2016;2016:2527349.

7. Solli M, Toyskani NM, Bille C, et al. Autologous fat grafting as treatment of postmastectomy pain syndrome: a randomized controlled trial. *Plast Reconstr Surg* 2022;149:295–305.

8. Delgado DA, Lambert BS, Boutris N, et al. Validation of digital visual analog scale pain scoring with a traditional paper-based visual analog scale in adults. *J Am Acad Orthop Surg Glob Res Rev* 2018;2:e088.

9. To K, Crowley C, Lim SK, et al. Autologous adipose tissue grafting for the management of the painful scar. *Cytotherapy* 2019;21:1151–1160.

10. Negenborn VL, Groen JW, Smit JM, et al. The use of autologous fat grafting for treatment of scar tissue and scar-related conditions: a systematic review. *Plast Reconstr Surg* 2016;137:31e–43e.

11. Krastev TK, Schop SJ, Hommes J, et al. Autologous fat transfer to treat fibrosis and scar-related conditions: a systematic review and meta-analysis. *J Plast Reconstr Aesthet Surg* 2020;73:2033–2048.

12. Al Qurashi AA, Siddiqi AK, Alghamdi AA, et al. Effectiveness of autologous fat transfer in the treatment of scar-related conditions: a systematic review and meta-analysis. *Aesthetic Plast Surg* 2022.

13. Vaïenti L, Merle M, Villani F, et al. Fat grafting according to Coleman for the treatment of radial nerve neuromas. *Plast Reconstr Surg* 2010;126:676–678.

14. Vaïenti L, Gazzola R, Villani F, et al. Perineural fat grafting in the treatment of painful neuromas. *Tech Hand Up Extrem Surg* 2012;16:55–55.

15. Vaïenti L, Merle M, Battiston B, et al. Perineural fat grafting in the treatment of painful end-nerveomomas of the upper limb: a pilot study. *J Hand Surg Eur Vol* 2013;38:36–42.

16. De Jongh F, Pouwels S, Tan LT. Autologous fat grafting for the treatment of a painful neuroma of the hand: a case report and review of literature. *Carrus* 2020;12:e10381.

17. Sollie M, Thomsen JB, Sorensen JA. Autologous fat grafting seems to alleviate postoperative neuralgia - a feasibility study investigating patient-reported levels of pain. *J Plast Reconstr Aesthet Surg* 2021;74:350–356.

18. James IB, Gusenoff BR, Wang S, et al. A step in the right direction: a prospective randomized, controlled crossover trial of autologous fat grafting for rejuvenation of the heel. *Aesthetic Surg J* 2021;41:NP95–NP972.

19. Maione L, Lisa A, Vinci V, et al. Autologous fat graft in foot calcaneal posttraumatic chronic ulcer. *Injury* 2019;50(Suppl 4):S64–S67.

20. Minteer DM, Gusenoff BR, Gusenoff JA. Fat grafting for pedpal fat pad atrophy in a 2-year, prospective, randomized, crossover, single-center clinical trial. *Plast Reconstr Surg* 2018;142:862e–871e.

21. Raposo E, Calderazzi F. Fat grafting for chronic heel pain following surgery for adult flatfoot deformity: pilot study. *Foot (Edinb)* 2017;31:56–60.

22. Gusenoff JA, Mitchell RT, Jeong K, et al. Autologous fat grafting for pedpal fat pad atrophy: a prospective randomized clinical trial. *Plast Reconstr Surg* 2016;138:1099–1108.

23. Pignatti M, Spinella A, Cocchiara E, et al. Autologous fat grafting for the oral and digital complications of systemic sclerosis: results of a prospective study. *Aesthetic Plast Surg* 2020;44:1820–1832.

24. Strong AL, Adilbarma W, Brown OH, et al. Fat grafting subjectively improves facial skin elasticity and hand function of scleroderma patients. *Plast Reconstr Surg Glob Open* 2021;9:e3373.

25. Bene MD, Pozzi MR, Novati L, et al. Regional grafting of autologous adipose tissue is effective in inducing prompt healing of indolent digital ulcers in patients with systemic sclerosis: results of a monocentric randomized controlled study. *Arthritis Res Ther* 2019;21:7.

26. Del Papa N, Di Luca G, Andracco R, et al. Regional grafting of autologous adipose tissue is effective in inducing prompt healing of indolent digital ulcers in patients with systemic sclerosis: results of a monocentric randomized controlled study. *Arthritis Res Ther* 2019;21:7.

27. Fredman R, Edkins RE, Hultman CS. Fat grafting for neuropathic pain after severe burns. *Ann Plast Surg* 2016;76(Suppl 4):S289–S303.

28. Byrne M, O'Donnell M, Fitzgerald L, et al. Early experience with fat grafting as an adjunct for secondary burn reconstruction in the hand: technique, hand function assessment and aesthetic outcomes. *Burns* 2016;42:356–365.

29. Ahmed A. Effect of autologous fat transfer in acute burn wound management: a randomized controlled study. *Burns* 2021.

30. Kenny EM, Ego FM, Eja A, et al. Fat grafting in radiation-induced soft-tissue injury: a narrative review of the clinical evidence and implications for future studies. *Plast Reconstr Surg* 2021;147:819–838.

31. Jackson IT, Simman R, Tholen R, et al. A successful long-term method of fat grafting: recontouring of a large subcutaneous posttrauma thigh defect with autologous fat transplantation. *Aesthetic Plast Surg* 2001;25:165–169.

32. Rigotti G, Marchi A, Galié M, et al. Clinical treatment of radiotherapy tissue damage by liposarpirate transplant: a healing process mediated by adipose-derived adult stem cells. *Plast Reconstr Surg* 2007;119:1409–1422.

33. Phulpin B, Gangloff P, Tran N, et al. Rehabilitation of irradiated head and neck tissues by autologous fat transplantation. *Plast Reconstr Surg* 2009;123:1187–1197.

34. Klinger F, Maione L, Vinci V, et al. Autologous fat graft in irradiated orbit postenuclerization for retinoblastoma. *Orbit* 2018;37:344–347.

35. Vuks KS, Saha ES, Tran N. Regenerative properties of autologous fat grafting in a complicated radiation-induced wound. *Wounds* 2021;33:E20–E23.

36. Almodari A, Hansen E, Boyle D, et al. Fat grafting improves fibrosis and scarring in vulgar lichen sclerosis: results from a prospective cohort study. *J Low Genit Tract Dis* 2020;24:305–310.

37. Boero V, Brambilla M, Sipio E, et al. Vulvar lichen sclerosis: a new regenerative approach through fat grafting. *Gynecol Oncol* 2015;139:471–475.

38. Kokai LE, Marra K, Rubin JP. Adipose stem cells: biology and clinical applications for tissue repair and regeneration. *Transl Res* 2014;163:399–408.

39. Keyser KA, Beagles KE, Kiern HP. Comparison of mesenchymal stem cells from different tissues to suppress T-cell activation. *Cell Transplant* 2007;16:555–562.

40. Huang S, Wu Y, Gao D, et al. Paracrine action of mesenchymal stromal cells delivered by microspheres contributes to cutaneous wound healing and prevents scar formation in mice. *Cytotherapy* 2015;17:922–931.

41. Gwatt GH, Oxman AD, Vist GE, et al: GRADE Working Group. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924–926.