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The Future of Noninvasive Procedural Dermatology

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Noninvasive procedural dermatology has evolved rapidly during the past decade. An array of skin tightening, resurfacing, and fat-reducing energy devices can now be combined with filler and neurotoxin injectables to reduce the visible signs of aging with minimal downtime and risk. In the future, such advances will likely continue, although the pace of technological breakthroughs is difficult to predict. Complex feedback devices, nanotechnology, and cell-based therapies will eventually begin to fulfill the promise of scar removal, pigmentation correction, and replacement of aged skin with skin that is new and completely functional. Dermatologists are well equipped to retain their leadership in noninvasive esthetic medicine, and they will, to the extent that they continue to pioneer outstanding therapies that are effective, affordable, and safe.
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Procedural dermatology has evolved rapidly over the past several decades, and continues to change. Although prognostication is always fraught, some short-term predictions can be made with reasonable surety, and longer-term predictions with much less accuracy.

Precise Feedback and Automated Setting Changes During Minimally Invasive Procedures

Traditional laser and energy devices, and even devices for cautery and suction, are bulky, expensive, and relatively inflexible.[1] Settings may be adjustable before the procedure commences, or at several points after it is underway, but are seldom changed dynamically during the energy-on period. To the extent that patients have different thickness and quantity of skin and subcutaneous tissue, these traditional approaches are not optimized for specific patient needs. Over time, the reduced cost of microelectronics, feedback controls, and computing power is simplifying the capacity of devices to analyze intraoperative information and adjust the procedure to compensate. For instance, certain laser and energy devices already have tips, either externally or internally placed, that are able to sense the temperature in the microenvironment and adjust power output to maintain site-specific temperature within a narrow band. This is similar to computer chips in modern vehicles, which can change the steering and braking in response to environmental conditions. Implementing such systems in procedural dermatology may increase effectiveness and reduce safety risks, as less expert operator time and effort is required, and computer-mediated setting changes can occur faster than human responses.

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Autonomous Nanotechnology Devices

Devices will change in size and become smaller as miniaturization becomes more feasible and affordable.[2] In turn, the decreased material and power needs of smaller devices will make them more affordable. At some point, devices will become so exceedingly small that they will be mostly disposable and deployed in large numbers to the treatment site. The many orders of magnitude of increased device power inherent in this army of devices will create a qualitative difference in their functionality, and the collective devices will become an electronic organism with a high degree of autonomy, and even task-directed consciousness. The concept of hundreds of minute machines deployed to resurface the skin or rapidly repair a wound may not be as farfetched as it seems, given rapid advances in nanotechnology. The potential benefits of this approach will include:

1. The robustness of the treatment process, which will not be dependent on the optimal functioning of any particular device because there are so many doing the same work simultaneously;
2. Cost savings, as less expensive and less durable devices can be effectively deployed in parallel; and
3. The emerging practicality of previously impossible procedures that may become feasible due to the ability of these tiny devices to affect the skin with a high level of resolution.

This is particularly important from a clinical standpoint, as it is not merely a matter of efficiency but rather of creating new procedures. For instance, at present, many scars and minor textural imperfections that are visible remain too fine to be addressed by available technology, as they are below the threshold of resolution of our current instruments. Similarly, although some large scars may be theoretically amenable to treatment even now, in the absence of physician-guided, partly autonomous nanodevices, the physician work involved may be prohibitive and render the procedures infeasible.

Optimized Minimally Invasive Procedures for Fat Reduction and Skin Tightening

With age, the face sags and the torso widens.[3,4] Fat reduction and skin tightening are therefore highly desired by a large proportion of aging adults. The caveat is that most of these potential patients are reluctant to undergo an invasive procedure, and are price sensitive. Although some procedures in this area are now available, they continue to offer only mild-to-modest effectiveness and longevity of effect at a moderate price point. Delivering heat or cold into the skin or subcutis is currently the most optimal strategy, and further dramatic improvements in treatment effectiveness will likely require entirely novel approaches. Ideally, such new technologies would also reduce cost, decrease intraoperative pain, and offer more predictable degrees of benefit.

Stem Cells for Augmentation of Tissue Layers, Including Epidermis, Dermis, and Subcutis

Stem cells offer the promise of genuine rejuvenation rather than mere repair and concealment.[5] Pluripotent stem cells can be harvested from various body tissues and can be used to facilitate wound healing. Cell-based therapies currently available also include those using autologous-cultured fibroblasts for soft-tissue augmentation. It is now possible to obtain postauricular skin biopsies from patients and ship them to a center where the fibroblasts are extracted and grown in culture. These autologous-cultured fibroblasts are reimplanted into the fine lines and facial rhytids of the patient. As a result, the fine lines and rhytids are diminished, potentially for a long period of time. As stem cell therapies improve, they could be used for high-volume long-lasting soft-tissue augmentation.

Cellular products may also facilitate repair of epidermal and dermal photodamage. Challenges regarding the implementation of such therapies include high cost, substantial physician and technician time, as well as the potential risk of inducing malignant degeneration at the site of cell placement. Improved bioengineered cell matrices need to be developed so that cells survive at the point of implantation. Effective matrices can improve the ability of cells to be well-spaced within the stroma and have adequate perfusion, such that they are neither physically crushed nor metabolically starved.

Artificial Skin and Scar Removal

The public is convinced that "scarless" surgery is possible, and scars can be removed; however, these remain elusive goals.[6,7] In the future, artificial dermal substitutes matching the color and texture of the skin will be improved to the point where they develop many of the functions of live skin and can be grafted in various sizes without inducing contractures. Ultimately, autologous skin will be developed that can be applied by simply applying "skin paint" to the affected area. Scars will be dissolved and replaced with new skin similar in appearance and function. Current surgical instruments, which create as many scars as they replace, will become obsolete, as replacement skin is applied precisely, and in minute quantities, through complex guidance mechanisms. Traumatic scars, acne scars, and keloids will become curable.

Rapid Treatment of Pigmentation, Including Postinflammatory Hyperpigmentation

For much of the world's non-Caucasian majority, pigmentary abnormalities are the major esthetic skin complaint. Whereas hypopigmentation is difficult to improve by any means, at present, the treatment of postinflammatory hyperpigmentation entails mostly watchful waiting. With nanotechnology and cellular therapies, there will emerge a means of melanocyte and melanosome transfer so precise and effective that color irregularities will be treated immediately. The discolored skin will be recolored automatically based on measurements of the adjacent skin, which will serve as a palette benchmark.

Increasing Autonomy for Midlevel Providers

Physician assistants and nurse practitioners frequently have a significant role in procedural dermatology.[8-10] As devices become increasingly complex, the need for specialized operators will likewise grow. Over time, dermatology physician assistants may come to resemble anesthesia nurses, operating complex machinery with minimal physician supervision. Delegation of tasks to nonphysicians will be important to ensure that these evolving procedures are affordable, and also to ensure adequate expertise in the operator. Dermatologists will simply not have enough time to master the operation of every device that they need in their practices. As a result, dermatologists' expertise in complex cosmetic and oncological procedures may be challenged, as midlevel providers will be perceived as technicians or caregivers who can function independently of physicians.

Blurring of the Line Between Prescription and Over-the-Counter Devices

In a similar vein, skin surgery devices may no longer be available primarily in the doctor's office.[11,12] The trend toward over-the-counter home devices, already marketed for hair removal, photo rejuvenation, hair growth, and other applications, will accelerate. As devices become easier for patients to use without special training, the need for operators will diminish. The device will function as the physician and, as such, will make decisions pertaining to the presence of an appropriate indication, determine patient suitability, decide the length and intensity of treatment, and decide the lag time between treatments. Such at-home devices may be bundled with materials for postoperative management as well as use feedback information to instruct the users in the management of their postoperative wound and any treatment-related complications.

Cycles of Commoditization and Differentiation

For several decades, dermatologists have worked closely with start-up companies to commercialize new devices and technologies, especially in the cosmetic and esthetic realm.[13] As an example, when new toxins, fillers, and energy devices have been marketed, dermatologists have been early adopters. Over time, each device or procedure has diminished in cost and exclusivity as other physicians and nonphysicians have entered the market, and dermatologists have then moved onto greener pastures. In all likelihood, this cycle will continue. Dermatologists cannot prevent the dissemination of stable technologies, but they can continue to innovate and create new ones.

One concern is that innovations do not always come on schedule and may be clumped together, with fallow periods in between. In the past few years, nonablative skin tightening and noninvasive fat removal have been areas for growth in the device market, but it is unclear how durable growth in this segment will be; moreover, fillers and neurotoxins appear to be a mature technology. Cell-based approaches and nanotechnology are promising and may provide dramatic increases in treatment effectiveness, but they may take longer than expected to be perfected. In the meantime, the continued success of dermatologists in esthetic medicine will be largely contingent on their ability to nurture innovation and ensure a healthy pipeline of novel technologies.

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