Current status of surgery in dermatology

C. William Hanke, MD,[a] Ronald L. Moy, MD,[b] Randall K. Roenigk, MD,[z] Henry H. Roenigk, Jr, MD,[y] James M. Spencer, MD, MS,[c] Emily P. Tierney, MD,[d] Cynthia L. Bartus, MD,[e,f,g] Robert M. Bernstein, MD, MBA,[h,i] Marc D. Brown, MD,[j] Mariano Busso, MD, PA,[k] Alastair Carruthers, MD,[l] Jean Carruthers, MD,[m] Omar A. Ibrahimi, MD, PhD,[n,o] Arielle N. B. Kauvar, MD,[p,q] Kathryn M. Kent, MD,[r] Nils Krueger, PhD,[s] Marina Landau, MD,[t] Aimee L. Leonard, MD,[d,u] Stephen H. Mandy, MD,[v,w,x] Thomas E. Rohrer, MD,[aa,bb] Neil S. Sadick, MD,[cc] and Luitgard G. Wiest, MD, PhD[dd]

Carmel, Indiana; Los Angeles, California; New York and Rochester, New York; Boston, Springfield, and Chestnut Hill, Massachusetts; Allentown and Center Valley, Pennsylvania; Coconut Grove, Miami Beach, and Miami, Florida; Vancouver, British Columbia, Canada; Stamford, Connecticut; Hamburg and Munich, Germany; Holon, Israel; Chicago, Illinois; Rochester, Minnesota; and Providence, Rhode Island

An article titled "Current issues in dermatologic office-based surgery" was published in the JAAD in October 1999 (volume 41, issue 4, pp. 624-634). The article was developed by the Joint American Academy of Dermatology/American Society for Dermatologic Surgery Liaison Committee. A number of subjects were addressed in the article including surgical training program requirements for dermatology residents and selected advances in dermatologic surgery that had been pioneered by dermatologists. The article concluded with sections on credentialing, privileging, and accreditation of office-based surgical facilities. Much has changed since 1999, including more stringent requirements for surgical training during dermatology residency, and the establishment of 57 accredited Procedural Dermatology Fellowship Training Programs. All of these changes have been overseen and approved by the Residency Review Committee for Dermatology and the Accreditation Committee for Graduate Medical Education. The fertile academic environment of academic training programs with interaction between established dermatologic surgeons and fellows, as well as the inquisitive nature of many of our colleagues, has led to the numerous major advances in dermatologic surgery, which are described herein. (J Am Acad Dermatol 2013;69:972-1001.)

Learning objectives: Dermatologists have been responsible for multiple advances and refinements in dermatologic office-based surgery over many decades. Dermatologists receive extensive training in office-based surgical procedures during residency, fellowships, and continuing medical education courses. The last update on this subject appeared in the *Journal* in 1999. This article will document the multitude of advances that have occurred since 1999.

Key words: fellowship; office-based; quality; surgery; training.

From the Laser and Skin Surgery Center of Indiana[a]; David Geffen School of Medicine, University of California-Los Angeles[b]; Clinical Dermatology, Mount Sinai School of Medicine, New York[c]; Department of Dermatology, Tufts University School of Medicine, Boston[d]; Advanced Dermatology Associates, Allentown[e]; Lehigh Valley Health Network, Allentown[f]; DeSales University, Center Valley[g]; Bernstein Medical Center for Hair Restoration, New York[h]; Columbia University, New York[i]; University of Rochester Medical Center[j]; private practice, Coconut Grove[k]; Departments of Dermatology and Skin Science[l] and Ophthalmology,[m] University of British Columbia; Connecticut Skin Institute[n]; Wellman Center for Photomedicine, Massachusetts General Hospital, Harvard Medical School, Boston[o]; New York Laser and Skin Care[p]; New York University School of Medicine[q]; Boston University School of Medicine[r]; Division of Cosmetic Science, University of Hamburg[s]; Dermatology, Wolfson Medical Center, Holon[t]; New England Dermatology and Laser Center, Springfield[u]; South Beach Dermatology, Miami Beach[v]; Skin and Cancer Associates, Miami Beach[w]; University of Miami[x]; Feinberg School of Medicine, Northwestern University, Chicago[y]; Department of Dermatology, Mayo Clinic, Rochester[z]; SkinCare Physicians, Chestnut Hill[aa]; Brown University School of Medicine, Providence[bb]; Weill Cornell Medical College, New York[cc]; and Privatärztliches Zentrum München, Munich.[dd]

Funding sources: None.

Conflicts of interest: None declared.

Reprint requests: American Academy of Dermatology, Attn: Kristina M. Finney, MPH, 1445 New York Ave, Suite 800, Washington, DC 20005.

Published online October 7, 2013.

0190-9622/$36.00

http://dx.doi.org/10.1016/j.jaad.2013.04.067

TABLE OF CONTENTS

Abbreviations used:

AAD:	American Academy of Dermatology
ABD:	American Board of Dermatology
ABMS:	American Board of Medical Specialties
ACGME:	Accreditation Council for Graduate Medical Education
ACMS:	American College of Mohs Surgery
ASDS:	American Society for Dermatologic Surgery
ASMS:	American Society for Mohs Surgery
BoNT:	botulinum toxin
CaHA:	calcium hydroxylapatite
CO_2:	carbon dioxide
Er:	erbium
FDA:	US Food and Drug Administration
FTC:	Fellowship Training Committee
HA:	hyaluronic acid
MMP:	matrix metalloproteinase
MMS:	Mohs micrographic surgery
NASHA:	nonanimal stabilized hyaluronic acid
Nd:	neodymium
NLF:	nasolabial folds
NYU:	New York University
PGY:	postgraduate year
PLLA:	poly-L-lactic acid
RRC:	Residency Review Committee
TCA:	trichloroacetic acid
TLA:	tumescent local anesthesia
YAG:	yttrium-aluminum-garnet

I. SECTION AUTHORS

Surgical training in dermatology

C. William Hanke, MD
Ronald Moy, MD
Randall K. Roenigk, MD
Henry H. Roenigk, Jr, MD

Advances in dermatologic surgery

A. Marc D. Brown, MD
B. Alastair Carruthers, MD, Jean Carruthers, MD
C. Aimee L. Leonard, MD
D. Cynthia L. Bartus, MD
E. Mariano Busso, MD
F. Arielle N. B. Kauvar, MD
G. Kathryn M. Kent, MD, Thomas E. Rohrer, MD
H. Emily P. Tierney, MD
I. Omar A. Ibrahimi, MD, PhD
J. C. William Hanke, MD, Ronald L. Moy, MD
K. James M. Spencer, MD
L. Stephen Mandy, MD
M. Marina Landau, MD, Luitgard G. Wiest, MD, PhD
N. Emily P. Tierney, MD
O. Robert M. Bernstein, MD, MBA
P. Nils Krueger, PhD, Neil Sadick, MD

II. SURGICAL TRAINING IN DERMATOLOGY

Dermatology is an organ-based specialty of the skin, hair, and nails with major subspecialty fields of study in medical disease, pathology, pediatrics, and surgery. Dermatology is similar to other organ-based specialties such as ophthalmology, otolaryngology, and obstetrics-gynecology in which all medical and surgical aspects of the specialty are taught during residency training. Dermatology residents receive extensive training in the structure and function of skin, clinical diagnosis, and pathology, along with

Table I. Milestones in surgical training in dermatology

1970	ASDS is founded by Leonard Lewis, Sorrel Resnick, and 11 other founding member dermatologists. Norman Orentreich is elected as first president.
1970	First 1-year fellowship training program is started by Perry Robins at NYU.
1972	ASDS holds its first course: Basic surgical techniques for dermatologists.
1975	*Journal of Dermatologic Surgery* is founded by Perry Robins and George Popkin. Dr Robins is first editor-in-chief.
1982	First ASDS Core Curriculum for Dermatologic Surgery is completed by Ed Krull.
1987	ASDS Core Curriculum for Dermatologic Surgery is revised by C. William Hanke.
1988	Association of Academic Dermatologic Surgeons is founded by Ed Krull.
1990	Residency Review Committee for Dermatology (Ed Krull, Chair) receives approval from ACGME for special training requirements for all dermatology residency training programs to include complex closures, flaps, grafts, laser surgery, and nail surgery. ACGME also approves requirement for designated surgical program director for each dermatology residency program.
1991	ASDS Core Curriculum for Dermatologic Surgery is revised by C. William Hanke and Tom Meek.
1991	Testimony in favor of board certification in Mohs micrographic surgery and cutaneous oncology is given at COCERT by Ed Krull, C. William Hanke, and Martin Braun.
1998	Residency Review Committee for Dermatology (Randall Roenigk, Chair) receives approval from ACGME for revised surgical training requirements. Revised program requirements state "Residents should become familiar with hair transplantation, dermabrasion, sclerotherapy, laser resurfacing, liposuction, chemical peel, and tissue augmentation. In addition, residents should gain experience with Mohs micrographic surgery…Dermatologic surgery training should include appropriate anesthesia, electrosurgery, cryosurgery, laser surgery, biopsy techniques, and excisional surgery with appropriate closures, including flaps and grafts when indicated." The newly revised requirements for the surgical program director require "at least 5 years of experience (following residency) in the care of dermatology patients and as a teacher in a dermatology residency."
2003	ACGME approves 1-year procedural dermatology fellowship training program.
2004	First ACGME-approved 1-year procedural dermatology fellowship training programs begin.
2012	ACGME approves 57th procedural dermatology fellowship training program.

ACGME, Accreditation Council for Graduate Medical Education; *ASDS*, American Society for Dermatologic Surgery; *COCERT*, Committee on Certification; *NYU*, New York University.

medical and surgical treatment of over 3000 cutaneous diseases and tumors. Dermatologists have been responsible for many advances in dermatologic surgery over many decades.[1]

A postgraduate year (PGY)-1 (medicine, rotating, surgical) is completed before 3 years of dermatology residency training (PGY 2-4). Some dermatology residents complete elective rotations in general surgery, otolaryngology, plastic surgery, and other surgical disciplines during PGY-1, PGY-2, PGY-3, and PGY-4. The surgical training in dermatology is taught during residency as is required and documented by the Accreditation Council for Graduate Medical Education (ACGME). Some residents choose to receive added fellowship training (PGY 5), which is currently available in pathology and surgery (procedural dermatology) as overseen by the ACGME and pediatrics, which is overseen by the American Board of Dermatology (ABD). The ABD tests and certifies that dermatologists are competent in all aspects of the specialty including surgery. Subspecialty certification through the ABD is available in dermatopathology and pediatric dermatology, but is not currently available in procedural dermatology.

Many of the surgical procedures that are performed by dermatologists today did not exist 25 years ago. This is also the case for most specialties in medicine. The new procedures are learned by all physicians in the same way after residency. This is done through postgraduate medical education, which includes courses, seminars, and live surgery workshops. The postgraduate courses are attended by practicing physicians and also residents in training. These courses are rich learning experiences that are attended by thousands of dermatologists each year.

A. An abbreviated history of dermatologic surgery and early surgical postgraduate courses

Although surgery has long been part of the specialty of dermatology, a new era of dermatologic surgery began at New York University (NYU, New York, NY) in the 1950s. Dermatologists at NYU became leading practitioners of dermabrasion (Kurtin, Orentreich), chemical peel (MacKee), hair transplantation (Orentreich), Mohs Chemosurgery (Robins), and excisional skin surgery (Popkin). Goldman began performing cutaneous laser surgery at the University of Cincinnati in Cincinnati, Ohio in the early 1960s. The first surgery course to be held at the American

Academy of Dermatology (AAD) Annual Meeting was directed by Krull in 1967, the same year that Mohs founded the American College of Chemosurgery (now the American College of Mohs Surgery [ACMS]). The American Society for Dermatologic Surgery (ASDS) was started by Leonard Lewis and Sorrel Resnick and 11 other founding members in 1970 (Table I). The ASDS now has more than 5000 members.

The first comprehensive postgraduate courses on dermabrasion/chemical peel were held in New Orleans, LA, in the late 1970s. The course evolved into rotating postgraduate courses that were held in various parts of the country, directed by Henry Roenigk, Sam Stegman, and John Yarborough. The course that was held at Northwestern University Medical Center, Chicago, IL in 1983 included multiple live surgery demonstrations for the first time. Northwestern University later collaborated with the Cleveland Clinic Foundation and the University of California-San Francisco to hold courses in Florida, California, and Arizona. Live surgery demonstrations were beamed via satellite to packed lecture halls. The Skin Disease Educational Foundation later took over administration of the courses. Accreditation of postgraduate courses for continuing medical education became necessary for physician medical licensure and renewal.

Hugh Greenway began a comprehensive cadaver-based cutaneous anatomy course at Scripp's Clinic in San Diego, CA, in 1981. The course has been held continuously for the last 31 years. Surgery workshops using pig's feet were also organized in many parts of the country.

Many dermatologists traveled to Madison, WI, for short preceptorships with Fred Mohs in the 1960s and 1970s. The first formal 1-year fellowship training program in Mohs micrographic surgery (MMS) was founded by Robins at NYU in 1970. Shortly thereafter, training programs were started by Tromovitch and Stegman at University of California-San Francisco and Bailin at Cleveland Clinic Foundation under the auspices of the American College of Chemosurgery (now the ACMS), which had been established in 1967. Another organization, the American Society for Mohs Surgery (ASMS) was established in 1990. The ASMS does not require that members have fellowship training in MMS, whereas the ACMS requires it. Tromovitch and Stegman[2] later popularized the Mohs fresh-tissue technique in the early 1970s. This advance allowed immediate reconstruction of skin cancer wounds, which was not possible with the older fixed-tissue technique.

B. Surgical training program requirements in dermatology

Surgical training in dermatology takes place during the 3 years of dermatology residency in programs accredited by the Residency Review Committee (RRC) for dermatology on behalf of the ACGME. Surgical training in dermatology has expanded over the years to encompass a large variety of cosmetic, reconstructive, and dermatologic surgery procedures. The 3 years of dermatology residency is preceded by an introductory year of residency in internal medicine, pediatrics, or surgery.

Dermatology residents have always been taught surgical operative techniques necessary to perform excisional surgery for the treatment of skin cancers. Suturing techniques, local anesthesia, sterilization of instruments, skin preparation, and scar revision techniques have always been a part of dermatology training. The development of the 1-year surgical fellowship programs by the ACMS, beginning with Perry Robins' training program at NYU in 1970, had the effect of greatly expanding the number of academic surgical faculty dedicated to teaching residents skin surgery in dermatology residency programs and providing surgical procedures to dermatology patients. The number of full-time dermatologic surgeons at every major medical center had the effect of exposing most dermatology residents to sophisticated procedures such as complicated skin flaps, skin grafts, liposuction, laser procedures, scar revision techniques, and MMS. Ed Krull used survey results from dermatology residency programs to change the core ACGME requirements so that all programs were required to teach complex repairs, transposition flaps, rotation flaps, advancement flaps, and skin grafts. MMS was added in 1998, when Randall Roenigk chaired the RRC.

This surgical foundation established during medical school and dermatology residency and augmented by fellowship programs in procedural dermatology has been sustained and built upon in subsequent years of practice through courses and symposia accredited by the Accreditation Council on Continuing Medical Education and offered by educational institutions and professional societies such as the AAD, ASDS, ACMS, and ASMS. Some dermatologists also complete 1- to 2-year cosmetic surgery fellowship training programs administered by the American Academy of Cosmetic Surgery and other non-ACGME-approved fellowships in cosmetic laser procedures.

Dermatology training program requirements and board certification by the ABD. The core of dermatology and dermatologic surgery knowledge

and skills for all graduates of dermatology residency programs is derived from the standard requirements for dermatology residency training. These requirements are established and monitored by the RRC for Dermatology on behalf of the ACGME. The ABD requires graduation from an accredited ACGME-approved residency and passing the ABD certifying examination. The ABD outlines for graduates the surgical subjects that are contained in the certifying examination. These surgical subjects include suturing techniques, anesthesia, electrosurgery, nail surgery, cryosurgery, excisions, hemostasis, sterilization, MMS, flaps (advancement, rotation, and transposition), grafts, scar revisions, complex closures, lasers, phlebology, tumescent liposuction, hair restoration, use of neurotoxins, and use of fillers. These surgical subjects are developed by surgical dermatologists who are experts in these surgical subjects. An educational in-training examination is given yearly to all dermatology residents in addition to the certifying examination, which leads to the distinction of being board certified in dermatology.

Training as outlined by the RRC/ACGME should be sufficient to ensure knowledge or competence in the performance of cryosurgery, dermatologic surgery, cosmetic surgery, and laser surgery. Dermatologic surgery should be given emphasis and should include appropriate local anesthesia, electrosurgery, cryosurgery, laser surgery, nail surgery, biopsy techniques, excisional surgery, advancement flaps, transposition flaps, rotation flaps, and grafts. Residents should have exposure through observation or assisting with hair restoration, Mohs micrographic surgery, sclerotherapy, laser resurfacing, and use of neurotoxins, chemical peels and tissue augmentation. In addition, residents should be provided education relating to cosmetic procedures such as tumescent liposuction, scar revision and dermabrasion. Didactic training in cosmetic surgery is required by the RRC/ACGME. This surgical training is documented both by the program and the ACGME case log system by the residents. The ACGME case logs are used by all surgical specialties to document resident experience. Based on the program requirements, a lack of experience by residents in key surgical procedures can result in a program citation. The ACGME also uses this system to monitor the surgical experience in a specialty and has plans to make these data public.

The level of training in dermatologic surgery is divided into 3 categories. Dermatology residents should achieve competency in biopsy techniques, destruction of benign and malignant tumors, use of lasers for the treatment of superficial vascular tumors (eg, port wine stains), and excision of benign and malignant tumors with simple, intermediate, and complex repair techniques including flaps and grafts. Significant exposure to other procedures either through direct observation or as an assistant at surgery is required. Examples in this category include MMS and reconstruction of surgical defects, the application of a wide range of lasers and other energy sources, sclerotherapy, botulinum toxin (BoNT) injection, soft-tissue augmentation, and chemical peels.

Program faculty must provide education relating to certain cosmetic techniques without necessarily affording direct exposure. Among these are liposuction, scar revision, and dermabrasion. The program's experience in cosmetic surgery may vary depending on the nature and experience of the practice; however, didactic training in this area is required.

Dermatologists are specialists with expertise in the diagnosis and treatment of pediatric and adolescent patients with benign and malignant disorders of the skin, mouth, external genitalia, hair, and nails. Dermatologists have extensive training and experience in the diagnosis and treatment of all types of skin cancers. The dermatologists have expertise in the management of cosmetic disorders of the skin such as removal of excess hair, wrinkles, sun-damaged skin, hair loss, scars, and loose skin. Among the techniques used by dermatologists for the correction of cosmetic defects are laser resurfacing, tumescent liposuction, dermabrasion, chemical peels, hair transplantation, phlebology, and tightening procedures including face, brow and neck lifting, and injections of fillers.

C. History of fellowship training in dermatologic surgery

The ACMS was formed in 1967 with a principal mission to advocate for and train physicians in MMS. Soon thereafter, the Fellowship Training Committee (FTC) of ACMS was formed and program requirements developed. In the early years the training requirements were modest, but over time and under the leadership of the chairs of the FTC such as Drs Philip Bailin, Ted Tromovitch, Sam Stegman, Rex Ammonette, John Zitelli, Barry Leshin, and Ron Moy, the requirements evolved into a 1-year structured program that required a minimum of 500 MMS cases to be performed by the program with the fellow, along with a diverse array of other topics in cutaneous oncology and reconstructive surgery. Ron Moy, who chaired the FTC for 8 years, and the FTC members implemented the site visits, national matching program (1995), frozen section quality review, more stringent facility criteria, and the

transition to the future ACGME fellowship training programs that are now in existence.

In the early years there were a very few fellowship training programs, most notably at the University of California-San Francisco, the Cleveland Clinic, and NYU followed later by the University of Wisconsin at Madison where Fred Mohs developed the technique.

In the late 1980s, the ABD sought to create a subspecialty in MMS. In the 1970s the ABD had successfully codified the subspecialty of dermatopathology by developing ACGME-accredited standards for training and a subspecialty certifying examination, which greatly benefits all dermatologists to this day. Ed Krull founded the Association of Academic Dermatologic Surgeons in 1988, to promote, support, and critically assess the quality and scope of surgical teaching of residents and fellows by academic-based dermatologic surgeons. The group provided support for the concept of ACGME accreditation of surgical fellowships in dermatology. In 1991, Drs Ed Krull and Irwin Friedberg, on behalf of ABD, with testimony to American Board of Medical Specialties (ABMS) Committee on Certification by C. William Hanke and Martin Braun, proposed the new subspecialty to ABMS. However, the representatives from general surgery, plastic surgery, and otolaryngology were strongly opposed for a variety of reasons and the proposal was defeated.

In the 1990s, Dr Krull was chair of the RRC for Dermatology of the Accreditation Council for Graduate Medical Education (ACGME), which is charged with the oversight of all dermatology specialty and subspecialty training programs in the United States. Dr Randall Roenigk joined the committee in 1994 and succeeded Dr Krull as chair of the committee. After much discussion, Drs Krull and Roenigk led the effort to seek accreditation of a subspecialty training program in dermatologic surgery. The proposal was developed and first finalized in 1997. Unfortunately at the same time Medicare published IL-372, the intermediary letter clarifying the role of teaching physicians at academic medical centers for billing purposes. This ruling was followed by a series of audits (Physicians at Teaching Hospitals [PaTH] Audits). Program directors and department chairs were concerned about the impact of these new rules on their ability to be reimbursed for patient care provided in teaching programs. As a result, the creation of the new subspecialty was delayed as it was thought that ACGME accreditation of the new program might limit the ability of departments to bill for patient care services. There was also opposition from some dermatologists who thought that accreditation would put those without fellowship training at a disadvantage.

In 2000, the RRC decided to reopen the proposal for accreditation in the subspecialty. Between the years of 2000 through 2003, a series of negotiations occurred between specialties represented by the ACGME to vet concerns expressed by general surgery, plastic surgery, and otolaryngology. Some of the concerns centered on the amount of surgical training in dermatology and the name "dermatologic surgery." At that time, general surgeons thought that the word "surgery" should be limited to specialists who complete training in general surgery. ACGME policy at that time allowed ownership of certain terms by a specialty and hence required that the use of the term "surgery" be limited to the title of specialties that required a general surgery residency; just as the term "dermatology" could not be used by other specialties. For example, surgical specialties such as otolaryngology, ophthalmology, and obstetrics-gynecology do not use the term "surgery" to describe their specialty or subspecialties. After much discussion, a program in procedural dermatology was approved by the ACGME in 2003 allowing the first programs to become accredited in 2004.[4]

Between the years of 2004 and 2012, 57 programs in procedural dermatology were accredited. An important part of the process during this period included dual accreditation/approval from both the ACGME and ACMS. Some members of ACMS were still concerned about giving up the approval process for these programs. Under the leadership of Roenigk, Moy, the ACMS Fellowship Training Committee, the ACMS Board, and ACMS President Whitaker, it was recognized that ACGME accreditation of the fellowships would be a better process in the long run and consistent with that used by almost all specialties and subspecialties in organized medicine. There was a transition from the ACMS site visit accreditation to the ACGME accreditation process that includes ongoing program review, site visits, and review by the RRC and the use of the ACGME case log system to document the fellows surgical experience. The incorporation of cosmetic surgery into the training was a change for some ACMS programs. Fellowship training programs in private practice settings were required to adopt the same policies and procedures that were required of large university residency programs. ACMS completely discontinued the process of approving US programs by 2013 but continued to approve a small number of international programs. The ACMS continues to provide other resources including sponsorship of the annual match, conducting a slide review program needed

for accreditation, receiving grievances from fellows who are trained in private practice programs, and maintaining a forum for discussion between program directors.

After several years of preparation the ABD submitted its application for subspecialty certification in procedural dermatology to the ABMS in 2009. What happened in 2009 was quite different compared with the process in the late 1980s. General surgery, plastic surgery, otolaryngology, and other specialties now recognized that dermatologists had developed a surgical subspecialty in MMS, cutaneous reconstruction, and related procedures that was unique and valuable. They had very few concerns about giving a certification examination in this subspecialty sponsored by ABMS. Concerns about certification came mainly from the specialty of dermatology. One issue centered on the name "procedural dermatology" because it was considered to be too generic and did not properly reflect the practice of those who had been trained. All dermatologists are trained in skin surgery during their residency and most perform surgical procedures daily. In addition, there was concern about whether or not subspecialty certification would have an impact on a dermatologists' ability to bill insurance companies for surgical services. The ABD put a pause on the process after its first review by Committee on Certification to examine these concerns in more detail. As of this writing, the future of subspecialty certification in procedural dermatology is uncertain.

Subspecialty programs in procedural dermatology remain accredited by the ACGME. Many programs have undergone several reviews and continue to improve through this process. The program requirements have also undergone review and will continue to be improved with input from organized medicine.

Based on a review of claims data from the Center for Medicare and Medicaid Services it is clear that dermatologists perform more surgery on the skin than any other specialty.[5] This is in great part because of our aging population and the epidemic of skin cancer. MMS and the other dermatologic surgical procedures for the treatment of skin cancer continue to be important tools to manage an increasingly significant health care problem in this country. Access to dermatologic surgical care for the treatment of skin cancer and other cosmetic procedures unique to our specialty must be taught in residency and fellowship programs, and be a part of continuing medical education for physicians engaged in lifelong learning. Regardless of whether a dermatologist has taken an added year of fellowship training, it is the expectation of the ACGME, ABMS, and ABD that all dermatologists be competent in the surgical treatment of skin disease.

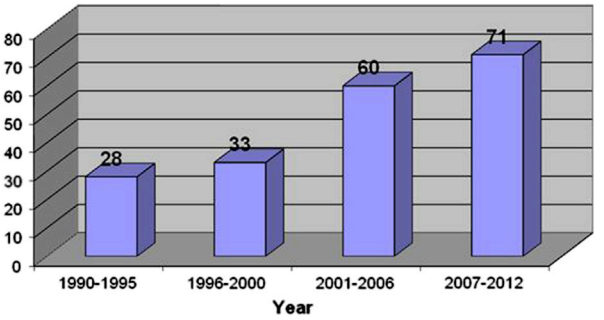

Fig 1. Number of new dermatologic surgery/oncology textbooks published during recent 5-year periods.

D. The literature and books of dermatologic surgery

Journals. The founding of the *Journal of Dermatologic Surgery* by Robins and Popkin in 1975 was an important event in the evolution of dermatologic surgery. The journal has published a steady stream of instructional and research articles covering dermatologic oncology, reconstructive surgery, laser and cosmetic surgery, and cosmetic dermatology. The journal was purchased from Elsevier Science Publishers by the ASDS in 1995. The journal name has evolved from the Journal of Dermatologic Surgery (1975) to the Journal of Dermatologic Surgery and Oncology (1977) to Dermatologic Surgery (1995). Special topic issues such as lasers and fillers are frequently published alongside regular monthly issues.

Other major dermatology journals such as the *Journal of the American Academy of Dermatology* and the *Archives of Dermatology* regularly publish articles on many aspects of dermatologic surgery. Other dermatology journals such as the *Journal of Drugs in Dermatology* also publish surgical articles and special surgical issues.

Books. A multitude of books on dermatologic surgery and oncology have been authored or edited by dermatologists over many decades. The number of new books has steadily increased from 28 (1990-1995) to more than 70 (2007-2012) (Fig 1).

Many of these journals and books are formally reviewed by dermatology residents and procedural dermatology fellows, along with academic faculty and physicians in private practice.

E. History of patient safety and the AAD

The safety of the patient is the most important thing, and the AAD has been active in the

area of patient safety for a number of years. Dermatologists have pioneered minimally invasive outpatient dermatologic surgery procedures that are performed safely and effectively using topical, local, or tumescent local anesthesia (TLA). The outcomes are superior and complications are infrequent and minor. MMS for skin cancer and liposuction using TLA are 2 well-documented examples whereby patients are spared more invasive procedures under general anesthesia.

The AAD was one of the first national specialty organizations to develop a patient safety initiative. The AAD held a Patient Safety Summit on August 7, 2007, in New York, NY. More than 100 AAD leaders and many leaders in other areas of medicine attended. Many patient safety subject areas were covered by experts in the field including: "Establishing a strategy for patient safety in a medical specialty: lessons from the anesthesia experience" (Jeffrey B. Cooper, PhD, Executive Vice-President, Anesthesia Patient Safety Foundation); "Scope of practice in medicine" (James N. Thompson, MD, President/CEO, Federation of State Licensing Boards); "Scope of practice panel" (William H. Beeson, MD, Vice-President, Indiana Medical Licensing Board); "Scope of practice expansion by nonphysicians" (Stephen H. Mandy, MD); "Lasers and scope of practice" (Roy G. Geronemus, MD); "Day spa nightmares" (Deborah Sarnoff, MD); "Supervision of PAs and NPs" (Roger I. Ceilley, MD); "Mandatory adverse event reporting" (Brett M. Coldiron, MD); "Office accreditation panel" (Duane C. Whittaker, MD, Roy C. Grekin, MD, W. Patrick Davey, MD, Pat Ferrigno, MS); "Dermatology malpractice: a 20-year analysis of malpractice claims against dermatologists" (Sandra I. Read, MD); "Patient safety organizations" (William H. Beeson, MD); "Patient safety research" (Doral Rosauer, MBA, Katie B. Baeverstad, MD); and "The case for a dermatology credentialing verification organization" (C. William Hanke, MD, Pat Ferrigno, MS, William H. Beeson, MD).

After the Patient Safety Summit, an AAD Ad Hoc Task Force on Patient Safety was formed with James S. Taylor, MD, as Chair. The charge of the ad hoc task force was to: (1) define the current state of patient safety in dermatology; (2) evaluate existing academy activities; (3) identify gaps and priorities; (4) recommend changes in the existing portfolio; and (5) develop a strategic plan for patient safety for the AAD. A strategic plan for patient safety for the AAD was completed. The ad hoc task force was then disbanded and an AAD Committee on Patient Safety and Quality was established in 2009 with C. William Hanke, MD, as Chair. The mission of the committee was to: (1) define the current state of patient safety and quality in dermatology; (2) evaluate existing academy activities, identify gaps and priorities, and recommend changes in the existing portfolio; and (3) develop a comprehensive strategy for developing a culture of patient safety and quality in dermatology within the AAD. Three task forces of the committee were established: (1) performance measurement; (2) patient safety curriculum; and (3) data collecting and reporting.

The AAD has been an advocate for mandatory adverse event reporting in every state. It is only through verifiable data collection on adverse events that problems can be identified and quantified.[6] Solutions can then be crafted to prevent future adverse events. Coldiron et al[7-9] reported multiple times on the Florida database for mandatory reporting of adverse events for offices that has been in place since 2000. The most recent report also included adverse event reporting for Alabama.[10] Reporting of surgical complications that occurred in the offices were reported by physicians to a central agency in both states. Cosmetic procedures were responsible for roughly half of all adverse events reported in Florida and Alabama. Plastic surgeons reported the greatest number of complications. The majority of the fatalities and complications occurred in patients who received general anesthesia. There were no fatalities reported by dermatologists, and the number of complications was extremely small.

F. Conclusion

The fertile academic environment of academic training programs with interaction between established dermatologic surgeons and fellows, along with the inquisitive and innovative nature of many of our colleagues, has led to numerous advances in dermatologic surgery, which are described subsequently.

III. ADVANCES IN DERMATOLOGIC SURGERY

In October 1999, an article titled "Current issues in dermatologic office-based surgery" was published in this journal.[1] The article chronicled the myriad of cutaneous surgical techniques that have been developed and pioneered by dermatologists. Many more advances have occurred since 1999. In March 2012, the Board of Directors of the AAD commissioned the AAD Ad Hoc Task Force on Office-based Surgery to update the previous article. This article is intended as an update, and the reader is referred to the previous article for historical details. The authors and co-authors of the various sections of the new article are all dermatologists who have

been involved in the developments and refinements that have occurred since 1999.

Dermatologists and dermatologic surgeons have continued to demonstrate leadership in office-based surgery and cutaneous oncology. Training in dermatologic surgery is required for all dermatology residents. Some residents undergo additional surgical training through 1-year ACGME-approved fellowship-training programs in procedural dermatology. Of these programs, 57 are currently accredited by ACGME.

Dermatologists are the only specialists in medicine who receive comprehensive training in the clinical diagnosis, basic science, pathophysiology, dermatopathology, and medical and surgical treatment of over 3000 cutaneous diseases and tumors. This foundation is the key to the advancements that have occurred in dermatologic surgery and the other areas of dermatology as well.

A. MMS and reconstruction

MMS has advanced significantly since Fred Mohs[11] first described the surgical technique with zinc chloride paste more than 60 years ago. Tromovich and Stegman[12] reported on the success of MMS using the fresh tissue technique. Over the past 3 decades, MMS has expanded and flourished and has given us new insights into the management of complex and challenging skin cancers. Although the terms "gold standard" and "standard of care" should be used wisely and sparingly, it is likely the case that MMS has established itself as such for the treatment of nonmelanoma skin cancers. Reviews by Rowe et al[13,14] established a low recurrence rate of 1% for primary basal cell carcinomas and 5.6% for recurrent basal cell carcinomas treated with MMS. For squamous cell carcinoma, the success rate for primary tumors treated with MMS is approximately 95%.[15]

MMS is highly successful because of precise horizontal sectioning and meticulous microscopic inspection of tumor margins. The most unique aspect of the Mohs procedure is the fact that the physician serves as both the surgeon and pathologist, a role dermatology embraced because of our unique training in both skin surgery and dermatopathology. MMS has grown in popularity and demand because of the exploding incidence of skin cancer (approximately 3.5 million new cases per year of nonmelanoma skin cancer) and increased numbers of highly skilled trained Mohs surgeons performing the procedure. In addition, MMS has been established as an extremely safe, well-tolerated, and highly accepted surgical procedure with a very low incidence of nonlife-threatening complications.[16] Patients who might otherwise be at risk undergoing general anesthesia can safely complete MMS under local anesthesia.

MMS has the potential risk to be an overused procedure, which is why recent appropriate use criteria for MMS have been published.[17] MMS is best used for high-risk basal cell carcinomas including recurrent tumors, those in high-risk anatomic locations, aggressive histologic subtypes, incompletely excised tumors, larger size tumors, and for patients who are immunosuppressed. Likewise, invasive squamous cell carcinomas of the head and neck are indications for MMS. Melanoma in situ (>50,000 new cases per year) especially the lentigo maligna subtype, can be challenging because of the location on the face, ill-defined margins, and subclinical extension. MMS (especially with the use of immunostains) has been shown to be highly effective for lentigo maligna with a very low recurrence rate.[18] MMS has been described for the treatment of several rare cutaneous tumors. Although studies can be hampered by smaller numbers and retrospective reviews, there clearly is a robust literature to support MMS as a superior treatment versus standard wide excisions for these unusual cutaneous neoplasms. Rare tumors that are amenable to treatment with MMS include dermatofibrosarcoma protuberans, microcystic adnexal carcinoma, atypical fibroxanthoma, superficial leiomyosarcomas, sebaceous carcinomas, and extramammary Paget disease.[19-23] Merkel cell carcinomas, especially those on the head and neck, have been treated with MMS[24] but new standards also recommend the performance of sentinel lymph node biopsies, typically performed by surgical oncologists.

In summary, MMS has been documented to be safe and effective. Its use has increased 400% and currently 1 of every 4 skin cancers is treated with MMS.[17] It is a procedure of ongoing innovation and improvement. Its distinct advantages include: (1) the highest documented cure rate; (2) tissue conservation as a result of smaller margins; (3) safety and tolerability in an outpatient setting; and (4) immediate reconstruction with confidence that clear margins have been ascertained. Challenges include a longer procedure for the patient because of waiting time for the frozen sections and the need for excellent quality control of the laboratory. The preparation of excellent quality frozen sections is a highly skilled procedure and a Mohs surgeon is only as good as the technician and laboratory. MMS has been reported to be a more expensive procedure but studies have documented that it is very cost-effective, especially

compared with excision in an ambulatory surgery center.[25,26]

Along with the increased use of MMS has come the remarkable advancements and refinements in facial reconstruction. From the earliest days of allowing Mohs defects to heal by second intention, dermatologic surgeons have led the way in creative and novel reconstructions with advanced flaps and grafts. Zitelli[27] revolutionized the use of a bilobed flap for nasal reconstruction by redefining its arc of rotation.

Likewise, Zitelli[28] modified the melial labial transposition flap to make it a cosmetically acceptable 1-stage procedure. Dzubow[29] refined and popularized the dorsal nasal rotation flap for nasal defects. Skouge[30] described the use of the island pedicle flap for cutaneous lip reconstruction and others defined its use for the forehead, cheek, and nose. Papadopoulous and Triner[31] described a myocutaneous island pedicle flap for nasal tip reconstruction. More complex staged interpolation flaps, including paramedian forehead flaps and cheek-to-nose flaps were popularized by Mellette,[32] Brodland,[33] and Fader et al.[34] Cook[35] explained modifications of the Spear turnover flap and other creative approaches to alar reconstructions. Advanced skin grafting techniques with cartilage support have been described by Otley[36] and Adams and Ratner.[37] Finally, dermatologists have always been on the leading front to define when primary closures or even second-intention healing is not only simpler but likely to result in better cosmesis.[38]

B. Botulinum toxin

Although originally developed for therapeutic use, BoNT received international attention when Jean Carruthers[39] and her dermatologist spouse, Alastair Carruthers, published their landmark trial in 1992, demonstrating that small amounts of BoNT injected into the forehead could improve the appearance of glabellar rhytides for up to 3 months. A decade later, Carruthers et al[40] published the results of a multicenter, double-blind, placebo-controlled randomized trial that led to the Food and Drug Administration (FDA) approval of BoNT for the treatment of glabellar rhytides. In addition to further research by Carruthers and Carruthers,[41,42] many dermatologists—including Becker-Wegerich et al[43] and Lowe and Yamauchi[44]—contributed to the early research that furthered the understanding of the toxin and its use for the treatment of a variety of hyperkinetic facial lines in the upper and lower aspect of the face, neck, and chest with a high degree of patient satisfaction.

Over the next 10 years, the use of BoNT expanded to include facial sculpting and the restoration of symmetry: Flynn et al[45] widened eyes, whereas Huilgol et al[46] and Carruthers and Carruthers[47] induced a chemical brow lift. Moreover, it became apparent that BoNT was particularly effective when used in combination with soft-tissue augmentation, laser resurfacing, light-based therapies, and surgery, as reported by dermatologists West and Alster,[48] Fagien and Brandt,[49] Carruthers et al,[50-52] and Khoury et al.[53]

In 1994, researchers first demonstrated that BoNT produced localized anhidrosis in the faces of patients treated for hemifacial spasm.[54] Since then, a number of dermatologists have demonstrated the therapeutic efficacy of BoNT in patients with palmar and axillary hyperhidrosis, including Glogau,[55] Shelley et al,[56] Heckmann et al,[57] Lowe et al,[58] Glaser et al,[59] and Solish et al.[60]

Twenty years of cosmetic use has yielded a wealth of information regarding the efficacy and safety of long-term treatment. Dermatologist Arnold Klein[61] meticulously detailed side effects and more serious—although rare—complications, whereas Rzany et al,[62] Carruthers et al,[40,63] and Cohen et al[64] analyzed large pools of data to demonstrate minimal adverse effects and establish the long-term safety of BoNT for cosmetic indications.

C. Hyaluronic acid fillers

In the past 15 years, there has been an explosion of interest, use, and availability of hyaluronic acid (HA) filling agents. HAs have become the leading filler agents worldwide, surpassing collagen products, which had previously dominated the filler market. The most widely used HA fillers are produced from bacterial (*Streptococcus*) fermentation, with this class of dermal fillers designated as nonanimal stabilized HA (NASHA), distinguishing them from earlier animal-sourced products. Currently, there are dozens of NASHA formulations available worldwide. Variations in product performance, tolerance, and durability have been associated with differences in cross-linking, molecular weight, concentration, particle size, and addition of anesthetic agents.

Initial studies establishing the biologic compatibility and stability of HA as a filler material were pioneered by dermatologists Piacquadio et al[65,66] in both a guinea pig model and in a multicenter clinical study. Dermatologists Narins et al[67] led a pivotal randomized double-blind multicenter split-face study in 138 patients that first demonstrated superior efficacy and comparable safety of NASHA (Restylane) compared with

collagen (Zyplast) over 6 months. Subsequent studies led by dermatologists explored differences in efficacy and tolerability among the various HA fillers emerging in clinical use. In a randomized, double-blind comparison of 150 patients, Carruthers et al[68] demonstrated superior durability and comparable safety of the NASHA (Restylane Perlane) at 6 months compared with Hylaform, a cross-linked HA sourced from rooster combs. In a prospective, randomized, comparative, multicenter study of 248 patients, Dover et al[69] compared a large-particle NASHA-based filler with a small-particle NASHA filler and found similar efficacy, durability, and safety profiles. Narins et al[70,71] further explored the long-term efficacy and effects of different NASHA (Restylane) retreatment schedules, demonstrating persistence of correction beyond the expected 6 to 12 months when retreatment was performed before dissolution of the initial treatment product. Dermatologists were the first to describe in vivo deposition of new collagen after dermal injections of both HA filler and calcium hydroxylapatite (CaHA) via histologic and biochemical analysis. It is postulated that this stimulatory effect may be induced by mechanical stretching of the dermis thereby leading to activation of dermal fibroblasts.[72,73]

Dermatologists were among the first to establish safety data on HA fillers. Friedman et al[74] reported the first retrospective review of adverse reactions associated with early NASHA injection, which included data from over 144,000 patients worldwide. The authors found that localized hypersensitivity reactions were the major adverse event associated with injection, and that these declined dramatically after more purified source material became available.

Dermatologists made significant contributions to the early evolving literature on HA side effects and their appropriate management.[75-79] One benefit of HA fillers is the unique ability to correct and reverse complications through the injection of hyaluronidase to enzymatically degrade the HA material.[80] Glogau and Kane[81] demonstrated a direct correlation between injector techniques such as rapid injection and higher volumes with the rate of local adverse events in a prospective, blinded, controlled study of 283 patients undergoing NASHA injection. Taylor et al[82] and Grimes et al[83] have established safety and efficacy of HA filler injections in over 300 patients with skin of color in 2 prospective randomized clinical trials. Dermatologists have been leaders in establishing guidelines and consensus recommendations for appropriate use of HA dermal fillers to optimize patient safety and satisfaction.[84-86]

HA fillers are FDA approved for correction of "moderate to severe facial wrinkles and folds such as the nasolabial folds" (NLF). However, they have been widely and successfully used for off-label volume enhancement of the vermilion lip, perioral area, suprabrow region, earlobes, back of hands, prejowl sulcus, and tear troughs.[87-89] Dermatologists Alam et al,[90] Goldman et al,[91] and Carruthers et al[51,92] have also explored the safety and synergistic effects of combining HAs with other treatment modalities such as radiofrequency,[90] intense pulsed light,[91] and BoNT.[51,93] Dermatologists have helped to establish more recent advances in formulation and technique including combining HA fillers with lidocaine to optimize tolerability[93] and injection through a blunt-tipped cannula to minimize pain, bruising, and edema.[94]

As the demand for noninvasive cosmetic procedures continues to grow, the science of injectable soft-tissue fillers, including HAs, will continue to evolve. Dermatologists have been, and will continue to be, at the forefront of evolving HA filler practice, safety, and material technology.

D. Poly-L-lactic acid filler

Injectable poly-L-lactic acid (PLLA) is a filler device used to stimulate collagen production to restore lost facial volume. It differs from other facial fillers such as HA in that PLLA does not directly fill in lines or depressions, but instead induces a host response resulting in a gradual correction of the volume-depleted area.[95] As volume is restored, however, the NLF, marionette lines, and other undesirable lines are corrected.[96]

Injectable PLLA has been used worldwide for more than a decade to treat soft-tissue atrophy related to aging, photoaging, and HIV-related lipoatrophy. Safe use of PLLA requires working knowledge of facial anatomy including location of major nerves, vessels, and fat pads. An understanding of the changes to the face that occur with aging/photoaging and HIV-related lipoatrophy is imperative. Full comprehension and awareness of the different properties of the skin and soft tissue in the various cosmetic units of the face is necessary for the safe injection of PLLA.[85] This knowledge is not unique to dermatologists, but dermatologists have received extensive training on these topics through residency training, fellowship training, and continuing education.

Dermatologists have played an essential role in establishing the safety and efficacy of injectable PLLA. European dermatologists and skin specialists developed the safe injection techniques for this

unique device before the introduction of PLLA in the United States. Early work by Vleggaar[96] and Lowe[97] helped establish the injection techniques and demonstrated efficacy of PLLA for sculpting and rejuvenating the aging face. One of the noted frequent side effects of injectable PLLA was the delayed formation of subcutaneous nodules. Through the collective experiences of dermatologists, reconstitution protocols and injection techniques have evolved leading to a notable reduction in the formation of subcutaneous nodules.[98-102]

Injectable PLLA has been approved in the United States since 2004. The product was initially approved for treating HIV lipoatrophy associated with highly active antiretroviral therapies. Again, dermatologists played a pivotal part in understanding the role of PLLA in the management of this stigmatizing side effect of HIV treatment.[103] Hanke, Redbord, and Levy[99,100] published an extensive case series on the safety and efficacy of injectable PLLA for treating HIV lipoatrophy. Dermatologists have continued to provide their expertise in treating HIV facial lipoatrophy.

In 2009 PLLA was approved by the FDA for aesthetic use.[104] The experience of dermatologists was imperative in gaining FDA approval of the device. Work by dermatologists including Fitzgerald and Vleggaar,[105] Palm et al,[102] Hanke and Redbord,[99] Narins et al,[101] and Burgess and Quiroga[103] helped establish the efficacy of PLLA for cosmetic use and has continued to demonstrate the safety of this facial volume restoration device.

Injectable PLLA is a safe and effective filler to restore the lost facial volume that contributes to the appearance of the aged face. The skills and knowledge that are needed to perform PLLA injections in the office are taught to dermatology residents during their core training. Frequent publications in the dermatology literature on the use of PLLA further contribute to the knowledge base and keep dermatologists at the forefront of using this unique facial filler. Without the work of dermatologists, this product would not have its established safety profile or be widely available for treating facial soft-tissue atrophy.

E. Calcium hydroxylapatite filler

CaHA is one of the natural components found in human bone. Synthetic CaHA is manufactured as Radiesse by Merz Aesthetics (San Mateo, CA). It consists of microspheres of CaHA, 25 to 45 μm in diameter, in a soluble carboxymethylcellulose gel carrier. Although it is now a popular compound for aesthetic use, synthetic CaHA was originally developed for the treatment of stress urinary incontinence and oropharyngeal repair.[106]

In 2002, Dr Mariano Busso was the first dermatologist in the United States to explore the use of CaHA for aesthetic enhancement. He developed a novel 3-dimensional vectoring filler injection technique, in which the face is conceptualized in different mobility zones. Vectoring can address surplus skin reduction and structural enhancement.[107] Busso developed a series of injection techniques for optimum and safe use of CaHA for malar,[108] zygomatic, temporal, and supraciliary regions[109]; the lower aspect of the face[110]; and nonfacial areas such as hands.[111]

CaHA has several properties that make it an important tool in the facial recontouring armamentarium.[112,113] These include lack of allergenicity, longer tissue residence, and high elasticity (G′). Limiting factors include its radiopacity and tendencies to produce nodules when injected in lips and to show filler visibility after superficial injections. Instead, it should be injected at the junction of the dermis and the subcutaneous level or, when volumization is required, supraperiosteally.

The pivotal trial compared CaHA with human-based collagen for correction of NLF in 117 patients.[112] In the randomized, bilateral, and prospective study, subjects were treated with CaHA in one fold and with collagen in the other; they were followed up for as long as 6 months. Of subjects, 79% had superior improvement on the CaHA side through 6 months ($P < .000$) using the Global Aesthetic Improvement Scale ($P < .0001$). Significantly less volume of CaHA was needed for optimal correction, compared with collagen ($P < .0001$). Adverse events were generally comparable between the 2 groups, though increases in bruising and edema were noted in the CaHA-treated fold.

Subsequent results of this same trial were reported extending more than 3 years.[113] Of the original 117 subjects, 99 subjects were available for all 3 years. Using the Global Aesthetic Improvement Scale, researchers found that, at 30 months, 40% of the CaHA-treated folds were rated as "improved" or better. No long-term or delayed-onset adverse events were reported, including "no reports of nodules, granulomata, or infections."

Patients reported immediate post-CAHA injection discomfort. To address the issue of pain control, Busso and Applebaum[114,115] developed a method of mixing lidocaine with CaHA immediately before injection. A Luer lock-to-Luer lock connector between a syringe containing lidocaine and a syringe containing CaHA allows the lidocaine to

mix with the CaHA without altering the duration of the correction. In 2009, the FDA approved the technique for mixing lidocaine with CaHA.

In the controlled, randomized, patient-blinded, split-face clinical trial, 50 subjects received CaHA without lidocaine in one NLF and CaHA premixed with 2% lidocaine in the other NLF.[116] Subjects reported statistically significantly less pain in the NLF treated with CaHA premixed with lidocaine immediately posttreatment ($P < .001$) and 48 subjects (96%) expressed a preference for CaHA premixed with lidocaine.

In nonfacial areas, the Busso hand injection technique of CaHA was the basis of the first clinical trial to measure the efficacy of a dermal filler for hand augmentation.[117] A multicenter, blinded, randomized clinical trial addressed the use of CaHA in hand rejuvenation. In this study, 101 subjects were randomized to receive CaHA (76 patients) or to receive no treatment. Using the validated Busso Hand Volume Severity Scale, researchers found that the treatment group was statistically significantly improved compared with the control ($P < .0001$). No adverse effect on hand function was noted in the study.

The Busso method of CaHA mixed with lidocaine has since been expanded to adjust rheological properties of CaHA[118] and other fillers as well.[119] Today, use of a Luer lock-to-Luer lock connector to tailor filler characteristics has become a familiar technique in the field of tissue augmentation.

F. Laser treatment of vascular lesions

The treatment of congenital and acquired vascular lesions is one of the most commonly requested and performed cutaneous laser and light-based office procedures. The pulsed dye laser was the first laser that was developed based on the theory of selective photothermolysis, a conceptual framework proposed by dermatologists Anderson and Parrish[120] in the 1980s. Their theory revolutionized the treatment of vascular lesions, and continues to serve as the basis for most cutaneous laser and energy-based treatments today.

Clinical studies of the original pulsed dye laser and its subsequent refinements by dermatologists Garden et al,[121,122] Ashinoff and Geronemus[123] and others[124] demonstrated its efficacy and high safety profile for treating pediatric and adult port wine stains, infantile hemangiomas, and other vascular lesions. Before the development of pulsed laser therapy, there was no adequate treatment method for port wine stain birthmarks that characteristically hypertrophy with time, leading to cosmetic disfigurement, psychological impairment, and other medical complications.[125,126] Numerous studies have demonstrated that the best results are achieved when treatment is initiated early in infancy or childhood, and that even with multiple, repetitive treatment sessions in a pediatric population, the risk of scarring or long-term pigment alteration is rare.[127] Recent studies by dermatologists Izikson et al[128] and Tierney and Hanke[129] demonstrated the benefit of the more deeply penetrating alexandrite laser for the treatment of hypertrophic and recalcitrant port wine stains. Dermatologists are currently investigating novel techniques to improve port wine stain treatment, including the combination of laser and antiangiogenic or immunomodulatory drugs.[130]

Infantile hemangiomas are common, benign vascular lesions of infancy that are often present on the head and neck. During their growth phase, hemangiomas can obstruct vital organs; they often heal with residual fibrofatty tissue and they negatively impact the psychosocial development of the affected children. Dermatologists Garden et al,[124] Morelli et al,[131] and Geronemus and Kauvar[132] showed that pulsed dye laser can slow the proliferation of hemangiomas during their growth phase, speed their involution, and stimulate epithelialization of ulcerated lesions. Fractional resurfacing lasers are now being used to treat the residdum of involuted hemangiomas.[133]

Dermatologists developed and improved the techniques to treat telangiectases, rosacea, poikiloderma, spider angiomas, cherry angiomas, pyogenic granulomas, and venous lakes.[134] Bernstein and Kligman[135] showed that laser treatment of rosacea-associated telangiectasia and erythema also improves the symptomology associated with the flushing and blushing and reduces the number of inflammatory lesions. Studies by dermatologists revealed that the pulsed dye laser, used with repetitive high-energy pulses, effectively treats recalcitrant warts, including plantar and periungual lesions, without the morbidity and scarring observed with other destructive methods.[136] Pioneering work by Alster and Williams[137,138] using the pulsed dye laser at low fluences transformed the treatment of erythematous and hypertrophic scars, and McDaniel et al[139] demonstrated its efficacy in treating stretch marks.

In the 1990s, the 532-nm pulsed KTP, 755-nm long-pulsed alexandrite, and 1064-nm pulsed neodymium (Nd):yttrium-aluminum-garnet (YAG) lasers were explored for vascular lesion treatment. Goldman et al[140] pioneered the use of intense pulsed light, noncoherent light delivered by a flashlamp with millisecond domain pulses, for the treatment

of vascular and pigmented lesions. Studies by dermatologists Dierickx et al[141] showed that longer pulse durations were ideally suited for the treatment of telangiectasia and enabled purpura-free treatment of most acquired vascular lesions and greater patient acceptance of these procedures. The introduction of skin cooling techniques using cryogen, cold air, or contact cooling devices improved treatment outcomes for congenital and acquired vascular lesions by protecting the epidermis and allowing the safe use of higher energy laser pulses.[142,143]

Kauvar and Lou,[144] Kauvar and Khrom,[145] Omura et al,[146] and Parlette et al,[147] optimized parameters for the treatment of spider and reticular leg veins by using the more deeply penetrating, near-infrared alexandrite and Nd:YAG lasers. Goldman and Weiss were instrumental in developing endovenous closure, a technique that has largely replaced venous stripping for greater saphenous vein incompetence, whereby a bare laser fiber or radiofrequency-emitting catheter is introduced directly into the vein.[148]

G. Treatment of tattoos and pigmented lesions

Three years after Dr Theodore Maiman[149] created the first laser using a synthetic ruby crystal, dermatologist Dr Leon Goldman[150] became the first physician to use therapeutic laser energy on the skin. Goldman observed highly selective injury of pigmented structures after treatment with the laser, prompting further investigation into its potential applications. In the years that followed these initial observations, Goldman et al[150] conducted experiments demonstrating the ability of the ruby laser to selectively destroy pigmented lesions, tattoo, and blood vessels. In 1983, dermatologists Anderson and Parrish[120] described their groundbreaking theory of selective photothermolysis, shedding light on the physics at work in earlier observations of Goldman. Their groundbreaking theory that set the stage for the modern laser era states that through the use of the appropriate wavelength of light and pulse duration one may precisely target and destroy a given chromophore.

Since the field's inception, dermatologists have been at the forefront of laser skin surgery. Armed with the knowledge of selective photothermolysis, in the late 1980s and 1990s pioneering dermatologists such as, Geronemus, Kilmer, Wheeland, Goldberg, and Anderson[151,152] continued to explore the clinical use of lasers for the treatment of both endogenous and exogenous pigment in the skin. The theory of selective photothermolysis predicted that the small size of melanosomes and tattoo particles would benefit from the use of very short pulse durations, in the submillisecond range. Clinically, this has been accomplished through the use of Q-switched lasers. Today the Q-switched ruby, Q-switched Nd:YAG, and Q-switched alexandrite lasers remain the workhorses for the treatment of pigmented lesions. However, over the past decade there have been many exciting discoveries, innovations, and new additions to the armamentarium.

Although Q-switched lasers emit laser light with pulse durations in the nanosecond range, data now suggest tattoo pigment particles may be more precisely targeted and completely destroyed by even shorter pulse durations, in the picosecond range. In 1998, dermatologists Ross et al[153] treated 16 black tattoos in a split lesion study with a Q-switched Nd:YAG laser and a picosecond Nd:YAG laser. While holding all other parameters constant, picosecond laser pulses were more efficient at clearing tattoo pigment than nanosecond domain pulses. One year later, dermatologists Herd et al[154] demonstrated superior tattoo clearance in a guinea pig model with a picosecond titanium:sapphire (795-nm) laser versus the Q-switched alexandrite (755-nm) laser. In a more recent study, Izikson et al[155] showed superiority of a picosecond laser when treating tattoo in a pig model when compared with a nanosecond laser of similar wavelength.

Another study by Saedi et al[156] also showed superiority of the picosecond alexandrite laser in tattoo removal. Benign pigmented lesions and colored tattoos also respond favorably to treatment with picosecond laser pulses. Dover et al[157] achieved 100% clearance of pigmented lesions by 2 treatments with a picosecond alexandrite laser. Brauer[158] found this same laser to be effective in clearing difficult-to-treat blue and green tattoos.

Depending on color, age, and mechanism of placement, tattoo removal may require 6 to 10 treatments or more. Typically treatment sessions are spaced at 4- to 6-week intervals, necessitating that the patient return for multiple visits over a treatment period that may span years. However, recent work by dermatologists Kossida et al[159] suggest that this observed time between treatment sessions may be unnecessary. In their study 18 tattoos were divided in half and randomized. One half was treated with a single pass from a Q-switched alexandrite laser while the other half was treated with 4 passes with the same laser separated by 20 minutes. At 3 months the 4-pass treatment showed significantly greater clearing than the conventional single-pass treatment, often with complete tattoo clearing after the single treatment. This new

technique may significantly reduce the number of treatment visits to clear tattoos.

In 2004, another breakthrough in laser skin surgery introduced a different approach to the elimination of unwanted skin pigment. Fractional photothermolysis, first described by Manstein et al,[160] delivers laser light to only a fraction of the treated surface area by splitting it into many microbeams. Vertical microscopic columns of tissue damage are created leaving intervening tissue intact and allowing more rapid healing. Using a novel fractionated 1540-nm nonablative laser, dermatologists Laubach et al[161] observed the microepidermal necrotic debris generated by the laser to be eliminated transepidermally. As the microepidermal necrotic debris was eliminated it carried excess and unwanted pigment with it, acting as a vehicle for controlled melanin release. Later it was confirmed that dermal necrotic debris created may be eliminated in the same manner.[162]

Fractional photothermolysis has proved to be effective for many disorders of hyperpigmentation. Dermatologists Kouba et al[163] successfully treated nevus of Ota in Asian skin with a fractionated 1440-nm Nd:YAG laser without resultant postinflammatory hyperpigmentation. Dermatologists Weiss and Geronemus[164] showed improved tattoo clearing when conventional Q-switched pigment lasers were combined with fractionated devices.

One of the benefits of nonablative fractional photothermolysis as a means of pigment elimination is the low rate of posttreatment pigmentary complications, especially in darker skin. This attribute may be particularly useful in a condition such as melasma, which typically occurs in Fitzpatrick skin types III to V. Rokhsar and Fitzpatrick[165] showed a high rate of response in melasma treated with 1550-nm erbium (Er)-doped fiber laser. Rokhsar and Ciocon[166] and Katz et al[167] both demonstrated the 1550-nm Er-doped fiber laser to be effective in the treatment of postinflammatory hyperpigmentation as well. The fractionated 1927-nm laser was also shown to be very effective in the treatment of melasma by Polder and Bruce.[168] Recently, the use of very low fluence Q-switched Nd:YAG devices to treat melasma has been shown to be very effective in studies by Polnikorn,[169] Jeong et al,[170] and Kauvar.[171]

Dyschromia, universally a component of photodamaged skin, responds to nonablative fractional photothermolysis as well. Dermatologists Wanner et al[172] observed improvement in the dyspigmentation of photodamaged skin after treatment with 1550-nm Er-doped fiber laser. Other non-Q-switched devices such as intense pulsed light and pulsed dye lasers operating in the millisecond domain have also been shown be effective in the treatment of epidermal pigmented lesions.[173-175]

H. Nonablative fractional laser resurfacing

Dermatologists Manstein et al[160] pioneered the science of fractional resurfacing, a novel concept in which a device emits light in a pixilated fashion, producing a field of microthermal zones and small columns of thermal injury to the skin. Fractional emission of light to the skin promotes rapid collagen remodeling and re-epithelization and clinically manifests in a more advantageous side-effect profile and greater improvement in skin texture and tightening as a result of the increased depth of dermal injury.

Manstein et al[160] first postulated that fractional resurfacing may have a role in the treatment of skin laxity and textural anomalies as a result of their work with a prototype device that demonstrated tissue shrinkage in tattoos. In 2006, Hantash et al[162] further expanded upon the work of Manstein et al[160] and validated with histologic studies the mechanism of tissue injury and repair after fractional resurfacing. They used immunohistochemistry with human antielastin antibodies to identify that the product of thermal damage, degenerated dermal material, is shuttled up through the epidermis and ultimately, exfoliated through the stratum corneum within 7 days after injury.[162] This hallmark discovery identified that fractional resurfacing is the first nonablative laser technology to result in removal of damaged dermal material through a perforated dermoepidermal junction.[160] In 2006, Laubach et al[161] provided the clinical correlate to this study describing how fractional resurfacing results in improvement in dyschromia through creation of microscopic necrotic columns of epidermal debris containing melanocytes destroyed by thermal columns of injury. With this novel mechanism of injury and repair of dermal and epidermal zones of injury, a number of dermatologic investigators have used fractional resurfacing as a unique therapeutic option for the treatment of a diverse number of conditions of epidermal and dermal biology, including photoaging of the face, neck, and hands[161,176-178]; melasma[176]; and acne scarring.[179]

Ablative fractional resurfacing. Although many studies have demonstrated significant benefits of nonablative fractional resurfacing, with minimal adverse effects,[160,162,176-179] the resulting improvement in skin texture and pigmentary variation fell significantly behind those of traditional ablative carbon dioxide (CO_2) and Er:YAG laser resurfacing

and medium to deep chemical peels. As a result of the need for greater results with fractional photothermolysis with similar minimal side-effect profiles, Hantash et al[180,181] published the first results with an ablative fractional CO_2 device in 2007. The excitement of this discovery stemmed from initial reports of the efficacy of ablative fractional photothermolysis in skin tightening, with similar results to those of traditional ablative CO_2 and Er:YAG resurfacing, with advantages of only 5 to 7 days of downtime and less risk of permanent scarring and dyspigmentation. Ablative fractional resurfacing has recently demonstrated significant promise in moderate to severe acne scarring in terms of clinical improvement and topographic mapping of decreases in individual scar volume.[182] In addition, ablative fractional resurfacing has shown great promise in reducing skin surface and texture abnormalities, including moderate to severe rhytides and skin laxity of the face, including the neck, chest, and hands.[183-185]

Hantash et al[181] introduced the first ablative fractional CO_2 device in 2007, with a similar column of thermal coagulation as with the nonablative fractional device of Manstein et al[160] with the differentiation of technology of a confluent column of tissue ablative injury from the dermis through the stratum corneum. Using immunohistochemistry, Hantash et al[180] demonstrated persistent collagen remodeling that occurred for at least 3 months after injury with an ablative fractional resurfacing device. Subsequently, dermatologists Goldberg et al[186] demonstrated clinical improvement in photoaging and histologic and ultrastructural change in collagen deposition on both light and electron microscopy.

Resurfacing of the face with ablative fractional resurfacing marks a significant advantage over traditional ablative resurfacing, where significant risks of prolonged erythema, scarring, and dyspigmentation complicate treatment. Stebbins and Hanke[183] treated a series of patients with photoaging of the hands and noted significant improvement in wrinkles, pigment, and texture, with no adverse effects. Resurfacing of the neck is complicated by unpredictable and prolonged wound healing owing to the ultrastructure of the skin with a decreased number and density of pilosebaceous units, which is thought to delay re-epithelialization and increase scarring risk. Tierney and Hanke[184] treated a series of patients with moderate to severe photoaging and laxity of neck skin, and found significant improvement in skin texture, skin laxity, and overall cosmetic outcome with ablative fractional resurfacing.

Sukal et al[187] first evaluated treatment of eyelid skin laxity with nonablative fractional resurfacing where investigators noted that patients experienced improvement in eyelid skin tightening and had a significant improvement in eyelid aperture as a result of skin tightening achieved with fractionated resurfacing. Tierney et al[185] performed a single blinded study with an ablative fractional CO_2 device and observed significant improvement in lower eyelid laxity with 2 to 3 sessions.

I. Laser (nonvascular) and energy-based devices

Dermatologist Leon Goldman et al[188] was the first adopter of laser technology in medicine applying the work of American physicists such as Charles Townes and Theodore Maiman to treat a variety of skin conditions. In 1983, Anderson and Parrish[120] revolutionized the specialty of laser surgery by proposing the theory of selective photothermolysis. The Department of Dermatology at Harvard Medical School encompasses the Wellman Center for Photomedicine, headed by Anderson, and is responsible for the majority of advances in modern laser medicine and energy-based devices. Notably, roughly half of the technology developed at the Wellman Center of Photomedicine has applications beyond the skin, and has led to major advances in other specialties including ophthalmology, gastroenterology, and cardiology, thus highlighting the leading role dermatologists have played in advancing medicine in general.

The development of pulsed lasers based on the theory of selective photothermolysis has led to safe and effective treatment for vascular lesions, including many pediatric vascular malformations, pigmented lesions, tattoos, the permanent removal of hair, and photoaging/resurfacing.[189] Lasers have also been found to be useful for medical dermatologic conditions, such as psoriasis.[190] Current investigations by the dermatologists Hongcharu et al[191] are developing novel future applications of selective photothermolysis, including the treatment of fat and acne with lasers. The use of photodynamic therapy to treat acne, actinic keratoses, and nonmelanoma skin cancer has also been pioneered by many dermatologists. Fractional photothermolysis developed by dermatologists Anderson et al[192] has revolutionized the treatment of scarring. Interestingly, fractional laser treatments hold the potential to impact medicine beyond dermatology, as it allows for the systemic delivery of large molecules across the skin barrier.[193] Numerous contributions to laser surgery have also come from the Beckman Laser Institute at University of California-Irvine, where dermatologists, other physicians, and basic scientists collaborate to advance laser medicine.

Innovation by dermatologists has resulted in the development of other devices within the electromagnetic spectrum or through controlled cooling. Dermatologists Manstein et al[160,194] developed a novel method of noninvasive localized fat removal through the controlled cooling of skin. The use of focused ultrasound for skin tightening was also developed by Laubach et al,[195] and clinical trials performed by dermatologists such as Alam et al.[196] The fractional treatment model has also been extended to radiofrequency to result in skin tightening and elastin production. Clinical studies have been led by dermatologists Hruza et al[197] and Alexiades-Armenakas et al.[198] A microwave-based device to treat axillary hyperhidrosis was also guided in the earliest clinical testing by several dermatologists.[199]

J. Liposuction using TLA

Several US dermatologists, including Saul Asken[200,201] and Sam Stegman and Ted Tromovitch,[202] began performing liposuction using local anesthesia in the mid-1980s. Asken[200,201] was the first dermatologist to author 2 elegantly illustrated books on the subject. Liposuction safety took a major step forward when Jeffrey Klein[203] described the tumescent technique in 1987. The work of Klein has been truly revolutionary in that liposuction could be performed safely and effectively on awake patients thereby avoiding the risks of general anesthesia. Bleeding was minimized with the technique of Klein and the cosmetic results were excellent. Multiple studies by dermatologists have demonstrated the safety and effectiveness of the tumescent technique.[204-206] The tumescent technique was also adapted by nondermatologists who performed liposuction using general anesthesia. However, the safety profile for liposuction changes when general anesthesia is added. Guidelines for the safe use of TLA have been published on multiple occasions by the AAD and the ASDS.[207,208] When these guidelines are followed, the safety of patients undergoing liposuction using TLA is maximized, and significant postoperative complications are minimized.[209,210] To date, there have been no documented fatalities from liposuction using strictly TLA on awake patients when safety guidelines are followed.

Tumescent Technique was the title of Klein's[211] hallmark book on microcannular liposuction published in 2000. A more descriptive term, "tumescent local anesthesia," was first used in the title of a German textbook on liposuction in 1999.[212] The book *Tumescent Local Anesthesia* was published in English in 2001.[213] Klein's book is currently out of print, but other books have been published on the subject.[214,215]

K. Microdermabrasion

Since ancient times it has been appreciated that removing the superficial layers of the skin ultimately results in improved appearance of the skin. During the 20th century dermatologists led the way in resurfacing techniques such as chemical peels and wire-brush dermabrasion, then into the 21st century with ablative and fractionated laser resurfacing. Among the gentler resurfacing techniques is microdermabrasion. The first mention of this technique in the medical literature is found in the dermatology journal *Dermatologic Surgery* when Tsai et al[216] discussed the use of this device for acne scars. Since that time microdermabrasion has found widespread acceptance in cosmetic practice.

Microdermabrasion originally consisted of a hand piece connected to a suction line that drew the skin gently into the hand piece itself. Then, a second line blew aluminum oxide crystals onto the skin to produce a gentle abrasion. Histologic studies carried out by dermatologists suggest the technique removes only the stratum corneum,[217,218] but there may be a contribution of the suction itself to the success of the technique.[218] Detailed molecular studies, carried out by dermatologists at the University of Michigan,[219] have convincingly demonstrated biochemical changes associated with dermal remodeling with this procedure. These changes include increased gene expression of c-Jun component of activator protein 1, interleukin 1-beta, tumor necrosis factor-alfa, and matrix metalloproteinases (MMP) associated with dermal remodeling (MMP-1, MMP-3, MMP-9). Further studies from the same group also found molecular changes associated with the wound-healing process including induction of cytokeratin 16 and activation of the activator protein-1 transcription factor in the epidermis.[220] Again, induction of MMP-mediated degradation of the extracellular matrix in the dermis was observed, and significant dermal remodeling as evidenced by induction of type I and type III procollagen, and collagen production enhancers heat shock protein 47 and prolyl 4-hydroxylase was seen.

Since the original aluminum oxide crystal devices were introduced, a number of modifications have appeared on the market. These modifications were induced by a desire to avoid the use of aluminum, which has been suggested to be associated with the development of Alzheimer disease,[221] but not convincingly so. One modification simply substituted sodium chloride for aluminum oxide crystals. More recently, small metal plates coated with diamond dust have been incorporated into the hand piece to replace any crystals at all. The skin is drawn into the

hand piece, and then rubbed with the diamond fraise plate to produce a superficial abrasion.

Beyond cosmetic use, dermatologists have used these devices to increase penetration of topical medications. For example, dermatologists Katz et al[222] demonstrated microdermabrasion used before application of topical d-aminolevulinic acid for photodynamic therapy dramatically improved clinical response to the photodynamic therapy procedure, presumably by enhanced penetration of the aminolevulinic acid. It has now become common practice to combine microdermabrasion with topical medications to enhance penetration of the topical itself. Dermatologists have combined microdermabrasion with medications as diverse as 5-fluorouracil in a report that suggested the combination was more effective in treating vitiligo compared with using 5-fluorouracil alone.[223] Microdermabrasion is now firmly established as a gentle cosmetic procedure and a device to enhance topical medication and product delivery.

L. Dermabrasion

Over the past century, dermatologists originated, developed, and mastered the techniques of resurfacing the skin by the use of dermabrasion. "Cold steel" dermabrasion is a means of removing the epidermis by means of a rotating diamond fraise or wire brush to create a papillary or mid-dermal wound. Subsequent healing results in the formation of new collagen and a renewed epidermis generated from cells deep within the follicles, without a scar. The reorganized collagen and fresh epidermis provide superb cosmetic improvement in actinically damaged or scarred skin. This was first described in 1905 by Kronmayer,[224] a dermatologist in Germany. He adapted the use of power tools and skin refrigeration to the technique. Abner Kurtin,[225] a New York dermatologist, developed the wire brush and its adaptation to a power dental tool to treat scars and wrinkles. Burks[226] treatise modernized the wire-brush technique and expanded the scope of the procedure in the late 1950s. These advances energized Orentrich, Ayres, and others to refine the procedure further in the 1970s and 1980s.[227] Nelson et al[228] contrasted the effects of wire-brush and diamond fraise methods, and then used immunohistology to show the development of transforming growth factor β, procollagen, and type I and III collagen after dermabrasion in photoaged skin. Mandy and others[229,230] improved the preoperative and postoperative management of dermabrasion by the preoperative use of topical retinoids, and the postoperative use occlusive dressings as described by Maibach and Rovee.[231] Rubenstein et al[232] created controversy by reporting that treatment of acne with isotretinoin in proximity to dermabrasion adversely affected healing, possibly resulting in hypertrophic scarring. Other studies by Moy et al[233] failed to confirm an affect on dermal healing. Coleman et al[234] expanded the indications for dermabrasion demonstrating its benefit in the management of precancerous skin to prevent the development to carcinoma.

Thorough descriptions of dermabrasive techniques have been written by Burks,[226] Yarborough,[235] Alt,[236] and Mandy and Monheit.[237] Many practitioners of the art have different preferences as to the use of wire brush versus diamond fraise for abrasion, but the most important element is prior hands-on training in a preceptor environment. An area in which dermabrasion has recently changed is in pain management during the procedure. In prior years, chlorofluorocarbon refrigerant aerosol spray was used to anesthetize and solidify the skin.

By freezing the skin, it became simultaneously numb and rigid, facilitating the sanding while preventing pain. Controversy about the possible scarring caused by freezing was described by Hanke et al[238] but became mute after chlorofluorocarbons were banned from production in the United Stated in 1996 because of their theoretical atmospheric impact.

Consequentially, analgesia today involves regional nerve blocks described by Countryman and Hanke[239] and supplementation with modified TLA also described by Hanke.[240] These techniques can provide adequate full-face anesthesia for dermabrasion and laser procedures as well.

As lasers have become the most frequently used method of resurfacing, some believe that dermabrasion will soon be absent from the dermatologic tool box. Yet the cost of the equipment is far less than lasers, is technologically stable, and consumes little space. The procedure has broad application in the treatment of actinic damage, tattoos, and traumatic, burn, surgical, and acne scars. Fitzpatrick et al[241] has shown that the ultrastructural changes seen after laser, trichloroacetic acid (TCA) peeling, and dermabrasion are all comparable. Giese et al[242] showed that at 6 months dermabraded skin was stronger and more supple than skin after phenol peel. Dermabrasion remains an effective, economical, and some might argue superior, resurfacing modality addressing many indications. Perhaps the single impediment to its remaining a vital part of the dermatology armamentarium is that as the artisans in this procedure retire, there will be few left to provide the hands-on training necessary to be proficient in its application.

M. Chemical peels

During 1980s Stegman[243] paved the way for a scientific investigation of chemical peels by analyzing the histologic sections of human skin after TCA and phenol peels. He further compared the effect of occluded versus unoccluded procedures.

Unfortunately dermatologists, with a few exceptions, gave up almost completely in recent years the privilege of performing deep chemical peels, leaving this field to other medical specialties.[244]

From the end of the 20th century dermatologists concentrated their effort in the optimization of the medium-depth peels. Various combinations have been used to increase the efficacy of TCA peel without affecting its safety. Brody and Hailey[245] implemented the combination of TCA with CO_2 freeze. Monheit[246] publicized the combination of TCA and Jessner solution, whereas Coleman and Futrell[247] suggested skin pretreatment with glycolic acid to create a more even penetration of TCA. CROSS technique (chemical reconstruction of skin scars), in which highly concentrated TCA is applied topically into ice-pick acne scars, was described in 2002 by a group of Korean dermatologists.[248]

Dermatologists Van Scott and Yu[249] revealed the properties of alpha hydroxy acids as both topical skincare and peeling agent. Kligman and Kligman[250] revived the salicylic acid as a superficial peeling agent by increasing its concentration above that available in Jessner solution. After light-based technologies entered the cosmetic market, the necessity of chemical peels was questioned. Rubin[251] reviewed combination techniques for full-face medium-depth peel with perioral and periorbital CO_2 laser resurfacing. Grimes[252,253] assessed the safety of chemical peeling procedures in darker-skinned racial-ethnic groups. However, without the triple combination of tretinoin, hydroquinone, and dexamethasone, developed by Kligman and Willis[254] performance of deeper peels on dark-skinned individuals would be impossible. In the recent years the effect of chemical peeling on photodamaged skin with ultraviolet irradiation has been studied by a group of dermatologists from Nippon Medical School in Tokyo, Japan.[255] They demonstrated in an animal model a positive preventive effect of chemical peeling on photocarcinogenesis.

N. Repair of acne scars

Facial scarring associated with moderate to severe acne in teenage and early adult years is a common concern and reason for presentation to dermatologists. Acne scars arise from decreased collagen formation in the normal wound-healing and remodeling process resulting in visibly depressed scars. Treatments for acne scars are highly specific to the type of scar morphology (ie, rolling, boxcar, ice pick), patient's skin type, and patient's age and distribution of scars. Dermatologists have developed a comprehensive understanding of which patients will benefit from which treatment approach as a result of their understanding of wound remodeling and scar pathophysiology.

The current armamentarium of treatment approaches for acne scarring ranges from superficial approaches, such as glycolic acid, chemical peels, topical tretinoin, and topical hydroquinone for skin surface improvement and pigmentary variation, to more moderate approaches to address deeper and widespread scarring, such as scar subcision, dermabrasion, punch grafts, ablative CO_2, and Er:YAG laser resurfacing and most recently, fractional photothermolysis.

Dermatologists Alam et al[256] reported on the specificity of the technique of subcision for patients with extensive rolling scars, where significant improvement in textural abnormalities can be achieved with this minimally invasive, low-risk technique. Fulchiero et al[257] evaluated the effects of combination therapy with subcision and the 1320-nm Nd:YAG nonablative laser in patients with severe rolling and boxcar acne scars and found the combination treatment provided significant improvement in scar topography with added improvement in scar pigmentation and overall softening of scar morphology with the addition of the laser resurfacing. For more extensive scarring, ablative laser resurfacing, using CO_2 and Er:YAG lasers, has been performed by dermatologists for acne scarring for the last 2 decades. Dermatologists Alster and West[258] reported on a series of 50 patients with moderate to severe acne scars with improvement of 81.4% in all patients. However, the adverse effects experienced were significant, where 36% of patients had transient hyperpigmentation, and all patients had a significant degree of posttreatment erythema that persisted at 3-month follow-up.

In the last decade, fractional resurfacing for acne scars has been developed by dermatologists Manstein et al.[160] The significance of fractional resurfacing for acne scarring is associated with a significantly lesser degree of risk of posttreatment induction of pigmentation and scarring. The pixilated nature of fractional resurfacing, in which the laser stimulates the adjacent stem cells in adjacent intact columns of tissue, promotes collagen remodeling and neocollagenesis and results in the clinical improvement in the atrophic component of acne scarring. Dermatologist Roy Geronemus[176]

was the first to report on fractional photothermolysis for acne scarring, where 17 subjects with ice-pick, boxcar, and rolling scars received a series of 5 treatments. No instances of posttreatment hyperpigmentation, hypopigmentation, or scarring were observed.

A recent consensus statement about the use of the nonablative fractionated laser by Sherling et al[259] divided acne scars into 2 categories: distensible or nondistensible scars. Distensible scars improve more readily with fillers and laser resurfacing than nondistensible scars. Physicians may consider doing punch excisions of nondistensible acne scars, especially narrow, deep acne scars (ice-pick scars) before nonablative laser resurfacing. The panel contended that nonablative fractional lasers improved the appearance of acne scars by as much as 50%; however, treatment requires an extensive series of 4 to 5 treatments, each spaced 1 month apart. Uniquely, nonablative fractional resurfacing has been shown to improve acne scars in patients with darker skin phototypes (IV-VI) with minimal risks of postinflammatory hyperpigmentation.[260]

Although the initial reports of nonablative fractional laser technology for acne scarring were promising, recent work has shown that this technology provides limited efficacy in the treatment for deeper scars, such as those of the ice-pick morphology, with a rapid drop-off in depth from the surface. Most recently, the advent of ablative fractional resurfacing as a safe and effective treatment for acne scarring represents a significant advance. It promotes greater efficacy in atrophic scars through the delivery of high fluences to reticular dermal tissue and results in efficacy in a decreased number of treatments compared with nonablative fractional resurfacing.

Ortiz et al[261] presented the first results of a fractionated CO_2 device for the treatment of acne scarring. A total of 15 subjects underwent up to 3 treatments. Patients with a diversity of skin types (I-V) were treated with no complications such as short- or long-term hyperpigmentation reported. Of patients, 87% sustained significant improvement in the appearance of acne scarring at 3-month follow-up visits.

In 2008, dermatologists Chapas et al[182] published the results of the largest study of an ablative fractional resurfacing device to date, which resulted in significant improvement in patients with moderate to severe acne scarring. In vivo studies by Hantash et al[181] with this device have shown tissue ablation and thermal effects as deep as 1 mm into this skin. This likely accounts for the effect on moderate to severe acne scarring observed. Side effects with the ablative fractional device were mild to moderate, including posttreatment erythema, edema, and petechiae, all of which resolved within 7 days after treatment. Most importantly, unlike traditional ablative CO_2 resurfacing, no incidence of delayed dyspigmentation was noted during the treatment interval or during the 3 months of follow-up posttreatment.

The high degree of efficacy in the absence of significant adverse side effects makes fractional resurfacing a novel and safe addition to the treatment armantarium for acne scarring.

O. Hair transplantation

The dermatology residency is unique in that it trains its physicians in the biology of hair follicles, encourages research in both the basic science and clinical aspects of hair, and teaches its residents to perform hair transplantations. Hair transplantation was pioneered by the dermatologist Norman Orentreich. Dermatologists continue to make major contributions to this very specialized branch of medicine.

Dermatologist Bobby Limmer[262] had the novel idea of using a microscope to aid in the dissection of grafts to avoid follicular transection. His method was described in his 1994 article, "Elliptical donor stereoscopically assisted micrografting as an approach to further refinement in hair transplantation."

The following year, dermatologists Bernstein et al[263] laid down the conceptual framework for follicular unit transplantation in their 1995 article, "Follicular transplantation." In 1997, they detailed its clinical application in the paired articles, "Follicular transplantation: patient evaluation and surgical planning"[264] and "The aesthetics of follicular transplantation."[265]

The 2 advances, the application of the stereomicroscope to follicular dissection and the use of follicular units as the basic element of hair transplantation, arose from a background in dermatology. They moved the field of hair restoration surgery from plugs and mini-micrografting, where this basic anatomical feature of the hair follicle was ignored, to follicular unit transplantation, where the follicular unit became sacrosanct. These 2 ideas, when put to clinical use, allowed the once elusive goal of a completely natural-looking hair transplant to finally be achieved.

Stereomicroscopic dissection is a powerful tool for avoiding follicular unit damage when isolating the units from a donor strip; however, it is unable to prevent transection when the strip is first removed from the scalp. For more than 25 years the donor strip had been excised from the surrounding tissue using a scalpel. It took dermatologist Robert

Haber[266] to design a spreading device that could remove the strip using blunt manipulation. This innovation helps surgeons reduce follicular transection in the important first step of a follicular unit transplantation procedure.

A number of hair-implanting devices have been devised over the years, but none have been as popular as the Choi hair transplanter. This ingenious hand-held device, created by the dermatologist Yung Choi and his colleague Jung Kim[267] in 1992, simultaneously creates a recipient site and inserts a hair-bearing graft that had been loaded into its chamber. It was equally as useful for the micrografts of 20 years ago as it is for the follicular unit hair transplantations performed today.

Limmer[268] suspected that the time grafts were held outside the body was an important variable in graft survival. In a landmark study, he showed a high, but diminishing, survival for micrografts held in chilled saline for the first 8 hours. Dermatologist Jerry Cooley[269] took it a step further, exploring whether the characteristics of the holding solution itself can be modified to enhance the survival of follicular unit grafts. With his work on both ischemia-reperfusion injury and storage injury, Cooley[269] has shown that the use of antioxidants to lower free radical activity can significantly increase graft survival time. This is an important modification of the hair transplantation procedure because, over the years, the number of grafts transplanted per session and the length of time grafts are held outside the body continue to grow.

Dermatologist Dow Stough,[270] appreciating the inexorable progression of androgenetic alopecia, was one of the first physicians to stress a conservative, long-term approach to hair transplantation. This included: creating an irregular pattern of single-hair grafts at the frontal hairline; using a mature, adult pattern for its position; and focusing on restoring hair to the frontal scalp. Most importantly, he encouraged doctors to delay hair transplantation in younger patients until their hair-loss patterns could be better assessed and their expectations set appropriately.

Stough, with dermatologist O'tar Norwood, founded the International Society for Hair Restoration Surgery, an organization with over 800 physician members that has become the foremost international association of hair restoration surgeons. Norwood also launched the bimonthly journal *Hair Transplant Forum International* that now serves as the educational hub through which hair restoration surgeons around the globe communicate new ideas and present preliminary scientific data in an informal, but timely, way. Stough, with fellow dermatologist Haber,[271,272] has published 2 concise, but excellent, texts on hair replacement.

Dermatologist Walter Unger et al[273] edited *Hair Transplantation*, the first comprehensive multiphysician reference textbook dedicated to hair transplantation surgery. Now in its fifth iteration, this encyclopedic series of textbooks has become the standard reference text in the field. Unger et al[273] has served as an important cautionary influence on the impetuosity of many newer members of our profession. He astutely warned that ideas, which initially seem to hold promise, warrant further scientific investigation before being adopted.

The office clinician is unable to precisely measure the natural progression of hair loss and its response to treatment. Densitometry can assess the percent of hair affected by miniaturization, but is unable to quantify the wide range of hair diameters seen in androgenetic alopecia. Dermatologist Bernard Cohen[274] cleverly solved this problem with an instrument called the cross-section trichometer. This instrument measures hair mass: the cross-sectional area of a bundle of hair present in a premeasured area of scalp. It detects small changes in both hair density and diameter, and is an objective way to measure the effectiveness of various therapies provided by the hair restoration physician.

A method of removing follicular unit grafts directly from the scalp, without the need for a linear incision, had been worked out by an Australian physician in the 1990s. He was, however, secretive with his techniques, and few other doctors attempted to duplicate this new procedure. With the publication of the article, "Follicular unit extraction," by Rassman et al[275] in 2002, the follicular unit extraction procedure gained popular appeal and was rapidly adopted by doctors worldwide. The authors cautioned on the limitations of this harvesting technique and the risk of follicular damage. Dermatologists Berman, Zering, and Bernstein—along with their colleagues in other specialties—continue to work on the problem of harvesting in follicular unit extraction, with the application of robotic technology showing particular promise.[276]

Although donor dominance has been the guiding principle for hair transplantation surgeons over the past half century, this did not deter dermatologist Hwang et al[277] from challenging the very concept. Hwang et al[277] showed that when hair was transplanted from one part of the body to another, the recipient site can influence such factors as hair growth and survival, hair shaft diameter, and length. His work has profound implications for transplanting hair into a balding

scalp from other parts of the body—such as the trunk, legs, and beard—potentially expanding a person's supply of donor hair.

Going forward, the field of hair transplantation will be shaped by advances in biotechnology that will, in time, enable the cloning of human hair and possibly make a person's donor supply unlimited. Although it is not clear who will be the first to achieve this elusive goal, important research is currently underway by a number of dermatologist investigators.[278-281]

This article has surveyed some of the important contributions dermatologists have made to the field of hair restoration surgery over the past 2 decades. Because of space constraints, the contributions of a number of other notable dermatologists have not been mentioned including James Arnold, Marc Avrum, Pierre Bouhanna, Francisco Jimenez, Matt Leavitt, William Parsley, Paul Rose, and Arthur Tykocinski. That this writing is a snippet of contributions, rather than a continuous story, underscores the fact that many of the great strides in hair transplantation are attributable to the hard work of so many physicians who have not been acknowledged in this very brief text.

P. Sclerotherapy and varicose vein therapy

Vascular lesions including varicose veins or telangiectases are common and affect up to 50% of the adult population. Several studies show that these lesions, even if they are typically not painful, can have a great impact on quality of life.[282] Although leg lesions with symptoms such as aching, discomfort, or muscle cramps primarily affect the health-related quality of life, facial lesions such as rosacea or telangiectasia can lead to psychological discomfort.[283] This can lead to embarrassment, anxiety, decreased self-esteem, and avoidance of social situations in those affected. Seen from this perspective it becomes apparent that the treatment of vascular lesions has a high medical relevance and is far from just being cosmetically important.

An early development was the use of injectable sclerosants to block or shrink vessels. After first attempts with several agents beginning at the end of the 19th century, the foundation of modern sclerotherapy began in 1916, when the dermatologist Paul Linser[284] reported successful treatments using perchloride of mercury with an intravascular technique. Over the years the procedure was improved steadily and became fully accepted by the medical community. Even today, innovations are still evolving, making the procedure safer and more effective for patients and physicians.

An example of the steady evolution of sclerotherapy is the recently FDA-approved sclerosant polidocanol, a mixture of ethers, macrogols, and fatty alcohols, which produces endothelial damage by multiple mechanisms. It shows equal clinical efficacy to sodium tetradecyl sulfate, but with less severe complications.[285] A pivotal study actually showed a higher treatment success rate and statistical superiority in patient satisfaction of polidocanol over sodium tetradecyl sulfate and isotonic saline. The incidence of side effects was generally lower for patients treated with polidocanol than for patients treated with sodium tetradecyl sulfate.[286] Experimental studies show that polidocanol has a lower probability for tissue necrosis than any other sclerosant.[287] Furthermore, because of its anesthetic effect, it does not cause pain.[288]

Another innovation that enhanced the spectrum of minimally invasive treatment options for varicose veins was the use of endovenous radiofrequency ablation, first described by Weiss and Goldman[289] in 1999. Radiofrequency energy is delivered through a special catheter with deployable electrodes at the tip; the electrodes contact the vein walls and deliver energy directly into the tissues, where the radiofrequency is converted into heat and causes irreversible localized tissue damage. The endovenous radiofrequency ablation procedure can be performed entirely under local tumescent anesthesia, with patients resuming normal activities 1 to 2 days postoperatively.

In 2001, only a short time after the introduction of endovenous radiofrequency ablation, another endovenous procedure was introduced by Navarro et al.[290] The procedure is based on laser energy delivered endovenously via a fiberoptic laser fiber. The laser energy leads to the formation of steam bubbles at the tip of the laser fibers, which causes thermal damage to the venous endothelium and results in thrombotic occlusion of the vessel lumen. Endovenous laser treatment is a safe and well-tolerated alternative in the management of uncomplicated varicose veins and has subsequently to its introduction undergone a rapid increase in popularity and use with a concomitant decrease in traditional operative saphenectomy.[291]

The goal of several studies in recent years was to identify the influence of using a foamed sclerosant. A study published by Ouvry et al[292] in 2008 showed that with 3% polidocanol foam complete elimination of reflux was obtained in 85% of patients after 3 weeks, whereas 3% liquid polidocanol was effective in only 35%. There was no difference in the incidence of ecchymosis, inflammatory reactions,

or other side effects. A large multicenter study by Rabe et al[293] confirmed these results by finding 3% polidocanol foam to be more efficient and equally safe compared with 3% liquid polidocanol for treatment of the greater saphenous vein. After showing the superiority of foam sclerotherapy for many indications, the latest research focuses on the ideal gas for the foaming process. Peterson and Goldman[294,295] identified room air as being perfectly suited to be used for foam sclerosing, as it has the same efficacy and safety profile as CO_2, but the half-life is 3 times longer and less sclerosant is needed.

Another goal in the recent years has been to identify the relevance of compression after sclerotherapy, a technique that has been used since the 1960s but is still controversial. Although Weiss et al[296] and Kern et al[297] found that wearing compression stockings for 3 weeks enhances the efficacy of sclerotherapy of leg telangiectasias, a study by Hamel-Desnos et al[298] found no difference between compression and control groups when comparing efficacy, side effects, satisfaction scores, symptoms, and quality of life after foam sclerotherapy of the saphenous veins.

The management of both cosmetic telangiectasias and medical indications has been advanced by dermatologists and encompasses a multiple modality approach using sclerosants, radiofrequency, light sources, and minimally invasive techniques. This multimodality approach has changed the scope of management of both cosmetic and medical venous disorders.

IV. REFERENCES

1. Geronemus R, Bissacia E, Brady JH, Gaston DA, Glogau RJ, Hanke CW, et al. Current issues in dermatologic office-based surgery. J Am Acad Dermatol 1999;41:624-32.
2. Tromovitch TA, Stegman SJ. Microscopically controlled excision of skin tumors. Arch Dermatol 1974;110:231-2.
3. Accreditation Council for Graduate Medical Education. Medical accreditation. Available from: URL: http://www.acgme.org/acgmeweb/tabid/130/ProgramandInstitutionalGuidelines/MedicalAccreditation/Dermatology.aspx. Accessed September 11, 2013.
4. Nestler SP, Roenigk RK. Accreditation and certification in dermatologic surgery. Semin Cutan Med Surg 2005;24:133-6.
5. Roenigk RK. Dermatologists perform more skin surgery than any other specialist: implications for health care policy, graduate and continuing medical education. Dermatol Surg 2007;34:1-8.
6. Hanke CW. Advocating for mandatory adverse event reporting. Dermatol Surg 2012;38:178-9.
7. Coldiron B. Patient injuries from surgical procedures performed in medical offices. JAMA 2001;285:2582.
8. Coldiron B. Office surgical incidents: 19 months of Florida data. Dermatol Surg 2002;28:710-2.
9. Coldiron BM, Healy C, Bene NI. Office surgery incidents: what seven years of Florida data show us. Dermatol Surg 2007;34:285-91.
10. Starling J, Thosani MK, Coldiron BM. Determining the safety of office-based surgery: what 10 years of Florida data and 6 years of Alabama data reveal. Dermatol Surg 2012;38:L171-7.
11. Mohs FE. Chemosurgery: A microscopically controlled method of cancer excision. Arch Dermatol 1941;42:279.
12. Tromovich TA, Stegman SJ. Microscopically controlled excision of skin tumors: Chemosurgery (Mohs). Fresh tissue technique. Arch Dermatol 1974;110:231-2.
13. Rowe DE, Carroll RJ, Day CL. Long-term recurrence rates in previously untreated (primary) basal cell carcinoma: implications for patient follow-up. J Dermatol Surg Oncol 1989;15:315-28.
14. Rowe DR, Carroll RJ, Day CL. Mohs surgery is the treatment of choice for recurrent (previously treated) basal cell carcinoma. J Dermatol Surg Oncol 1989;15:424-31.
15. Leibovitc I, Huilgol SC, Selva D, Hill D, Richards S, Paver R. Cutaneous squamous cell carcinoma treated with Mohs micrographic surgery in Australia: experience over 10 years. J Am Acad Dermatol 2005;53:253-60.
16. Bordeaux JS, Martires KJ, Goldberg D, Pattee SF, Fu P, Maloney ME. Prospective evaluation of dermatologic surgery complications including patients on multiple antiplatelet and anticoagulant medications. J Am Acad Dermatol 2011;65:576-83.
17. Ad Hoc Task Force: Connolly SM, Baker DR, Coldiron BM, Fazio MJ, Storrs PA, Vidimos AT, et al. AAD/ACMS/ASDSA/ASMS 2012 appropriate use criteria for Mohs micrographic surgery: A report of the American Academy of Dermatology, American College of Mohs Surgery, American Society for Dermatologic Surgery Association, and the American Society for Mohs Surgery. J Am Acad Dermatol 2012;67:531-50.
18. Bene NI, Healy C, Coldiron BM. Mohs micrographic surgery is accurate 95.1% of the time for melanoma in situ: a prospective study of 167 cases. Dermatol Surg 2008;34:660-4.
19. Spencer JM, Nossa R, Tse DT, Sequeira M. Sebaceous carcinoma of the eyelid treated with Mohs micrographic surgery. J Am Acad Dermatol 2001;44:1004-9.
20. O'Connor WJ, Lim KK, Zalla MG, Gagnot M, Otley CC, Nguyen TH, et al. Comparison of Mohs micrographic surgery and wide excision for extramammary Paget's disease. Dermatol Surg 2003;29:723-7.
21. Chiller K, Passaro D, Scheuller M, Singer M, McCalmont T, Grekin RC. Microcystic adnexal carcinoma: 48 cases, their treatment and their outcome. Arch Dermatol 2000;136:1355-9.
22. Snow SN, Gordon EM, Larson PO, Bagheri MM, Bentz ML, Sable DB. Dermatofibrosarcoma protuberans: a report on 29 patients treated with Mohs micrographic surgery with long-term follow-up and review of the literature. Cancer 2004;101:28-38.
23. Ang GC, Roenigk RK, Otley CC, Phillips PK, Weaver AL. More than two decades of treating atypical fibroxanthoma at Mayo Clinic: what have we learned from 91 patients? Dermatol Surg 2009;35:765-72.
24. Boyer JD, Zitelli JA, Brodland DG, D'Angelo G. Local control of primary Merkel cell carcinoma: review of 45 cases treated with Mohs micrographic surgery with and without adjuvant radiation. Dermatol Surg 2002;47:885-92.
25. Tierney EP, Hanke CW. Cost effectiveness of Mohs micrographic surgery: review of the literature. J Drugs Dermatol 2009;8:914-22.

26. Cook J, Zitelli JA. Mohs micrographic surgery: a cost analysis. J Am Acad Dermatol 1998;39:698-703.
27. Zitelli JA. The bilobed flap for nasal reconstruction. Arch Dermatol 1989;125:957-9.
28. Zitelli JA. The nasolabial flap as a single stage procedure. Arch Dermatol 1990;126:1445-8.
29. Dzubow LM. Dorsal nasal flaps. In: Balcer SR, Swanson NA, editors. Local flaps in facial reconstruction. St Louis (MO): Mosby; 1995.
30. Skouge JW. Upper lip reconstruction: the subcutaneous island pedicle flap. J Dermatol Surg Oncol 1990;16:63-8.
31. Papadopoulous DJ, Triner FA. Superiorly based nasalis myocutaneous island pedicle flap with bilevel undermining for nasal tip and superior tip reconstruction. Dermatol Surg 1999;25:530-6.
32. Mellette JR. The paramedian forehead flap for nasal reconstruction. Facial Plast Surg Clin North Am 1998;6: 365-78.
33. Brodland DG. Paramedian forehead flap reconstruction for nasal defects. Dermatol Surg 2005;31:1046-52.
34. Fader DJ, Baker SR, Johnson TM. The staged cheek-to-nose interpolation flap for reconstruction of the nasal alar rim/lobule. J Am Acad Dermatol 1997;37:614-9.
35. Cook JL. Reconstruction of a full thickness alar wound with a single operative procedure. Dermatol Surg 2003;29:956-62.
36. Otley CC. Alar batten cartilage grafting. Dermatol Surg 2000; 26:969-72.
37. Adams C, Ratner D. Composite and free cartilage grafting. Dermatol Clin 2005;23:129-40.
38. Leonard AL, Hanke CW. Second intention healing for intermediate and large post-surgical defects of the lip. J Am Acad Dermatol 2007;57:832-5.
39. Carruthers JDA, Carruthers JA. Treatment of glabellar frown lines with C. botulinum A exotoxin. J Dermatol Surg Oncol 1992;18:17-21.
40. Carruthers JA, Lowe NJ, Menter MA, Gibson J, Nordquist M, Mordaunt J, et al. A multicenter, double-blind, randomized, placebo-controlled study of the efficacy and safety of botulinum toxin type A in the treatment of glabellar lines. J Am Acad Dermatol 2002;46:840-9.
41. Carruthers A, Carruthers J. Botulinum toxin type A: history and current cosmetic use in the upper face. Semin Cutan Med Surg 2001;20:71-84.
42. Carruthers J, Carruthers A. Botulinum toxin A in the mid and lower face and neck. Dermatol Clin 2004;22:151-8.
43. Becker-Wegerich PM, Rauch L, Ruzicka T. Botulinum toxin A: successful décolleté rejuvenation. Dermatol Surg 2002;28: 168-71.
44. Lowe NJ, Yamauchi P. Cosmetic uses of botulinum toxins for lower aspects of the face and neck. Clin Dermatol 2004;22: 18-22.
45. Flynn TC, Carruthers JA, Carruthers JA. Botulinum-A toxin treatment of the lower eyelid improves infraorbital rhytides and widens the eye. Dermatol Surg 2001;27:703-8.
46. Huilgol S, Carruthers JA, Carruthers JDA. Raising eyebrows with botulinum toxin. Dermatol Surg 1999;25:373-6.
47. Carruthers A, Carruthers J. Eyebrow height after botulinum toxin type A to the glabella. Dermatol Surg 2007;33: 26-32.
48. West TB, Alster TS. Effect of botulinum toxin type A on movement-associated rhytides following CO_2 laser resurfacing. Dermatol Surg 1999;25:259-61.
49. Fagien S, Brandt FS. Primary and adjunctive use of botulinum toxin type A (Botox) in facial aesthetic surgery: beyond the glabella. Clin Plast Surg 2001;28:127-48.
50. Carruthers J, Carruthers A, Zelichowska A. The power of combined therapies: Botox and ablative facial laser resurfacing. Am J Cosmet Surg 2000;17:129-31.
51. Carruthers J, Carruthers A. A prospective, randomized, parallel group study analyzing the effect of BTX-A(Botox) and nonanimal sourced hyaluronic acid (NASHA, Restylane) in combination compared with NASHA (Restylane) alone in severe glabellar rhytides in adult female subjects: treatment of severe glabellar rhytides with a hyaluronic acid derivative compared with the derivative and BTX-A. Dermatol Surg 2003;29:802-9.
52. Carruthers J, Carruthers A. The effect of full-face broadband light treatments alone and in combination with bilateral crow's feet botulinum toxin type A chemodenervation. Dermatol Surg 2004;30:355-66.
53. Khoury JG, Saluja R, Goldman MP. The effect of botulinum toxin type A on full-face intense pulsed light treatment: a randomized, double-blind, split-face study. Dermatol Surg 2008;34:1062-9.
54. Bushara KO, Park DM. Botulinum toxin and sweating. Psychiatry 1994;59:1437-8.
55. Glogau RG. Botulinum A neurotoxin for axillary hyperhidrosis: no sweat Botox. Dermatol Surg 1998;24:817-9.
56. Shelley WB, Talanin NY, Shelley ED. Botulinum toxin therapy for palmar hyperhidrosis. J Am Acad Dermatol 1998;38:227-9.
57. Heckmann M, Ceballos-Baumann AO, Plewig G, Hyperhidrosis Study Group. Botulinum toxin A for axillary hyperhidrosis (excessive sweating). N Engl J Med 2001;344:488-93.
58. Lowe NJ, Yamauchi PS, Lask GP, Patnaik R, Iyer S. Efficacy and safety of botulinum toxin type A in the treatment of palmar hyperhidrosis: a double-blind, randomized, placebo-controlled study. Dermatol Surg 2002;28:822-7.
59. Glaser DA, Hebert AA, Pariser DM, Solish N. Palmar and plantar hyperhidrosis: best practice recommendations and special considerations. Cutis 2007;79(Suppl):18-28.
60. Solish N, Bertucci V, Dansereau A, Hong HC, Lynde C, Lupin M, et al, Canadian Hyperhidrosis Advisory Committee. A comprehensive approach to the recognition, diagnosis, and severity-based treatment of focal hyperhidrosis: recommendations of the Canadian hyperhidrosis advisory committee. Dermatol Surg 2007;33:908-23.
61. Klein AW. Complications, adverse reactions, and insights with the use of botulinum toxin. Dermatol Surg 2003;29: 549-56.
62. Rzany B, Dill-Müller D, Grablowitz D, Heckmann M, Caird D. Repeated botulinum toxin A injections for the treatment of lines in the upper face: a retrospective study of 4,103 treatments in 945 patients. Dermatol Surg 2007;33:S18-25.
63. Carruthers J, Carruthers A. Complications of botulinum toxin A. Facial Plast Surg Clin North Am 2007;15:51-4.
64. Cohen JL, Schlessinger J, Cox SE, Lin X, Reloxin Investigational Group. An analysis of the long-term safety data of repeat administrations of botulinum neurotoxin type A-ABO for the treatment of glabellar lines. Aesthet Surg J 2009; 29(Suppl):S43-9.
65. Piacquadio D. Crosslinked hyaluronic acid (hylan gel) as a soft tissue augmentation material: a preliminary assessment. In: Elson ML, editor. Evaluation and treatment of the aging face. New York: Springer-Verlag; 1995. pp. 304-8.
66. Piacquadio D, Jarcho M, Goltz R. Evaluation of hylan b gel as a soft tissue augmentation implant material. J Am Acad Dermatol 1997;36:544-9.
67. Narins RS, Brandt F, Leyden J, Lorenc ZP, Rubin M, Smith S. A randomized, double-blind, multicenter comparison of the

efficacy and tolerability of Restylane versus Zyplast for the correction of nasolabial folds. Dermatol Surg 2003;29:588-95.
68. Carruthers A, Carey W, De Lorenzi C, Remington K, Schachter D, Sapra S. Randomized, double-blind comparison of the efficacy of two hyaluronic acid derivatives, Restylane, Perlane and Hylaform, in the treatment of nasolabial folds. Dermatol Surg 2005;31:1591-8.
69. Dover JS, Rubin MG, Bhatia AC. Review of the efficacy, durability, and safety data of two nonanimal stabilized hyaluronic acid fillers from a prospective, randomized, comparative, multicenter study. Dermatol Surg 2009;35(Suppl): 322-31.
70. Narins RS, Dayan SH, Brandt FS, Baldwin EK. Persistence and improvement of nasolabial fold correction with nonanimal-stabilized hyaluronic acid 100,000 gel particles/mL filler on two retreatment schedules: results up to 18 months on two retreatment schedules. Dermatol Surg 2008;34(Suppl): S2-8.
71. Narins RS, Brandt FS, Dayan SH, Hornfeldt CS. Persistence of nasolabial fold correction with a hyaluronic acid dermal filler with retreatment: results of an 18-month extension study. Dermatol Surg 2011;37:644-50.
72. Wang F, Garza LA, Kang S, Varani J, Orringer JS, Fisher GJ, 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: 155-63.
73. Marmur ES, Phelps R, Goldberg DJ. Clinical, histologic and electron microscopic findings after injection of a calcium hydroxylapatite filler. J Cosmet Laser Ther 2004;6:223-6.
74. Friedman PM, Mafong EA, Kauvar AN, Geronemus RG. Safety data of injectable nonanimal stabilized hyaluronic acid gel for soft tissue augmentation. Dermatol Surg 2002;28: 491-4.
75. Lowe NJ, Maxwell CA, Lowe P, Duick MG, Shah K. Hyaluronic acid skin fillers: adverse reactions and skin testing. J Am Acad Dermatol 2001;45:930-3.
76. Lupton JR, Alster TS. Cutaneous hypersensitivity reaction to injectable hyaluronic acid gel. Dermatol Surg 2000;26:135-7.
77. Schanz S, Schippert W, Ulmer A, Rassner G, Fierlbeck G. Arterial embolization caused by injection of hyaluronic acid (Restylane). Br J Dermatol 2002;14:928-9.
78. Duffy DM. Complications of fillers: overview. Dermatol Surg 2005;31:1626-33.
79. Glaich AS, Cohen JL, Goldberg LH. Injection necrosis of the glabella: protocol for prevention and treatment after use of dermal fillers. Dermatol Surg 2006;32:276-81.
80. Brody HJ. Use of hyaluronidase in the treatment of granulomatous hyaluronic acid reactions or unwanted hyaluronic acid misplacement. Dermatol Surg 2005;31:893-7.
81. Glogau RG, Kane MA. Effect of injection techniques on the rate of local adverse events in patients implanted with nonanimal hyaluronic acid gel dermal fillers. Dermatol Surg 2008;34(Suppl):S105-9.
82. Taylor SC, Burgess CM, Callender VD. Safety of nonanimal stabilized hyaluronic acid dermal fillers in patients with skin of color: a randomized, evaluator-blinded comparative trial. Dermatol Surg 2009;35(Suppl):1653-60.
83. Grimes PE, Thomas JA, Murphy DK. Safety and effectiveness of hyaluronic acid fillers in skin of color. J Cosmet Dermatol 2009;8:162-8.
84. Matarosso SL, Carruthers JD, Jewell ML. Consensus recommendations for soft-tissue augmentation with nonanimal stabilized hyaluronic acid (Restylane). Plast Reconstr Surg 2006;117(Suppl):3-43S.
85. Alam M, Gladstone H, Kramer EM, Murphy JP, Nouri K, Neuhaus IM, et al. ASDS guidelines of care: injectable fillers. Dermatol Surg 2008;34:S115-48.
86. Hanke CW, Rohrich RJ, Busso M, Carruthers A, Carruthers J, Fagien S, et al. Facial soft-tissue fillers conference: assessing the state of the science. J Am Acad Dermatol 2011;64(Suppl): S66-85, S85.e1-136.
87. Dover JS, Carruthers A, Carruthers J, Alam M. Clinical use of Restylane. Skin Therapy Lett 2005;10:5-7.
88. Carruthers J, Klein AW, Carruthers A, Glogau RG, Canfield D. Safety and efficacy of nonanimal stabilized hyaluronic acid for improvement of mouth corners. Dermatol Surg 2005;31: 276-80.
89. Carruthers J, Rzany B, Sattler G, Carruthers A. Anatomic guidelines for augmentation of the cheek and infraorbital hollow. Dermatol Surg 2012;38:1223-33.
90. Alam M, Levy R, Pajvani U, Ramierez JA, Guitart J, Veen H, et al. Safety of radiofrequency treatment over human skin previously injected with medium-term injectable soft-tissue augmentation materials: a controlled pilot trial. Lasers Surg Med 2006;38:205-10.
91. Goldman MP, Alster TS, Weiss R. A randomized trial to determine the influence of laser therapy, monopolar radiofrequency treatment, and intense pulsed light therapy administered immediately after hyaluronic acid gel implantation. Dermatol Surg 2007;33:535-42.
92. Carruthers A, Carruthers J, Monheit GD, Davis PG, Tardie G. Multicenter, randomized, parallel-group study of the safety and effectiveness of onabotulinumtoxinA and hyaluronic acid dermal fillers (24-mg/mL smooth cohesive gel) alone and in combination for lower facial rejuvenation. Dermatol Surg 2010;36(Suppl):2121-34.
93. Weinkle SH, Bank DE, Boyd CM, Gold MH, Thomas JA, Murphy DK. A multi-center, double-blind, randomized controlled study of the safety and effectiveness of Juvederm injectable gel with and without lidocaine. J Cosmet Dermatol 2009;8: 205-10.
94. Hexsel D, Soirefmann M, Porto MD, Siega C, Schilling-Souza J, Brum C. Double-blind, randomized, controlled clinical trial to compare safety and efficacy of a metallic cannula with that of a standard needle for soft tissue augmentation of the nasolabial folds. Dermatol Surg 2012;38:207-14.
95. Gogolewski S, Jovanovic M, Perren SM, Dillon JG, Hughes MK. Tissue response and in vivo degradation of selected polyhydroxyacids: polylactides (PLA), poly(3-hydroxybutyrate) (PHB), and poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHB/VA). J Biomed Mater Res 1993;27:1135-48.
96. Vleggaar D. Facial volumetric correction with injectable poly-L-lactic acid. Dermatol Surg 2005;31:1511-8.
97. Lowe NJ. Dispelling the myth: appropriate use of poly-l-lactic acid and clinical considerations. J Eur Acad Dermatol Venereol 2006;20:2-6.
98. Woerle B, Hanke CW, Sattler G. Poly-L-lactic acid: temporary filler for soft tissue augmentation. J Drugs Dermatol 2004;3: 385-9.
99. Hanke CW, Redbord KP. Safety and efficacy of poly-L-lactic acid in HIV lipoatrophy and lipoatrophy of aging. J Drugs Dermatol 2007;6:123-8.
100. Levy RM, Redbord KP, Hanke CW. Treatment of HIV lipoatrophy and lipoatrophy of aging with poly-L-lactic acid: a prospective 3-year follow-up study. J Am Acad Dermatol 2008;59:923-33.
101. Narins RS, Baumann L, Brandt FS, Fagien S, Glazer S, Lowe NJ, et al. A randomized study of the efficacy and safety of injectable poly-L-lactic acid versus human-based collagen

implant in the treatment of nasolabial fold wrinkles. J Am Acad Dermatol 2010;62:448-62.
102. Palm MD, Woodhall KE, Butterwick KJ, Goldman MP. Cosmetic use of poly-l-lactic acid: a retrospective study of 130 patients. Dermatol Surg 2010;36:161-70.
103. Burgess CM, Quiroga RM. Assessment of the safety and efficacy of poly-L-lactic acid for the treatment of HIV-associated facial lipoatrophy. J Am Acad Dermatol 2005;52:233-9.
104. US Food and Drug Administration. Available from: URL: http://www.accessdata.fda.gov/cdrh_docs/pdf3/P030050S002a.pdf. Accessed July 22, 2012.
105. Fitzgerald R, Vleggaar D. Facial volume restoration of the aging face with poly-l-lactic acid. Dermatol Ther 2011;24: 2-27.
106. Yamashita Y, Uchida A, Yamakawa T, Shinto Y, Araki N, Kato K. Treatment of chronic osteomyelitis using calcium hydroxyapatite ceramic implants impregnated with antibiotic. Int Orthop 1998;22:247-51.
107. Busso M. Vectoring approach to facial recontouring using calcium hydroxylapatite (Radiesse®) and hyaluronic acid (Restylane®). Cosmet Dermatol 2009;22:522-8.
108. Busso M, Karlsberg P. Cheek augmentation and rejuvenation using injectable calcium hydroxylapatite (Radiesse). Cosmet Dermatol 2006;19:583-8.
109. Busso M, Howell DJ. Forehead recontouring with calcium hydroxylapatite. Dermatol Surg 2010;36(Suppl):1910-3.
110. Busso M. Soft tissue augmentation: non-surgical approaches to treatment of the mid and lower facial regions. Dermatol Nurs 2008;20:211-8.
111. Werschler WP, Busso M. Prepackaged injectable soft-tissue rejuvenation of the hand and other nonfacial areas. In: Alam M, Pongprutthipan M, editors. Body rejuvenation (part 7). New York: Springer; 2010:30:221-5.
112. Smith S, Busso M, McClaren M, Bass LS. A randomized, bilateral, prospective and multi-center comparison of calcium hydroxylapatite microspheres in gel versus human-based collagen for the correction of nasolabial folds. Dermatol Surg 2007;33(Suppl):S112-21.
113. Bass LS, Smith S, Busso M, McClaren M. Calcium hydroxylapatite (Radiesse) for treatment of nasolabial folds: long-term safety and efficacy results. Aesthetic Surg J 2010;30:235-8.
114. Busso M. Calcium hydroxylapatite (Radiesse): safety, techniques and pain reduction. J Drugs Dermatol 2009;8(Suppl): s21-3.
115. Busso M, Applebaum D. Hand augmentation with Radiesse. J Dermatol Ther 2007;20:385-7.
116. Busso M, Moers-Carpi M, Storck R, Ogilvie P, Ogilvie A. Multicenter, randomized trial assessing the effectiveness and safety of calcium hydroxylapatite for hand rejuvenation. Dermatol Surg 2010;36:790-7.
117. Marmur M, Green L, Busso M. Controlled, randomized study of pain levels in subjects treated with calcium hydroxylapatite premixed with lidocaine for correction of nasolabial folds. Dermatol Surg 2010;36:309-15.
118. Busso M, Voigts R. An investigation of changes in physical properties of injectable calcium hydroxylapatite in a carrier gel when mixed with lidocaine and with lidocaine/epinephrine. Dermatol Surg 2008;34:S16-24.
119. Busso M. Additional commentary on "addition of lidocaine to fillers." Dermatol Surg 2010;36:1795-6.
120. Anderson RR, Parrish JA. Selective photothermolysis: precise microsurgery by selective absorption of pulsed radiation. Science 1983;220:524-7.
121. Garden JM, Polla LL, Tan OT. The treatment of port-wine stains by the pulsed dye laser: analysis of pulse duration and long-term therapy. Arch Dermatol 1988; 124:889.
122. Ashinoff R, Geronemus RG. Flashlamp-pumped pulsed dye laser for port wine stains in infancy: earlier versus later treatment. J Am Acad Dermatol 1991;24:467-72.
123. Ashinoff R, Geronemus RG. Capillary hemangiomas and treatment with the flashlamp-pumped pulsed dye laser. Arch Dermatol 1991;127:202-5.
124. Garden JM, Bakus AD, Paller AS. Treatment of cutaneous hemangiomas by the flashlamp-pumped pulsed dye laser: prospective analysis. J Pediatr 1992;120:555-60.
125. Geronemus RG, Ashinoff R. The medical necessity of evaluation and treatment of port-wine stains. J Dermatol Surg Oncol 1991;17:76-9.
126. McClean K, Hanke CW. The medical necessity for treatment of port-wine stains. Dermatol Surg 1997;23:663-7.
127. Kauvar ANB, Geronemus RG. Repetitive pulsed dye laser treatments improve persistent port-wine stains. Dermatol Surg 1995;21:515-21.
128. Izikson L, Nelson JS, Anderson RR. Treatment of hypertrophic and resistant port wine stains with a 755 nm laser: a case series of 20 patients. Lasers Surg Med 2009;41:427-32.
129. Tierney EP, Hanke CW. Alexandrite laser for the treatment of port wine stains refractory to pulsed dye laser. Dermatol Surg 2011;37:1268-78.
130. Chen JK, Ghasri P, Aguilar G, van Drooge AM, Wolkerstorfer A, Kelly KM, et al. An overview of clinical and experimental treatment modalities for port wine stains. J Am Acad Dermatol 2012;67:289-304.e29.
131. Morelli JG, Tan OT, Yohn JJ, Weston WI. Treatment of ulcerated hemangiomas in infancy. Arch Pediatr Adolesc Med 1994;148:1104-5.
132. Geronemus RG, Kauvar AN. The pulsed-dye laser for infantile hemangiomas. Plast Reconstr Surg 1996;97:1302-3.
133. Brightman LA, Brauer JA, Terushkin V, Hunzeker C, Reddy KK, Weiss ET, et al. Ablative fractional resurfacing for involuted hemangioma residuum. Arch Dermatol 2012;148:1294-8.
134. Dover JS, Arndt KA. New approaches to the treatment of vascular lesions. Lasers Surg Med 2000;26:158-63.
135. Bernstein EF, Kligman A. Rosacea treatment using the new-generation, high-energy, 595 nm, long pulse-duration pulsed-dye laser. Lasers Surg Med 2008;40:233-9.
136. Kauvar ANB, Geronemus RG, McDaniel DH. Pulsed dye laser treatment of warts. Arch Fam Med 1995;4:1035-40.
137. Alster TS. Improvement of erythematous and hypertrophic scars by the 585 nm flashlamp-pumped pulsed dye laser. Ann Plast Surg 1994;32:186-90.
138. Alster TS, Williams CM. Improvement of hypertrophic and keloidal median sternotomy scars by the 585 nm flashlamp-pumped pulsed dye laser: a controlled study. Lancet 1995;345:1198-200.
139. McDaniel DH, Ash K, Zukowski M. Treatment of stretch marks with the 585 nm flashlamp-pumped pulsed dye laser. Dermatol Surg 1996;22:332-7.
140. Goldman MP, Weiss RA, Weiss MA. Intense pulsed light as a nonablative approach to photoaging. Dermatol Surg 2005; 31:1179-87.
141. Dierickx CC, Casparian JM, Venugopalan V, Farinelli WA, Anderson RR. Thermal relaxation of port wine stain vessels probed in vivo: the need for 1-10 ms laser. J Invest Dermatol 1995;105:709-14.
142. Nelson JS, Milner TE, Anvari B, Tanenbaum BS, Kimel S, Svaasand LO, et al. Dynamic epidermal cooling during pulsed

laser treatment of port-wine stain: a new methodology with preliminary clinical evaluation. Arch Dermatol 1995;131: 695-700.
143. Geronemus RG, Quintana AT, Lou WW, Kauvar AN. High-fluence modified pulsed dye laser photocoagulation with dynamic cooling of port-wine stains in infancy. Arch Dermatol 2000;136:942-3.
144. Kauvar ANB, Lou WW. Pulsed alexandrite laser for the treatment of leg telangiectasia and reticular veins. Arch Dermatol 2000;136:1371-5.
145. Kauvar AN, Khrom T. Laser treatment of leg veins. Semin Cutan Med Surg 2005;24:184-92.
146. Omura NE, Dover JS, Arndt KA, Kauvar AN. Treatment of reticular leg veins with a 1064 nm long-pulsed Nd:YAG laser. J Am Acad Dermatol 2003;48:76-81.
147. Parlette EC, Groff WF, Kinshella MJ, Domankevitz Y, O'Neill J, Ross EV. Optimal pulse durations for the treatment of leg telangiectasias with a neodymium YAG laser. Lasers Surg Med 2006;38:98-105.
148. Nijsten T, van den Bos RR, Goldman MP, Kockaert MA, Proebstle TM, Rabe E, et al. Minimally invasive techniques in the treatment of saphenous varicose veins. J Am Acad Dermatol 2009;60:110-9.
149. Maiman T. Stimulated optical radiation in ruby. Nature 1960; 187:493-4.
150. Goldman L, Rockwell R, Meyer R, Otten R, Wilson RG, Kitzmiller KW. Laser treatment of tattoos: a preliminary survey of three year's clinical experience. JAMA 1967;201:841-4.
151. Geronemus R. Q-switched ruby laser therapy of nevus of Ota. Arch Dermatol 1992;128:1618-22.
152. Kilmer S, Wheeland R, Goldberg D, Anderson R. Treatment of epidermal pigmented lesions with the frequency-doubled Q-switched Nd:YAG laser: a controlled, single-impact, dose-response, multicenter trial. Arch Dermatol 1994;130: 1515-9.
153. Ross EV, Naseef G, Lin C, Kelly M, Michaud N, Flotte TJ, et al. Comparison of responses of tattoos to picosecond and nanosecond Q-switched neodymium: YAG lasers. Arch Dermatol 1998;134:167-71.
154. Herd R, Alora M, Smoller B, Arndt K, Dover J. A clinical and histologic prospective controlled comparative study of the picosecond titanium:sapphire (795 nm) laser versus the Q-switched alexandrite (752 nm) laser for removing tattoo pigment. J Am Acad Dermatol 1999;40:603-6.
155. Izikson L, Farinelli W, Sakamoto F, Tannous Z, Anderson R. Safety and effectiveness of black tattoo clearance in a pig model after a single treatment with a novel 758 nm 500 picosecond laser: a pilot study. Lasers Surg Med 2010;42:640-6.
156. Saedi N, Metelitsa A, Petrell K, Arndt KA, Dover JS. Treatment of tattoos with a picosecond alexandrite laser: a prospective trial. Arch Dermatol 2012;148:1360-3.
157. Dover J, Arndt K, Metelitsa A, Petrell K. Picosecond 755nm alexandrite laser for treatment of tattoos and benign pigmented lesions: a prospective trial. American Society for Laser Medicine and Surgery Annual Meeting. Kissimmee, FL. April 18-22, 2012.
158. Brauer JA, Reddy KK, Anolik R, Weiss ET, Karen JK, Hale EK, et al. Successful and rapid treatment of blue and green tattoo pigment with a novel picosecond laser. Arch Dermatol 2012;148:820-3.
159. Kossida T, Rigopoulos D, Katsambas A, Anderson R. Optimal tattoo removal in a single laser session based on the method of repeated exposures. J Am Acad Dermatol 2012;66:271-7.
160. Manstein D, Herron G, Sink R, Tanner H, Anderson R. Fractional photothermolysis: a new concept for cutaneous remodeling using microscopic patterns of thermal injury. Lasers Surg Med 2004;34:426-38.
161. Laubach H, Tannous Z, Anderson R, Manstein D. Skin responses to fractional photothermolysis. Lasers Surg Med 2006;38:142-9.
162. Hantash BM, Bedi VP, Sudireddy V, Struck SK, Herron GS, Chan KF. Laser-induced transepidermal elimination of dermal content by fractional photothermolysis. J Biomed Opt 2006; 11:041115.
163. Kouba D, Fincher E, Moy R. Nevus of Ota successfully treated by fractional photothermolysis using a fractionated 1440-nm Nd:YAG laser. Arch Dermatol 2008;144: 156-8.
164. Weiss ET, Geronemus R. Combining fractional resurfacing and Q-switched ruby laser for tattoo removal. Dermatol Surg 2011;37:97-9.
165. Rokhsar C, Fitzpatrick R. The treatment of melasma with fractional photothermolysis: a pilot study. Dermatol Surg 2005;31:1645-50.
166. Rokhsar C, Ciocon D. Fractional photothermolysis for the treatment of postinflammatory hyperpigmentation after carbon dioxide laser resurfacing. Dermatol Surg 2009;35: 535-7.
167. Katz T, Goldberg L, Firoz B, Friedman P. Fractional photothermolysis for the treatment of postinflammatory hyperpigmentation. Dermatol Surg 2009;35:1844-8.
168. Polder KD, Bruce S. Treatment of melasma using a novel 1927nm fractionated thulium fiber laser. Dermatol Surg 2012; 38:199-206.
169. Polnikorn N. Treatment of refractory dermal melasma with the MedLite C6 Q-switched Nd:YAG laser. J Cosmet Laser Ther 2008;10:167-73.
170. Jeong SY, Shin JB, Yeo UC, Kim WS, Kim IH. Low-fluence Q-switched neodymium-doped yttrium aluminum garnet laser for melasma with pre- or post-treatment triple combination cream. Dermatol Surg 2010;36:909-18.
171. Kauvar AN. Successful treatment of melasma using a combination of microdermabrasion and Q-switched Nd: YAG lasers. Lasers Surg Med 2012;44:117-24.
172. Wanner M, Tanzi E, Alster T. Fractional photothermolysis: treatment of facial and nonfacial cutaneous photodamage with a 1,550-nm erbium-doped fiber laser. Dermatol Surg 2007;33:23-8.
173. Bitter PH. Noninvasive rejuvenation of photodamaged skin using serial, full-face intense pulsed light treatments. Dermatol Surg 2000;26:835-42.
174. Ross EV, Smirnov M, Pankratov M, Altshuler G. Intense pulsed light and laser treatment of facial telangiectasias and dyspigmentation: some theoretical and practical comparisons. Dermatol Surg 2005;31:1188-98.
175. Galeckas KJ, Collins M, Ross EV, Uebelhoer NS. Split-face treatment of facial dyschromia: pulsed dye laser with a compression handpiece versus intense pulsed light. Dermatol Surg 2008;34:672-80.
176. Geronemus R. Fractional photothermolysis: current and future applications. Lasers Surg Med 2006;38:169-76.
177. Jih MH, Goldberg LH, Kimyai-Asadi A. Fractional photothermolysis for photoaging of hands. Dermatol Surg 2008; 34:73-8.
178. Rahman Z, Alam M, Dover JS. Fractional laser treatment for pigmentation and texture improvement. Skin Ther Lett 2006; 11:7-11.
179. Alster TS, Tanzi EL, Lazarus M. The use of fractional laser photothermolysis for the treatment of atrophic scars. Dermatol Surg 2007;33:295-9.

180. Hantash BM, Bedi VP, Chan KF, Zachary CB. Ex vivo histological characterization of a novel ablative fractional resurfacing device. Lasers Surg Med 2007;39:87-95.
181. Hantash BM, Bedi VP, Kapadia B, Rahman Z, Jiang K, Tanner H, et al. In vivo histological evaluation of a novel ablative fractional resurfacing device. Lasers Surg Med 2007;39: 96-107.
182. Chapas AM, Brightman L, Sukal S, Hale E, Daniel D, Bernstein LJ, et al. Successful treatment of acneiform scarring with CO_2 ablative fractional resurfacing. Lasers Surg Med 2008;40: 381-6.
183. Stebbins WG, Hanke CW. Ablative fractional CO_2 resurfacing for photoaging of the hands: pilot study of 10 patients. Dermatol Ther 2011;24:62-70.
184. Tierney EP, Hanke CW. Ablative fractionated CO_2, laser resurfacing for the neck: prospective study and review of the literature [review]. J Drugs Dermatol 2009;8:723-31.
185. Tierney EP, Hanke CW, Watkins L. Treatment of lower eyelid rhytids and laxity with ablative fractionated carbon-dioxide laser resurfacing: case series and review of the literature [review]. J Am Acad Dermatol 2011;64:730-40.
186. Goldberg DJ, Berlin AL, Phelps R. Histologic and ultrastructural analysis of melasma after fractional resurfacing. Lasers Surg Med 2008;40:134-8.
187. Sukal SA, Chapas AM, Bernstein LJ, Hale EK, Kim KH, Geronemus RG. Eyelid tightening and improved eyelid aperture through nonablative fractional resurfacing. Dermatol Surg 2008;34:1454-8.
188. Goldman L, Blaney DJ, Kindel DJ Jr, Richfield D, Franke EK. Pathology of the effect of the laser beam on the skin. Nature 1963;197:912-4.
189. Grossman MC, Dierickx C, Farinelli W, Flotte T, Anderson RR. Damage to hair follicles by normal-mode ruby laser pulses. J Am Acad Dermatol 1996;35:889-94.
190. Asawanonda P, Anderson RR, Chang Y, Taylor CR. 308-nm Excimer laser for the treatment of psoriasis: a dose-response study. Arch Dermatol 2000;136:619-24.
191. Hongcharu W, Taylor CR, Chang Y, Aghassi D, Suthamjariya K, Anderson RR. Topical ALA-photodynamic therapy for the treatment of acne vulgaris. J Invest Dermatol 2000;115: 183-92.
192. Anderson RR, Farinelli W, Laubach H, Manstein D, Yaroslavsky AN, Gubeli J III, et al. Selective photothermolysis of lipid-rich tissues: a free electron laser study. Lasers Surg Med 2006;38: 913-9.
193. Haedersdal M, Sakamoto FH, Farinelli WA, Doukas AG, Tam J, Anderson RR. Fractional CO(2) laser-assisted drug delivery. Lasers Surg Med 2010;42:113-22.
194. Manstein D, Laubach H, Watanabe K, Farinelli W, Zurakowski D, Anderson RR. Selective cryolysis: a novel method of non-invasive fat removal. Lasers Surg Med 2008;40: 595-604.
195. Laubach HJ, Makin IR, Barthe PG, Slayton MH, Manstein D. Intense focused ultrasound: evaluation of a new treatment modality for precise microcoagulation within the skin. Dermatol Surg 2008;34:727-34.
196. Alam M, White LE, Martin N, Witherspoon J, Yoo S, West DP. Ultrasound tightening of facial and neck skin: a rater-blinded prospective cohort study. J Am Acad Dermatol 2010;62: 262-9.
197. Hruza G, Taub AF, Collier SL, Mulholland SR. Skin rejuvenation and wrinkle reduction using a fractional radiofrequency system. J Drugs Dermatol 2009;8:259-65.
198. Alexiades-Armenakas M, Rosenberg D, Renton B, Dover J, Arndt K. Blinded, randomized, quantitative grading comparison of minimally invasive, fractional radio frequency and surgical face-lift to treat skin laxity. Arch Dermatol 2010; 146:396-405.
199. Glaser DA, Coleman WP III, Fan LK, Kaminer MS, Kilmer SL, Nossa R, et al. A randomized, blinded clinical evaluation of a novel microwave device for treating axillary hyperhidrosis: the dermatologic reduction of underarm perspiration study. Dermatol Surg 2012;38:185-91.
200. Asken S. Manual of liposuction surgery and autologous fat transplantation under local anesthesia. Irvin (CA): Terry and Associates; 1986.
201. Asken S. Liposuction surgery and autologous fat transplantation. Norwalk (CT): Appleton and Longe; 1988.
202. Stegman SJ, Tromovitch TA, editors. Cosmetic dermatologic surgery. Chicago: Year Book Medical Publishers; 1984.
203. Klein JA. The tumescent technique for liposuction surgery. Am J Cosmet Surg 1987;4:263-7.
204. Hanke CW, Bernstein G, Bullock S. Safety of liposuction in 15,336 patients. J Dermatol Surg Oncol 1995;21:459-62.
205. Housman TS, Lawrence N, Mellen BG, George MN, San Filippo J, Cerveny KA Jr, et al. The safety of liposuction: results of a national survey. Dermatol Surg 2002;39:971-8.
206. Habbema L. Safety of liposuction using exclusively tumescent local anesthesia in 3240 consecutive cases. Dermatol Surg 2009;35:1728-35.
207. Coleman WP, Glogau RG, Klein JA, Moy RL, Narins RS, Chuang T, et al. Guidelines of care for liposuction. J Am Acad Dermatol 2001;45:438-47.
208. Svedman KJ, Coldiron B, Coleman WP III, Cox SE, Jacob C, Lawrence N, et al. ASDS guidelines of care for tumescent liposuction. Dermatol Surg 2006;32:709-16.
209. Klein JA. Tumescent technique for regional anesthesia permits lidocaine doses of 35 mg/kg is safe for liposuction surgery. J Dermatol Surg Oncol 1990;16:248-63.
210. Ostad A, Kageyamam N, Moy RL. Tumescent anesthesia with lidocaine dose of 55 mg/kg is safe for liposuction. J Dermatol Surg Oncol 1988;14:112-4.
211. Klein JA. Tumescent technique: tumescent anesthesia and microcannular liposuction. St Louis (MO): Mosby; 2000.
212. Sommer B, Sattler G, Hanke CW, editors. Tumescenz Lokalanasthesie. Berlin (Germany): Springer; 1999.
213. Hanke CW, Sommer B, Sattler G, editors. Tumescent local anesthesia. Berlin (Germany): Springer; 2001.
214. Hanke CW, Sattler S, Sommer B. Textbook of liposuction. Abingdon (United Kingdom): Informa Healthcare; 2007.
215. Hanke CW, Sattler G. Liposuction procedures in cosmetic dermatology series. Philadelphia (PA): Elsevier; 2005.
216. Tsai RY, Wang CN, Chan HL. Aluminum oxide crystal microdermabrasion: a new technique for treating facial scarring. Dermatol Surg 1995;21:539-42.
217. Shim EK, Barnette D, Hughes K, Greenway HT. Microdermabrasion: a clinical and histopathologic study. Dermatol Surg 2001;27: 524-30.
218. Tan MH, Spencer JM, Pires LM, Ajmeri J, Skover G. The evaluation of aluminum oxide microdermabrasion for photodamage. Dermatol Surg 2001;27:943-9.
219. Karimipour DJ, Kang S, Johnson TM, Orringer JS, Hamilton T, Hammerberg C, et al. Microdermabrasion with and without aluminum oxide crystal abrasion: a comparative molecular analysis of dermal remodeling. J Am Acad Dermatol 2006;54: 405-10.
220. Karimipour DJ, Rittié L, Hammerberg C, Min VK, Voorhees JJ, Orringer JS, et al. Molecular analysis of aggressive microdermabrasion in photoaged skin. Arch Dermatol 2009;145: 1114-22.

221. Rifat SL, Eastwood MR, McLachlan DR, Corey PN. Effect of exposure of miners to aluminum powder. Lancet 1996;336: 1162-5.
222. Katz BE, Truong S, Maiwald DC, Frew KE, George D. Efficacy of microdermabrasion preceding ALA application in reducing the incubation time. J Drugs Dermatol 2007;6:140-2.
223. Garg T, Chandler R, Jain A. Combination of microdermabrasion and 5-fluorouracil to induce repigmentation in vitiligo: and observational study. Dermatol Surg 2011;37: 1763-6.
224. Kronmayer E. Did Heilung der Akne durch ein Never Narbe Lascs Operations ver Faren: das Strazen. Ilustr Monatssehr Aerztl Poly Tech 1905;27:101.
225. Kurtin A. Corrective surgical planning of skin. AMA Arch Derm Syphilol 1953;68:389-97.
226. Burks JW. Wire brush surgery. Springfield (IL): Charles C. Thomas; 1956.
227. Coleman W, Hanke CW, Alt T, Asken S. Dermabrasion: cosmetic surgery of the skin. Phladelphia: BC Decker; 1991. pp.147-97.
228. Nelson BR, Metz RD, Majmudar G, Hamilton TA, Gillard MO, Railan D, et al. A comparison of wire brush and diamond fraise superficial dermabrasion for photoaged skin: a clinical immunohistologic and biochemical study. J Am Acad Dermatol 1996;34:235-43.
229. Mandy S. Tretinoin in the pre and postoperative management of dermabrasion. J Am Acad Dermatol 1986;115:878.
230. Mandy S. A new primary wound dressing made of polyethylene oxide gel. J Dermatol Surg Oncol 1987;9:153.
231. Maibach H, Rovee D. Epidermal wound healing. Chicago: Year Book Medical Publishers; 1972.
232. Rubenstein R, Roenigk H, Stegman SJ, Hanke CW. Atypical keloids after dermabrasion of patients taking isotretinoin. J Am Acad Dermatol 1986;15:280-5.
233. Moy R, Zitelli J, Uitto J. Effect of 13C is retinoic acid on dermal wound healing [abstract]. J Invest Dermatol 1987;88:508.
234. Coleman W, Yarborough J, Mandy S. Dermabrasion for prophylaxis and treatment of actinic keratoses. J Dermatol Surg Oncol 1996;22:17-21.
235. Yarborough J. Dermabrasive surgery state of the art. In: Millikan LE, editor. Clinics in dermatology, advances in surgery. Philadelphia: JB Lippincott; 1987. pp. 75-80.
236. Alt T. Facial dermabrasion: advantages of the diamond fraise technique. J Dermatol Surg Oncol 1987;13:618.
237. Mandy S, Monheit G. Dermabrasion and chemical peels. In: Papel I, editor. Facial plastic and reconstructive surgery. New York: Thieme; 2002. pp. 223-40.
238. Hanke CW, Roenigk H, Pinsky J. Complications of dermabrasion resulting from excessively cold skin refrigeration. J Dermatol Surg Oncol 1985;11:896.
239. Countryman N, Hanke CW. Practical review of nerve blocks in dermatologic surgery of the face. Current Dermatology Reports. http://doi.dx.org/10.1007/s1367-012-007-9. pp. 49-54.
240. Hanke CW. The tumescent facial block: tumescent local anesthesia and nerve block anesthesia for full-face laser resurfacing. Dermatol Surg 2001;27:1003-5.
241. Fitzpatrick RE, Tope WD, Goldman MP, Satur NM. Pulsed CO_2 laser—cutaneous resurfacing vs TCA peel, dermabrasion and chemical peel: a clinical and histological study in a porcine model. Arch Dermatol 1996;132:469-71.
242. Giese SY, McKinney P, Roth SI, Zukowski M. The effect of chemosurgical peels and dermabrasion on dermal elastic tissue. Plast Reconstr Surg 1997;100:489-98.
243. Stegman SJ. A comparative histologic study of the effects of three peeling agents and dermabrasion on normal and sun damaged skin. Aesth Plast Surg 1982;6:123-35.
244. Landau M. Cardiac complications in deep chemical peels. Dermatol Surg 2007;33:190-3.
245. Brody HJ, Hailey CW. Medium depth chemical peeling of the skin: a variation of superficial chemosurgery. J Dermatol Surg Oncol 1986;12:1268-75.
246. Monheit G. The Jessner's+TCA peel: a medium-depth chemical peel. J Dermatol Surg Oncol 1989;15:945-50.
247. Coleman WT III, Futrell JM. The glycolic acid trichloroacetic acid peel. J Dermatol Surg Oncol 1994;20:76-80.
248. Lee JB, Chung WG, Kwahck H, Lee KH. Focal treatment of acne scars with trichloroacetic acid: chemical reconstruction of skin scars method. Dermatol Surg 2002;28:1017-21.
249. Van Scott EJ, Yu RJ. Alpha hydroxyl acids: procedures for use in clinical practice. Cutis 1989;43:222-9.
250. Kligman D, Kligman AM. Salicylic acid peels for the treatment of photoaging. Dermatol Surg 1998;24:325-8.
251. Rubin MG. A peeler's thoughts on skin improvement with chemical peels and laser resurfacing. Clin Plast Surg 1997;24: 407-9.
252. Grimes PE. The safety and efficacy of salicylic acid chemical peels in darker racial-ethnic groups. Dermatol Surg 1999;25: 18-22.
253. Grimes PE. Agents for ethnic skin peeling. Dermatol Ther 2000;13:159-64.
254. Kligman AM, Willis I. A new formula for depigmenting the skin. Arch Dermatol 1975;111:40-8.
255. Abdel-Daim M, Funasaka Y, Kamo T, Ooe M, Matsunaka H, Yanagita E, et al. Preventive effect of chemical peeling on ultraviolet induced skin tumor formation. J Dermatol Sci 2010;60:21-8.
256. Alam M, Omura N, Kaminer MS. Subcision for acne scarring: technique and outcomes in 40 patients. Dermatol Surg 2005; 31:310-7.
257. Fulchiero GJ Jr, Parham-Vetter PC, Obagi S. Subcision and 1320-nm Nd:YAG nonablative laser resurfacing for the treatment of acne scars: a simultaneous split-face single patient trial. Dermatol Surg 2004;30:1356-60.
258. Alster TS, West TB. Resurfacing of atrophic facial acne scars with a high-energy, pulsed carbon dioxide laser. Dermatol Surg 1996;22:151-5.
259. Sherling M, Friedman PM, Adrian R, Burns AJ, Conn H, Fitzpatrick R, et al. Consensus recommendations on the use of an erbium-doped 1,550-nm fractionated laser and its applications in dermatologic laser surgery. Dermatol Surg 2010;36:461-9.
260. Mahmoud BH, Srivastava D, Janiga JJ, Yang JJ, Lim HW, Ozog DM. Safety and efficacy of erbium-doped yttrium aluminum garnet fractionated laser for treatment of acne scars in type IV to VI skin. Dermatol Surg 2010;36:602-9.
261. Ortiz A, Elkeeb L, Truitt A, Tournas J, Zachary C. Evaluation of a novel fractional resurfacing device for the treatment of acne scarring. Abstract presented at: American Society for Laser Medicine and Surgery Conference; April 2-6, 2008; Kissimmee, FL.
262. Limmer BL. Elliptical donor stereoscopically assisted micrografting as an approach to further refinement in hair transplantation. Dermatol Surg 1994;20:789-93.
263. Bernstein RM, Rassman WR, Szaniawski W, Halperin A. Follicular transplantation. Int J Aesthetic Rest Surg 1995;3: 119-32.
264. Bernstein RM, Rassman WR. Follicular transplantation: patient evaluation and surgical planning. Dermatol Surg 1997;23: 771-84.

265. Bernstein RM, Rassman WR. The aesthetics of follicular transplantation. Dermatol Surg 1997;23:785-99.
266. Haber RS. Tissue spreader: analysis of transection reduction (abstract). Presented at: International Society of Hair Restoration Surgery Annual Meeting; September 26-30, 2007; Las Vegas, NV.
267. Choi YC, Kim JC. Single-hair and bundled-hair transplantation using the Choi hair transplanter. In: Stough DB, Haber RS, editors. Hair replacement: surgical and medical. St Louis (MO): Mosby-Year Book Inc; 1996. pp. 125-7.
268. Limmer BL. Micrograft survival. In: Stough DB, Haber RS, editors. Hair replacement: surgical and medical. St Louis (MO): Mosby-Year Book Inc; 1996. pp. 147-9.
269. Cooley JE. Ischemia-reperfusion injury and graft storage solutions. Hair Transplant Forum Int 2004;14: 121, 127, 130.
270. Stough D. Single hair grafting for advanced male pattern alopecia. Cosmet Dermatol 1993;6:11-5.
271. Stough DB, Haber RS. Hair replacement: surgical and medical. St Louis: Mosby-Year Book Inc; 1996.
272. Stough DB, Haber RS. Hair transplantation. Philadelphia (PA): Elsevier Inc; 2006.
273. Unger WP, Shapiro R, Unger R, Unger M. Hair transplantation. 5th ed. London (United Kingdom): Informa HealthCare; 2011.
274. Cohen BH. The cross-section trichometer: a new device for measuring hair quantity, hair loss and hair growth. Dermatol Surg 2008;34:900-11.
275. Rassman WR, Bernstein RM, McClellan R, Jones R, Worton E, Uyttendaele H. Follicular unit extraction: minimally invasive surgery for hair transplantation. Dermatol Surg 2002;28: 720-7.
276. Canales MG, Berman DA. The age of surgical robots. Hair Transplant Forum Int 2008;18:95-6.
277. Hwang S, Kim JC, Ryu HS, Cha YC, Lee SJ, Na YG, et al. Does the recipient site influence the hair growth characteristics in hair transplantation? Dermatol Surg 2002;28:795-8.
278. Zheng Y, Hsieh J, Washenik K. The promise of cell therapy. In: Unger W, et al, editor. Hair transplantation. 5th ed (1F: 23—28). New York: Marcel Dekker Inc; 2011.
279. Morris RJ, Liu Y, Marles L, Yang Z, Trempus C, Li S. Capturing and profiling hair follicle stem cells. Nat Biotechnol 2004;22: 411-7.
280. McElwee KJ, Kissling S, Wenzel E, Huth A, Hoffmann R. Cultured peribulbar dermal sheath cells can induce hair follicle development and contribute to the dermal sheath and dermal papilla. J Invest Dermatol 2003;121: 1267-75.
281. Zimber MP, Ziering C, Ziegler F, Hubka M, Mansbridge JN, Baumgartner M, et al. Hair regrowth following a Wnt- and follistatin containing treatment: safety and efficacy in a first-in-man phase 1 clinical trial. J Drugs Dermatol 2011;10: 1308-12.
282. van Korlaar I, Vossen C, Rosendaal F, Cameron L, Bovill E, Kaptein A. Quality of life in venous disease. Thromb Haemost 2003;90:27-35.
283. Aksoy B, Altaykan-Hapa A, Egemen D, Karagöz F, Atakan N. The impact of rosacea on quality of life: effects of demographic and clinical characteristics and various treatment modalities. Br J Dermatol 2010;163:719-25.
284. Linser P. Über die konservative Behandlung der Varizen. Med Klinik 1916:12897-8.
285. Conrad P, Malouf GM, Stacey MC. The Australian polidocanol (aethoxysklerol) study: results at 2 years. Dermatol Surg 1995; 21:334-8.
286. Rabe E, Schliephake D, Otto J, Breu FX, Pannier F. Sclerotherapy of telangiectases and reticular veins: a double-blind, randomized, comparative clinical trial of polidocanol, sodium tetradecyl sulphate and isotonic saline (EASI study). Phlebology 2010;25:124-31.
287. Kobayashi S, Crooks S, Eckmann DM. Dose- and time-dependent liquid sclerosant effects on endothelial cell death. Dermatol Surg 2006;32:1444-52.
288. Guex JJ, Schliephake DE, Otto J, Mako S, Allaert FA. The French polidocanol study on long-term side effects: a survey covering 3,357 patient years. Dermatol Surg 2010;36(Suppl): 993-1003.
289. Weiss R, Goldman M. Controlled radiofrequency-mediated endovenous shrinkage and occlusion. In: Goldman M, Weiss R, Bergan J, editors. Varicose veins and telangiectasias: diagnosis and treatment. 2nd ed. St Louis (MO): Quality Medical Publishing; 1999. pp. 217-24.
290. Navarro L, Min RJ, Boné C. Endovenous laser: a new minimally invasive method of treatment for varicose veins—preliminary observations using an 810 nm diode laser. Dermatol Surg 2001;27:117-22.
291. Goldman MP, Mauricio M, Rao J. Intravascular 1320-nm laser closure of the great saphenous vein: a 6- to 12-month follow-up study. Dermatol Surg 2004;30:1380-5.
292. Ouvry P, Allaert F-A, Desnos P, Hamel-Desnos C. Efficacy of polidocanol foam versus liquid in sclerotherapy of the great saphenous vein: a multicenter randomized controlled trial with a 2-year follow-up. Eur J Vasc Endovasc Surg 2008;36: 366-70.
293. Rabe E, Otto J, Schliephake D, Pannier F. Efficacy and safety of great saphenous vein sclerotherapy using standardized polidocanol foam (ESAF): a randomized controlled multicenter clinical trial. Eur J Vasc Endovasc Surg 2008;35:238-45.
294. Peterson JD, Goldman MP. An investigation into the influence of various gases and concentrations of sclerosants on foam stability. Dermatol Surg 2011;37:12-7.
295. Peterson JD, Goldman MP. An investigation of side-effects and efficacy of foam-based sclerotherapy with carbon dioxide or room air in the treatment of reticular leg veins: a pilot study. Phlebology 2012;27:73-6.
296. Weiss RA, Sadick NS, Goldman MP, Weiss MA. Post-sclerotherapy compression: controlled comparative study of duration of compression and its effects on clinical outcome. Dermatol Surg 1999;25:105-8.
297. Kern P, Ramelet A-A, Wütschert R, Hayoz D. Compression after sclerotherapy for telangiectasias and reticular leg veins: a randomized controlled study. J Vasc Surg 2007;45:1212-6.
298. Hamel-Desnos CM, Guias BJ, Desnos PR, Mesgard A. Foam sclerotherapy of the saphenous veins: randomized controlled trial with or without compression. Eur J Vasc Endovasc Surg 2010;39:500-7.