M. Eisenmann-Klein · C. Neuhann-Lorenz (Eds.)
Innovations in Plastic and Aesthetic Surgery

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Innovations in Plastic and Aesthetic Surgery

With 551 Figures in 1192 Parts

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Marita Eisenmann-Klein, M.D.
General Secretary of the International Confederation for Plastic, Reconstructive and Aesthetic Surgery
Direktorin der Klinik für Plastische und Ästhetische Hand- und Wiederherstellungschirurgie am Caritas-Krankenhaus St. Josef in Regensburg
Landshuter Straße 65
93053 Regensburg
Germany

Constance Neuhann-Lorenz, M.D.
Fachärztin für Chirurgie
Fachärztin für Plastische und Ästhetische Chirurgie
President IQUAM (International Committee for Quality Assurance and Medical Devices in Plastic Surgery)
Theatinerstraße 1
80333 München
Germany

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Preface

Plastic Surgery is the most coveted field among medical students all over the world.

Cynics might conclude that this is due to the attraction of aesthetic surgery, but they are wrong.

Students realize very early, that plastic surgery has much more to offer: we treat babies and old patients, from head to toe, with a variety of sophisticated techniques, with the challenge of microsurgery topping the list. Creativity is an integral part of our daily work.

We use these techniques to make individuals regain their physical integrity, we are the quality-of-life speciality.

On our way to competence in this field we need great examples, we need heroes. And we are lucky to have so many of them.

No other field in medicine is as much internationally oriented as plastic surgery: in IPRAS 96 national plastic surgery societies are represented. One of the main objectives of IPRAS is to increase the number of training sites and subsequently the number of fully and well trained plastic surgeons worldwide.

With pride I can say, that plastic surgery is also the field with the highest number of physicians involved in humanitarian missions. These missions not only provide free treatment for patients in need, they also serve the purpose of promoting the training of young plastic surgeons in developing countries.

Most of the contributors of this book have been and still are involved in these missions. They are dedicated to teaching.

Rather than inviting them to contribute a chapter to a textbook, we asked them to share their greatest contribution to the future of plastic surgery with us. We were thrilled when we first saw their articles.

Share our enthusiasm and be up front with techniques which are likely to represent tomorrow's state-of-the-art in plastic surgery.

Marita Eisenmann-Klein

Preface

"It is now Monday and we are in the second week of creation" *Peter Sloterdijk* just recently stated in his prize award speech for innovative publication management. Nanotechnology, biotechnology and gene technology are revolutionizing our scientific world as much as our every day life – comparable only to the changes at the turning towards the industrial age at the end of the 19th century.

Plastic Surgery, one of the youngest mono-specialties in medicine, historically has been innovative to a drastic extent by introducing and adding the treatment of external appearance of mankind into medical sciences of healing patients of exclusively functional diseases. As the quality of results is more obvious in plastic surgery than in other medical fields the search for constant perfection together with lesser traumatic techniques is inherent in our daily work.

This book intends to allow an up to date overview of the latest consented techniques in Plastic and Aesthetic surgery. The inspiring spark was the 14th quadrennial International Congress of the International Confederation for Plastic, Reconstructive and Aesthetic Surgery (IPRAS) 2007 Berlin, Germany. Plastic Surgeons from all over the world exchanged their expert knowledge, innovative ideas and experience.

From all representative sections of our fascinating specialty we are grateful to have been able to include altogether 58 contributions from autografting and allografts like face transplantation to xenografts, from microsurgical techniques to laser technology, from stem cell research to bodylifting refinements. The different chapters are not separated by indication such as reconstructive or aesthetic as every single technique or therapy in Plastic Surgery by definition will never be reconstructive without respect to the aesthetic outcome and vice versa. Chapter organisation has been introduced according to different techniques or anatomical units.

Science and progress cannot exist without innovative ideas and their creators, but all innovations are based on the experience and established knowledge of our predecessors. Many promising new findings will not survive forever or be rejected after a while or even innovated by the original authors or others. Many old techniques on the other hand have never been neglected: the ever-cited Indian Flap e.g. The coexistence of both: old and new – is the secret of good science.

Johann Wolfgang v. Goethe:
„Wir ehren froh mit immer gleichem Mute
Das Altertum und jedes neue Gute."
„With the same cheerful courage we value
every good thing, both old and new"
(translated from the German)

Constance Neuhann-Lorenz

Contents

List of Contributors

Tawfeik Al-Yafi, MD
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Luiz Roberto Araujo, MD, MSc
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Andreas Arkudas, MD
Department of Plastic and Hand Surgery, University of Erlangen Medical Center, Krankenhausstrasse 12 91054 Erlangen, Germany

Alessio Baccarani, MD
Division of Plastic Reconstructive Surgery, University of Modena, Policlinico via Largo del Pozzo, Modena 71, Italy

Ricardo Baroudi, MD
Rua Itabaquara, 48, 01234.020, São Paulo, Brazil

Alfred Karl Berger, MD, PhD
Emeritus Professor of Plastic Surgery, Holbeinstr. 1 30916 Isernhagen, Germany

Patricia E. Bergey, PAC
Suite 500, 975 Johnson Ferry Rd., Atlanta, GA 30342 USA

Pietro Berrino, MD
Viale Brigata Bisagno 6, 16129 Genoa, Italy

Thomas Biggs, MD
1315 St. Joseph Pkwy., Suite 900, Houston, TX 77002 USA

Vanni Borghi, MD
HIV Metabolic Clinic, Department of Infectious and Tropical Diseases, University of Modena and Reggio Emilia, Modena, Italy

Chiara Botti, MD
Villa Bella Clinic, Viale Europa 55, 25087 Salo' (BS) Italy

Giovanni Botti MD
Villa Bella Clinic, Viale Europa 55, 25087 Salo' (BS) Italy

Håkan Brorson, MD, PhD
Lymphedema Unit, Department of Plastic and Reconstructive Surgery, Malmö University Hospital Lund University, 205 02 Malmö, Sweden

Yan-Xian Cai, MD
Department of Plastic Surgery, Shanghai First People's Hospital, Shanghai Jiao Tong University No. 85, Wu Jin Road, Shanghai 200080, China

Antonio Cella, MD
Villa Bella Clinic, Viale Europa 55, 25087 Salo' (BS) Italy

David S. Chang, MD
Division of Plastic and Reconstructive Surgery University of California, 505 Parnassus Avenue, M593 San Francisco, CA 94143, USA

Yoon S. Chun, MD
Division of Plastic and Reconstructive Surgery Department of Surgery, Brigham and Women's Hospital/Faulkner Hospital, 1153 Centre Street Boston, MA 02130, USA

Silvia Cicchetti, MD
Plastic and Reconstructive Surgery Unit, Department of Morphological and Surgical Disciplines and Integrated Methodologies (DICMI), University of Genoa, Genoa, Italy

Bruce F. Connell, MD, FACS
College of Medicine, University of California, Irvine 2200 E. Fruit St., #101, Santa Ana, CA 92701, USA

Luis Contin, MD
Av. Ana Costa, No. 120, Vila Mathias, Santos, São Paulo, Brazil

Michel Costagliola, MD
Chirurgie Plastique, Polyclinique du Parc, 33 rue des Bûchers, 31400 Toulouse, France

Eva Csorba, Dr.
Burn and Plastic Surgical Department, St. Stephen Hospital, Budapest, XIII, Nagyvarad ter 1 1096 Hungary

Bruce Cunningham, MD
Division of Plastic and Reconstructive Surgery
Department of Surgery, University of Minnesota, 420 Delaware Street SE, Minneapolis, MN 55455, USA

Rosana Costa Damasio, MD
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Fabio Rosa de Almeida, MD
Rua Joaquim Floriano, 460 – Conj. 107, 04534.002 São Paulo, Brazil

Domenico de Fazio, MD
San Raffaele Hospital, Milan, Italy; Casa di cura S. Pio X, Milan, Italy

Luis de la Cruz, MD
Clínica La Luz, Consulta 208, General Rodrigo 8 28003 Madrid, Spain

Rafael de la Plaza, MD
C. Salou, 28, 28034 Madrid, Spain

Jorge I. de la Torre, MD
University of Alabama at Birmingham
Division of Plastic Surgery, 510 20th Street
South FOT – 1164, Birmingham, AL 35294-3411, USA

Ilario de Lorenzi
San Raffaele Hospital, Milan, Italy; Casa di cura S. Pio X, Milan, Italy

Sergio Ricardo Pita Pessoa de Melo, MD
"Dr. Ewaldo Bolivar de Souza Pinto" Plastic Surgery Service, Av. Ana Costa, No. 120, Vila Mathias, Santos São Paulo, Brazil

Giorgio De Santis, MD
Division of Plastic Reconstructive Surgery, University of Modena, Policlinico via Largo del Pozzo, Modena 71 Italy

Rodrigo Pessoa Martello de Souza, MD
Av. Ana Costa, No. 120, Vila Mathias, Santos
São Paulo, Brazil

Ewaldo Bolivar de Souza Pinto, MD
Av. Ana Costa, No. 120, Vila Mathias, Santos
São Paulo, Brazil

Giovanni Di Benedetto, MD
Department of Plastic and Reconstructive Surgery
Ancona University School of Medicine, Via Conca, 71
60020 Ancona, Italy

Alberto Di Giuseppe, MD
Department of Plastic and Reconstructive Surgery
Ancona University School of Medicine, Via Conca, 71
60020 Ancona, Italy

Doina Dumitrescu-Ionescu, Prof. Dr.
Plastic and Reconstructive Microsurgery Clinic
University Hospital, Str. Erou Iancu Nicolae 11–19
ALFA, Sat Pipera, Ilfov, Romania

Marketa Duskova, MD
Department of Plastic Surgery, Medical School
Charles University, Srobarova 50, 100 34 Prague 10
Czech Republic

Marita Eisenmann-Klein, MD
Klinik für Plastische-, Hand- und Wiederherstellungs-Chirurgie, Caritas-Krankenhaus, St. Josef, Landshuter Strasse 65, 93053 Regensburg, Germany

L. Franklyn Elliott, MD
Suite 500, 975 Johnson Ferry Rd., Atlanta, GA 30342 USA

Roberto Esposito, MD
HIV Metabolic Clinic, Department of Infectious and Tropical Diseases, University of Modena and Reggio Emilia, Modena, Italy

Rodrigo Federico, MD
"Dr. Ewaldo Bolivar de Souza Pinto" Plastic Surgery Service, Av. Ana Costa, No. 120, Vila Mathias, Santos São Paulo, Brazil

Marcus Castro Ferreira, MD, PhD
Division of Plastic Surgery, University of São Paulo School of Medicine, Rua Oscar Freire 1702, ap 78
05409-011 São Paulo, Brazil

Lucian Fodor, MD
Department of Plastic and Reconstructive Surgery
Rambam Medical Center, 8 Ha'Aliya St., Haifa 35254 Israel

Tal Friedman, MD
Department of Plastic Surgery, Assaf Harofe Medical Center, Zerifin 70300, Israel

Manuel García-Velasco, MD, FRCS (C)
Vialidad de la Barranca, SN, Hospital Angeles Lomas
Suite 550, Huixquilucan, Mexico City, Mexico 52763

Francesco Gargano, MD, PhD
Division of Plastic Reconstructive Surgery, University of Modena, Policlinico via Largo del Pozzo, Modena 71, Italy

Rolf Gemperli, MD, PhD
Division of Plastic Surgery, University of São Paulo School of Medicine, Rua Oscar Freire 1702, ap 78
05409-011 São Paulo, Brazil

Alain Gilbert, Prof.
Institut de la Main, 6 Square Jouvenet, 75016 Paris France

Robert M. Goldwyn, MD
Department of Surgery, Harvard Medical School, Beth Israel Deaconess Medical Center, 54 Willow Crescent Brookline, MA 02445, USA

Margarita Gonzalez Rodriguez de Azero, MD
Wound Healing Unit, Department of Plastic Surgery Cliniques Universitaires St. Luc, 1200 Brussels, Belgium

Ruth Graf, MD, PhD
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Andreas Gröger, MD
Klinik für Plastische Chirurgie, Hand- und Verbrennungschirurgie, Pauwelsstr. 30, 52074 Aachen Germany

Alessandro Gualdi, MD
Villa Bella Clinic, Viale Europa 55, 25087 Salo' (BS) Italy

Giovanni Guaraldi, MD
HIV Metabolic Clinic, Department of Infectious and Tropical Diseases, University of Modena and Reggio Emilia, Via Del Pozzo n. 71, 41100 Modena, Italy

Eyal Gur, MD
Tel Aviv Souraski Medical Center, Weizmann 6 Tel Aviv 64239, Israel

Franz Maria Haas, MD
Klinische Abteilung für Plastische Chirurgie Universitätsklinik für Chirurgie, Medizinische Universität Graz, Auenbruggerplatz 29, 8010 Graz Austria

Mutaz B. Habal, MD, FRCSC, FACS
The Tampa Bay Craniofacial Center/USF Tampa 801 West M.L. King Blvd., FL 33603, USA

Elizabeth J. Hall-Findlay, MD, FRCSC
340--317 Banff Avenue, Box 2009, Banff, Alberta Canada, T1L 1B7

Ed H.M. Hartman, MD, PhD
926 Department of Plastic Surgery, Radboud University Medical Centre, Reinier Postlaan 4, PB 9101, 6500 HB Nijmegen, The Netherlands

Robert Hierner, MD, PhD
Plastic, Hand and Reconstructive Surgery, Burn Centre, Medical University of Hanover; University Hospital, Plastic, Reconstructive and Aesthetic Surgery, Center for Microsurgery, Hand Surgery and Burns, Catholic University of Leuven, University Hospital Gasthuisberg, Belgium

Ming-Zhong Hou, MD
Department of Plastic Surgery, Shanghai First People's Hospital, Shanghai Jiao Tong University No. 85, Wu Jin Road, Shanghai 200080, China

Raymund E. Horch, MD, PhD
Department of Plastic and Hand Surgery, University of Erlangen Medical Center, Krankenhausstrasse 12 91054 Erlangen, Germany

Xie-Qing Huang, MD
Department of Plastic Surgery, Shanghai First People's Hospital, Shanghai Jiao Tong University No. 85, Wu Jin Road, Shanghai 200080, China

Yi-Xiong Huang, MD
Department of Plastic Surgery, Shanghai First People's Hospital, Shanghai Jiao Tong University No. 85, Wu Jin Road, Shanghai 200080, China

Mark Jewell, MD
630 East 13th Avenue, Eugene, OR 97401, USA

Wan-Xing Jia, MD
Department of Plastic Surgery, Shanghai First People's Hospital, Shanghai Jiao Tong University No. 85, Wu Jin Road, Shanghai 200080, China

Jin Wang Kim, MD, PhD
Department of Plastic and Reconstructive Surgery Hand and Microsurgery, and Aesthetic Surgery Hallym University College of Medicine, Chun Cheon Si Kyo Dong 153, Kang Won Do, Korea; Shincheon Severance Hospital Department of Plastic and Reconstructive Surgery, Yonsei University College of Medicine, Seo Dae Moon Gu Shin Chon Dong 134 Seoul, Korea; Medical Laser Research Laboratory, Dan Kook University College of Medicine, Chung Chung Nam Do, Korea; Seoul National University College of Medicine, Seoul National University Hospital, Chong Ro Gu Yeon Kun Dong 28, Seoul, Korea

Ulrich Kneser, MD
Department of Plastic and Hand Surgery, University of Erlangen Medical Center, Krankenhausstrasse 12 91054 Erlangen, Germany

Yalcin Kulahci, MD
Department of Plastic Surgery, A60, Cleveland Clinic 9500 Euclid Avenue, Cleveland, OH 44195, USA

Hannu Kuokkanen, MD, PhD
Department of Plastic Surgery, Tampere University Hospital, Box 2000, 33521 Tampere, Finland

Donald H. Lalonde, MD
The Saint John Campus of Department of Plastic Surgery, Dalhousie University, Saint John Regional Hospital, P.O. Box 2100, Saint John, New Brunswick Canada

Joung Ok Lee, MD
Department of Dermatology, Hallym University College of Medicine, Seoul, Korea

Jörn Andreas Lohmeyer, Dr. med.
Abteilung für Plastische, Hand- und Wiederherstellungschirurgie, Intensiveinheit für Schwerbrandverletzte, Universitätsklinikum Schleswig-Holstein, Campus Lübeck, Ratzeburger Allee 160, 23538 Lübeck, Germany

Peter Mailänder, Prof. Dr. med.
Abteilung für Plastische, Hand- und Wiederherstellungschirurgie, Intensiveinheit für Schwerbrandverletzte, Universitätsklinikum Schleswig-Holstein, Campus Lübeck, Ratzeburger Allee 160, 23538 Lübeck, Germany

James W. May, Jr., MD
Division of Plastic and Reconstructive Surgery
Department of Surgery, Massachusetts General Hospital, 55 Fruit Street, Boston, MA 02441, USA

Riccardo F. Mazzola, MD
Universitá degli Studi di Milano, via Marchiondi 7
20122 Milan, Italy

Marcel F. Meek, MD, PhD
Leeuwerikstraat 28, 9481 EP, Vries, The Netherlands

Bryan C. Mendelson, MD
109 Mathoura Road, Toorak, Victoria, Australia 3142

Henrik Menke, MD, PhD
Department of Plastic, Aesthetic and Hand Surgery
Burn Center, Klinikum Offenbach, Starkenburgring 66, 63069 Offenbach, Germany

Paolo Mezzana, MD
Department of Plastic Reconstructive Surgery
University of Rome „La Sapienza", Viale del Policlinico, 155, 00100 Rome, Italy

Dr. Rony A. Moscona, MD
Department of Plastic and Reconstructive Surgery
Rambam Medical Center, 8 Ha'Aliya St., Haifa 35254
Israel

A. Aldo Mottura, MD
Centro de Cirugía Estética, Friuli 2110, 5016 Córdoba
Argentina

Alexandre Mendonça Munhoz, MD
Breast Reconstruction Group, University of São Paulo
Rua da Consolação 3605 ap 91, 01416-001 Brazil

Egle Muti, MD
Department of Plastic Surgery, University of Turin
Strada S. Vincenzo, 40/35, 10131 Turin, Italy

Lincoln Graça Neto, MD, PhD
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Constance Neuhann-Lorenz, MD
Praxis für Plastische Chirurgie, Theatiner Str. 1
80333 Munich, Germany

Jean-Philippe A. Nicolai, MD, PhD
Department of Plastic Surgery, University Medical Center Groningen, University of Groningen
Hanzeplein 1, 9700 RB Groningen, The Netherlands

Chiara Novelli, Dr.
Institut de la Main, 6 square Jouvenet, 75016 Paris
France

Gabriella Orlando, MD
HIV Metabolic Clinic, Department of Infectious and Tropical Diseases, University of Modena and Reggio Emilia, Modena, Italy

Daniele Pace, MD, MSc
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR 80810-070, Brazil

Norbert Pallua, MD, PhD
Klinik für Plastische Chirurgie, Hand- und Verbrennungschirurgie, Universitätsklinikum der RWTH Aachen, Pauwelsstr. 30, 52074 Aachen
Germany

Gennady I. Patlazhan, MD
VIRTUS Clinic, Bunina str. 10, 65026 Odessa, Ukraine

Malcolm D. Paul, MD, FACS
Aesthetic and Plastic Surgery Institute, University of California, Irvine, USA

Antonio Pedone
HIV Metabolic Clinic, Department of Infectious and Tropical Diseases, University of Modena and Reggio Emilia, Modena, Italy

Massimo Pinelli, MD
Division of Plastic Reconstructive Surgery, University of Modena, Policlinico via Largo del Pozzo, Modena 71, Italy

Jan G. Poëll, MD
Plastisch-Rekonstruktive und Aesthetische Chirurgie
FMH, Sonnenstr. 6, 9000 St. Gallen, Switzerland

Elias Polykandriotis, MD
Department of Plastic Surgery, Friedrich-Alexander University Erlangen, Krankenhausstrasse 12
91054 Erlangen, Germany

Kirill P. Pshenisnov, MD
Division of Plastic Surgery, Yaroslavl Medical Academy, 5 Revolutsionnaya St., Yaroslavl 150000
Russia

Piero Raimondi, MD, PhD
Policlinico MultiMedica, 20099 Milan, Italy

Ronald Rippel, MD, MSc
Rua Solimóes, 1175, Merces, Curitiba, Paraná, PR
80810-070, Brazil

Antonio Rottino
San Raffaele Hospital, Milan, Italy; Casa di cura
S. Pio X, Milan, Italy

Maria Thereza Sarto Piccolo, MD, PhD
Scientific Department, Pronto Socorro para
Queimaduras Ltda., Rua 5, 439, Setor Oeste, Goiânia
Goiás, 74115 060, Brazil

Mônica Sarto Piccolo, MD
Pronto Socorro para Queimaduras Ltda., Rua 5
439 Setor Oeste, Goiânia, Goiás, 74115 060, Brazil

Nelson Sarto Piccolo, MD
Division of Plastic Surgery, Pronto Socorro para
Queimaduras Ltda., Rua 5, 439, Setor Oeste, Goiânia
Goiás, 74115 060, Brazil

Erwin Scharnagl, MD
Klinische Abteilung für Plastische Chirurgie
Universitätsklinik für Chirurgie, Medizinische
Universität Graz, Auenbruggerplatz 29, 8010 Graz
Austria

Michael Scheflan, MD
Atidim Medical Center, 24 Habarzel St., Tel-Aviv
69710, Israel

Jörg Schipper, MD
Department of Oto-Rhino-Laryngology, University of
Duesseldorf, Duesseldorf, Germany

Nicolò Scuderi, MD
Department of Plastic Reconstructive Surgery
University of Rome „La Sapienza“, Viale del
Policlinico, 155, 00100 Rome, Italy

Zun-Li Shen, MD, PhD
Department of Plastic Surgery, Shanghai First People’s
Hospital, Shanghai Jiao Tong University
No. 85, Wu Jin Road, Shanghai 200080, China

Ghaith F. Shubailat, MD, FRCS, FACS
28 Bin Khaldoun Street, PO Box 5180, Amman
11183 Jordan

Maria Siemionow, MD, PhD, DSc
Department of Plastic Surgery, A60, Cleveland Clinic
9500 Euclid Avenue, Cleveland, OH 44195, USA

Antonio Spaggiari
HIV Metabolic Clinic, Department of Infectious and
Tropical Diseases, University of Modena and Reggio
Emilia, Modena, Italy

Sinikka H.H. Suominen, MD, PhD
Department of Plastic Surgery, Helsinki University
Central Hospital, Pl 266, 00029 Hyks, Finland

Bryant A. Toth, MD
Plastic and Reconstructive Surgery, 2100 Webster
Street, Suite #424, San Francisco, CA 94115, USA

Carlos Oscar Uebel, MD
Vitor Hugo St. 78, 90630-070, Porto Alegre, Brazil

Philip A. Van Damme, DMD, MD, PhD
590 Department of Oral & Craniomaxillofacial
Surgery, Radboud University Medical Centre, PB
9101, 6500 HB Nijmegen, The Netherlands

Romain Vanwijck MD, FRCS
Wound Healing Unit, Department of Plastic Surgery
Cliniques Universitaires St Luc, 1200 Brussels
Belgium

Luis O. Vasconez, MD, FACS
Division of Plastic Surgery and Aesthetic Surgery at
the Kirklin Clinic, The University of Alabama at
Birmingham, Birmingham, Alabama, USA

Lan Wang, MD
Department of Plastic Surgery, Shanghai First People’s
Hospital, Shanghai Jiao Tong University
No. 85, Wu Jin Road, Shanghai 200080, China

Maria Wiedner, Dr.
Klinische Abteilung für Plastische Chirurgie
Universitätsklinik für Chirurgie, Medizinische
Universität Graz, Auenbruggerplatz 29, 8010 Graz
Austria

Introduction

Rediscovering the Wheel: Using the Past to Influence the Future

R.F. Mazzola

Very often scientific publications begin with the pompous words: “A new technique for...”, or “An innovative method for...”. But are these procedures really new? The French physician and philosopher Émile Littré (1801 – 1881) wrote the following in the foreword of his “*Oeuvres complètes d'Hippocrate*” (“Complete Works of Hippocrates”): “There is no development, even the most advanced of contemporary medicine, which is not found in embryo in the medicine of the past” [12]. This opinion is easy to demonstrate by doing some research in a historical library. One will discover that old books not only provide palpable contact with the medical past, but also serve to establish the precedence of an idea, a theory or a technique. Regrettably, we often realise that most of the so-called new techniques derive from ideas which were already published but then forgotten. Numerous examples exist, but we restrict our list to just a few for obvious reasons.

1.1 Nasal Surgery

Reconstructive nasal procedures using the forehead flap are countless, from the very simple to the most complicated. All aim to replace the missing parts in the best possible way.

In 1974, Ralph Millard described the so-called “flying seagull flap” outlined in the forehead and transposed to the lower half of the nose to repair a defect [14]. However, his flap reproduces almost completely the so-called “fleur de lys” design reported by the French surgeon Jacques Delpech (1777 – 1832) and published in 1828 (Fig. 1.1) [4]. The difference in shape is minimal; one has open wings, whereas the other resembles a partially opened bud, but the concept is the same; a well vascularised skin flap, drawn on the same donor site, the forehead, to repair the nose. What is surprising is the time it took to rediscover the wheel: almost 150 years!

A more recent sophisticated method for repairing a full thickness defect of the nose advocates the transposition of a prelaminated flap outlined on the forearm [17]. However, the German Carl Ferdinand von Gräfe (1787 – 1840), one of the founders of modern plastic surgery, developed a similar treatment plan in 1818, 193 years earlier [8]. The skin was prefabricated on the inner arm, shaped to match the missing part and sutured to the nasal stump according to the so-called Tagliacozzi procedure (or Italian technique) (Fig. 1.2). Von Gräfe's type of repair is a traditional, pedicled flap, separated at about day 15 after surgery, to allow good revascularisation, whereas the prelaminated fasciocutaneous flap proposed by Pribaz is lined on its undersurface and transferred microsurgically. These procedures were not available in the nineteenth century.

Modern aesthetic nasal surgery is often done using the open approach. Rhinoplasty surgeons consider this technique essential for a good visualisation and for achieving more predictable results. Evaluation and modifications of the tip are greatly improved, despite the transcolumellar scar, which is regarded as unimportant. But who introduced this method for the first time and when? We have to go back to 1934, when the Hungarian otolaryngologist Aurél Réthi (1884 – 1976) described it and demonstrated that it was possible to change the nasal tip in a very accurate way [18]. Regrettably, at the end of the operation Réthi removed a piece of columella, so as to make a long nose shorter (Fig. 1.3). The outcome was often poor and this explains why the operation fell rapidly from favour. It took almost 40 years until Goodman rediscovered and popularised the open rhinoplasty [7].

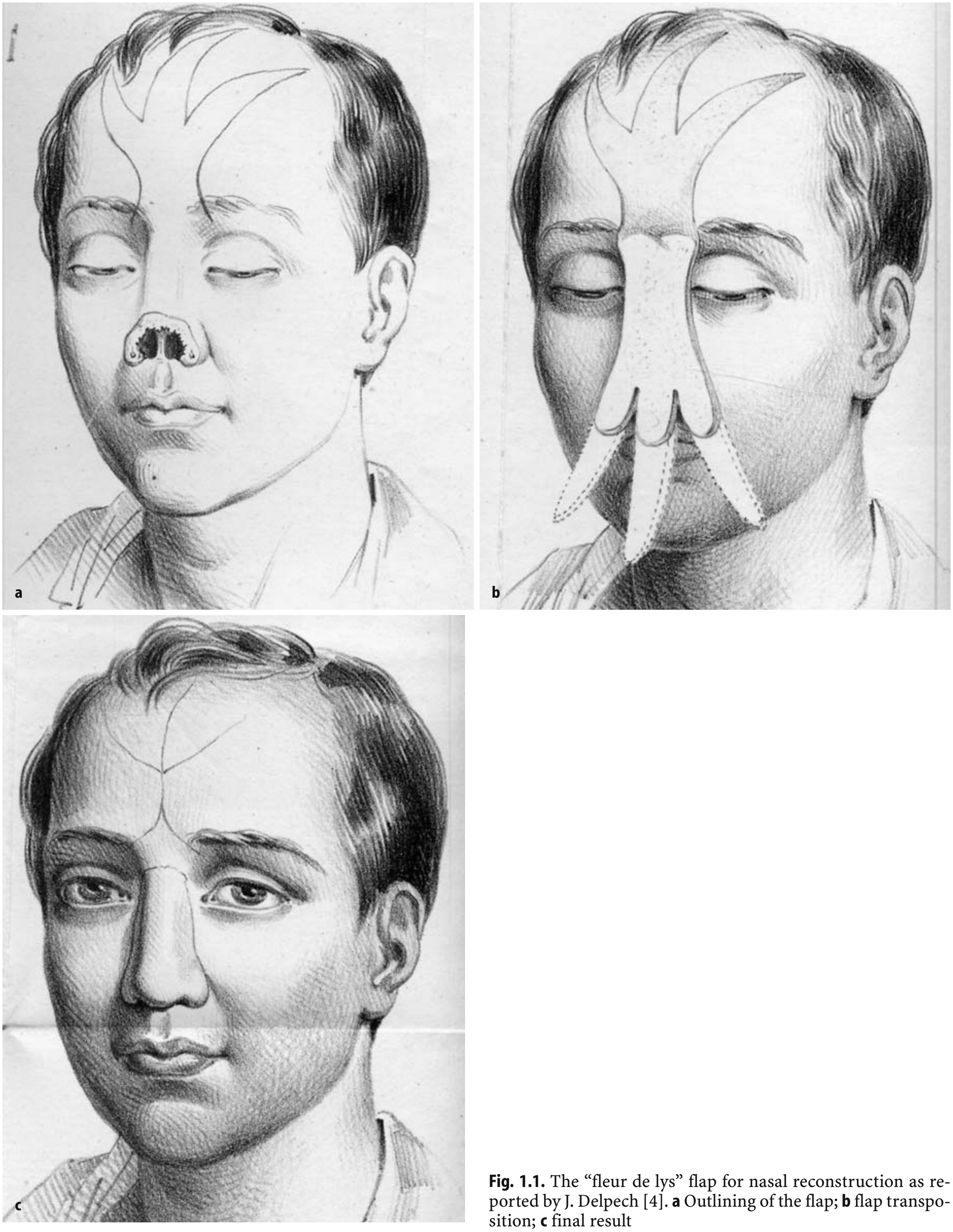


Fig. 1.1. The “fleur de lys” flap for nasal reconstruction as reported by J. Delpech [4]. **a** Outlining of the flap; **b** flap transposition; **c** final result

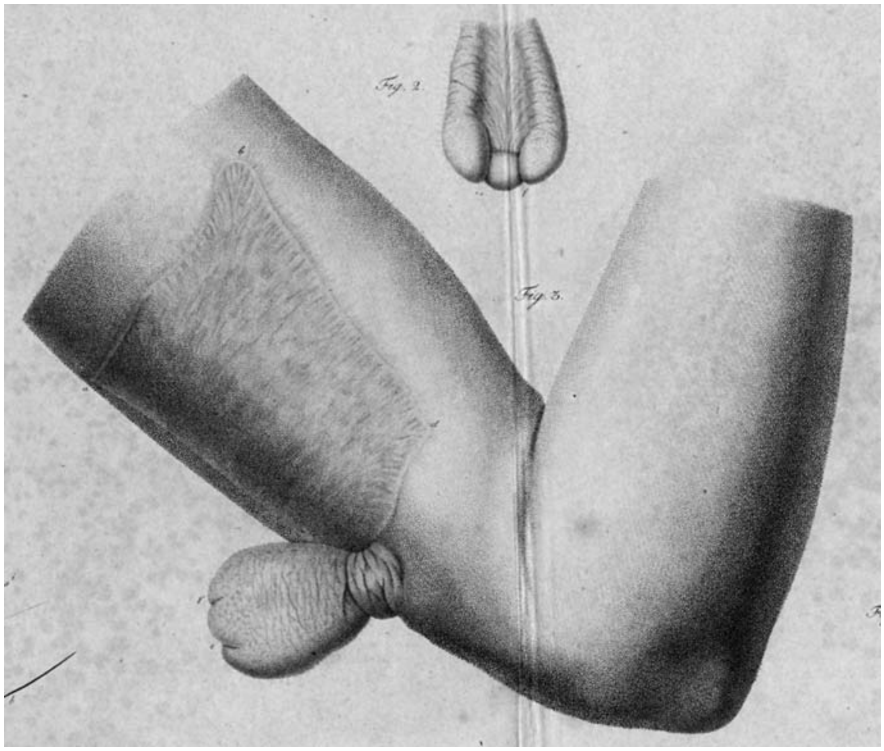
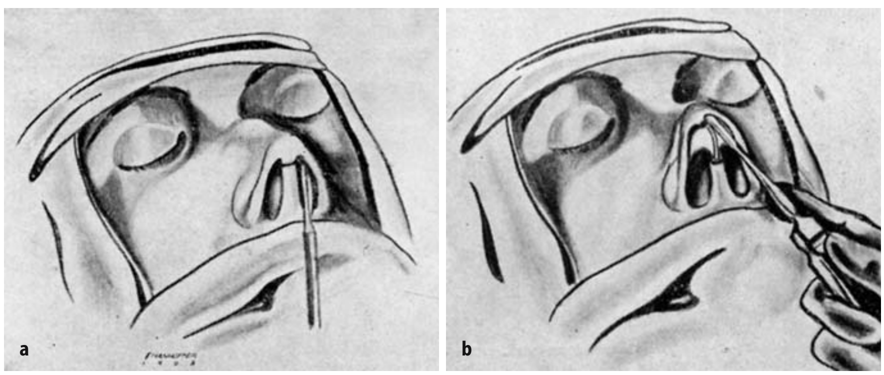


Fig. 1.2. The German method for nasal reconstruction by a prefabricated flap according to von Gräfe [6]. Outlining of the flap



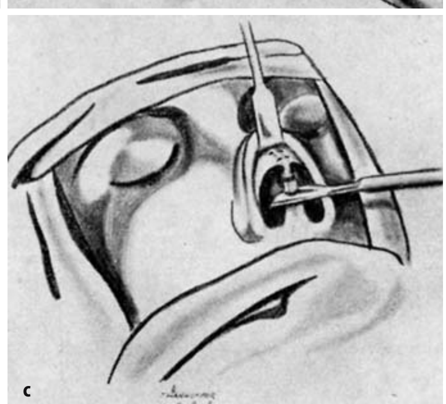


Fig. 1.3. The open approach technique as described by A. Réthi [18]. **a** Transcolumellar incision; **b** nasal tip exposure; **c** columella sectioning

1.2 Lower Eyelid

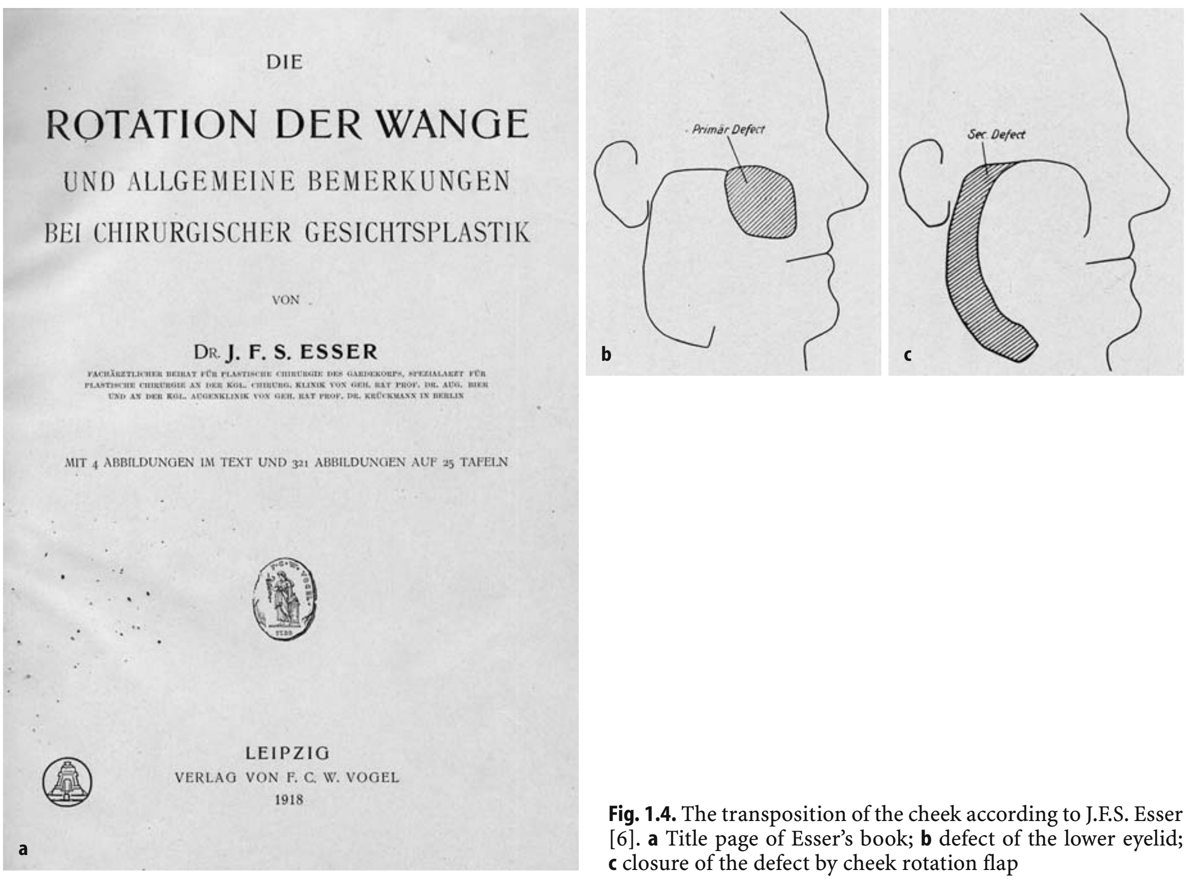
For full thickness lower eyelid repair, the rotation of the cheek constitutes one of the most common solutions. The well vascularised flap gives excellent aesthetic and functional results. It was eponymously called the Mustardé flap after the surgeon who described its use in 1966 [15]. However, the first report of the cheek rotation flap goes back to 1918, when the Dutchman J.F. Esser (1877–1946) published a whole book "*Die Rotation der Wange*" ("The Cheek Rotation"), devoted to this method and to its different applications for facial reconstruction [6]. Hence, this procedure should correctly be named the Esser flap (Fig. 1.4).

1.3 Lip

One of the basic principles of modern cheiloplasty is the use of lip tissue to repair a lip defect by transposing two full thickness flaps from the alar bases downward to the mentolabial groove [13]. The flaps, based at least 25 mm from the commissure, and with the same curvilinear incision, are sutured together along the midline, to re-establish the continuity of the oral sphincter. The technique, first described in 1857 by the German von Bruns (1812–1883) [2], was recently reintroduced by Karapandzic (1974) [11]. The only difference between the two procedures is the conservation of the neurovascular bundle that Karapandzic considers essential for the successful outcome of the operation. Thus von Bruns must be regarded as the pioneer of one of today's most frequently used procedures for lip repair, which he devised almost 130 years before Karapandzic (Fig. 1.5).

1.4 Breast

In 1932, for moderate breast hypertrophy, the Austrian surgeon Ernst Eitner advocated the periareolar suturing of the nipple without adding vertical or horizontal scars, an innovative solution in aesthetic breast surgery [5]. Reduction of the breast was achieved by mammary gland resection, according to breast size, with invagi-



DIE

ROTATION DER WANGE

UND ALLGEMEINE BEMERKUNGEN

BEI CHIRURGISCHER GESICHTSPLASTIK

VON

DR. J. F. S. ESSER

FACHÄRZTLICHER BEIRAT FÜR PLASTISCHE CHIRURGIE DES GARDEKORPS, SPEZIALARZT FÜR PLASTISCHE CHIRURGIE AN DER KGL. CHIRURG. KLINIK VON GEH. RAT PROF. DR. AUG. BIER UND AN DER KGL. AUGENKLINIK VON GEH. RAT PROF. DR. KRÜCKMANN IN BERLIN

MIT 4 ABBILDUNGEN IM TEXT UND 321 ABBILDUNGEN AUF 25 TAFELN

LEIPZIG

VERLAG VON F. C. W. VOGEL

1918

Fig. 1.4. The transposition of the cheek according to J.F.S. Esser [6]. **a** Title page of Esser's book; **b** defect of the lower eyelid; **c** closure of the defect by cheek rotation flap

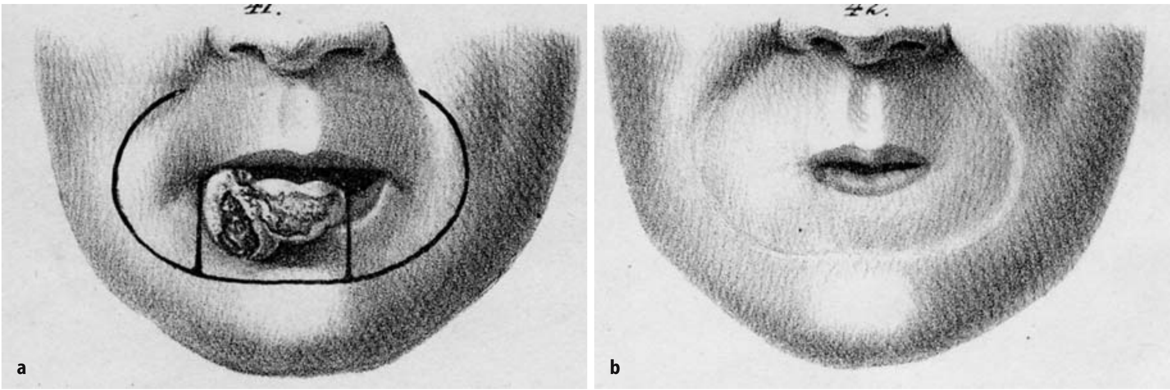
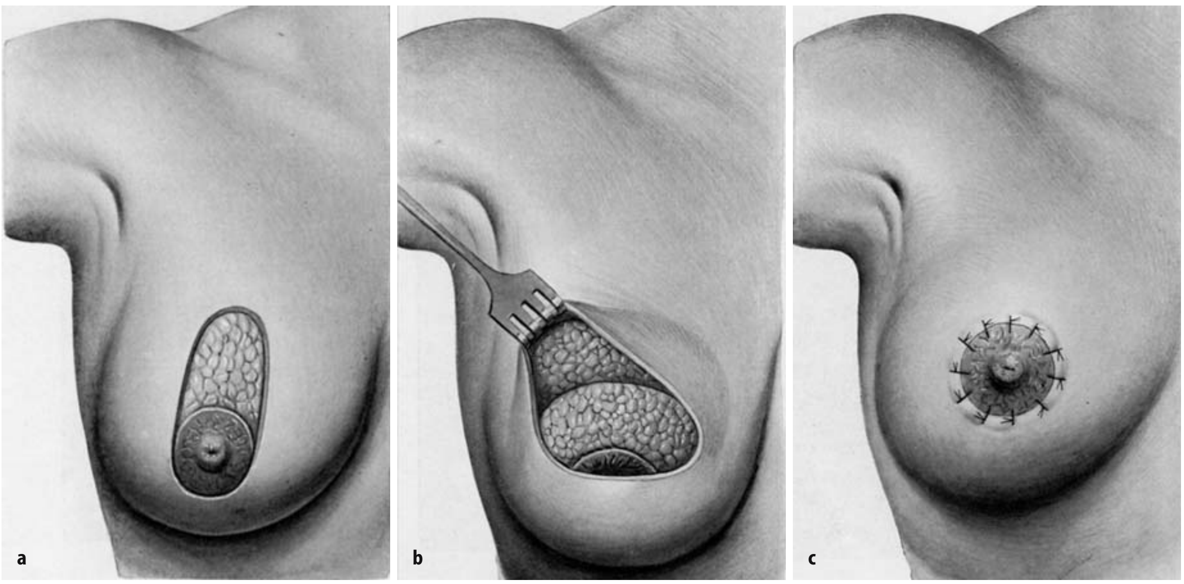


Fig. 1.5. Lower lip reconstruction following excision for cancer, according to von Bruns [2]. **a, b** Pre- and postoperative view of the patient



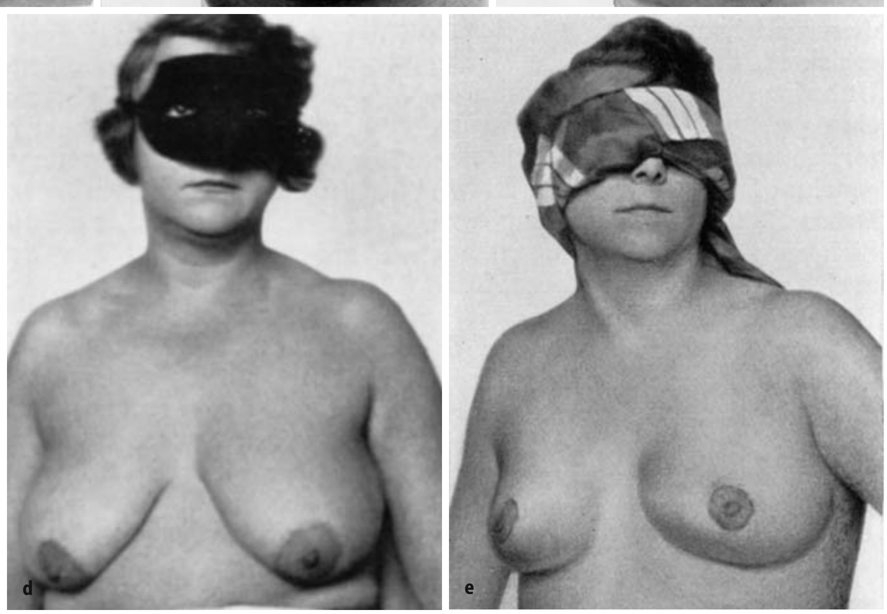


Fig. 1.6. Periareolar mammaplasty according to E. Eitner [5]. **a** Elevation of the nipple areola complex; **b** folding of the upper pole; **c** final result; **d, e** pre- and postoperative view of the patient

nation and folding of the upper pole, so as to allow elevation of the nipple-areola complex (Fig. 1.6). In 1990, almost 60 years after Eitner, the French surgeon Louis Benelli proposed a similar operation [1]. To avoid enlargement of the areola, he suggested a continuous cerclage stitch, passed as a purse string in the dermis, the so-called round block.

1.5 Anterior Chest Wall Defects

Worried by the unfavourable results obtained in covering anterior chest wall defects following excision for breast cancer, the Italian Iginio Tansini (1855–1943) reported the use of a large skin flap, with the underlying latissimus dorsi muscle, outlined on the back and transferred to fill the defect. In 1906, Tansini's anatomist, Professor Sala, demonstrated that the vascularisation of the skin was from the subscapular perforating arteries [20]. Its description constitutes the first example of a musculocutaneous flap to appear in the literature (Fig. 1.7). However, for various reasons its use was abandoned. It took 60 years for the German surgeon Neven Olivari to rediscover the wheel and to publish a paper in 1976 on the clinical application of the latissimus flap for different reconstructive purposes, mainly to cover defects of the irradiated anterior chest wall [16].

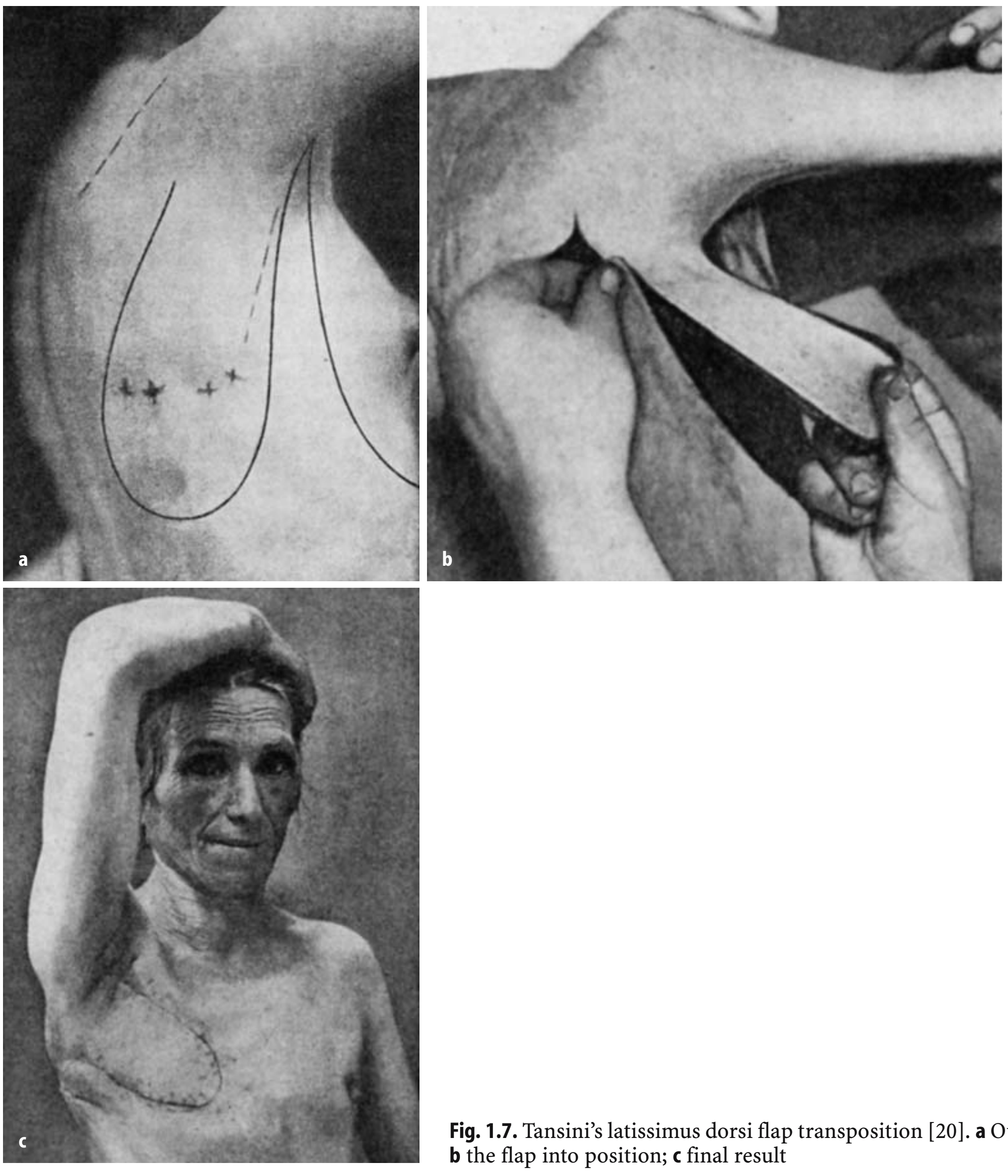


Fig. 1.7. Tansini's latissimus dorsi flap transposition [20]. **a** Outlining of the flap; **b** the flap into position; **c** final result

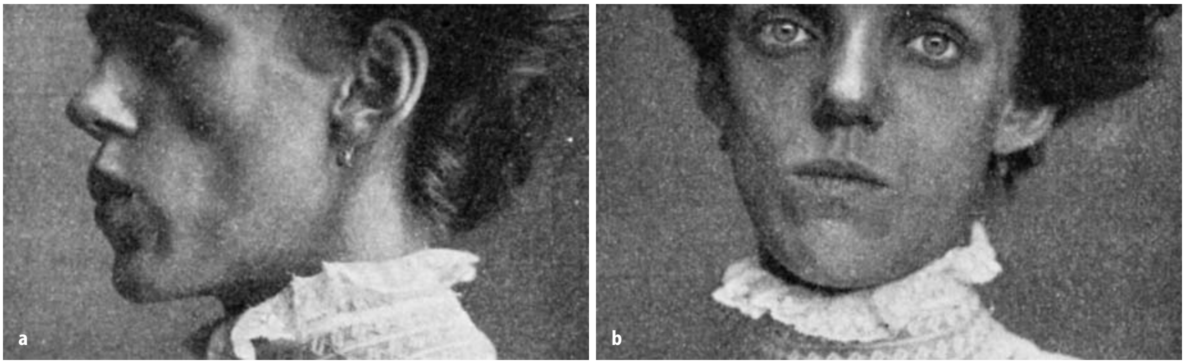


Fig. 1.8. Fat injection for management of facial atrophy by Holländer [10]. **a, b** Pre- and postoperative view of the patient

1.6 Fat Injection

One of the most recent advances in the correction of contour irregularities and for soft tissue augmentation in aesthetic and reconstructive surgery is the use of autologous fat injected locally. To avoid reabsorption and to ensure maximal cell survival, Coleman [3] systematised the procedure by means of fat centrifugation and placement of small amounts of cells in multiple tunnels so as to enhance contact between transplanted adipocytes and surrounding tissues. But who had the idea of injecting fat to correct contour irregularities? A search in the literature shows that in 1908, the Berlin surgeon Eugen Holländer (1867–1932) treated two cases of facial atrophy by injecting a blend of human and ram's fat locally. He considered this mixture the secret of success for avoiding reabsorption and for ensuring stability of the results. The pre- and postoperative photos appeared in a review paper published in 1912 in "*Handbuch der Kosmetik*" ("Handbook of Cosmetic Surgery") by Max Joseph (Fig. 1.8) [10].

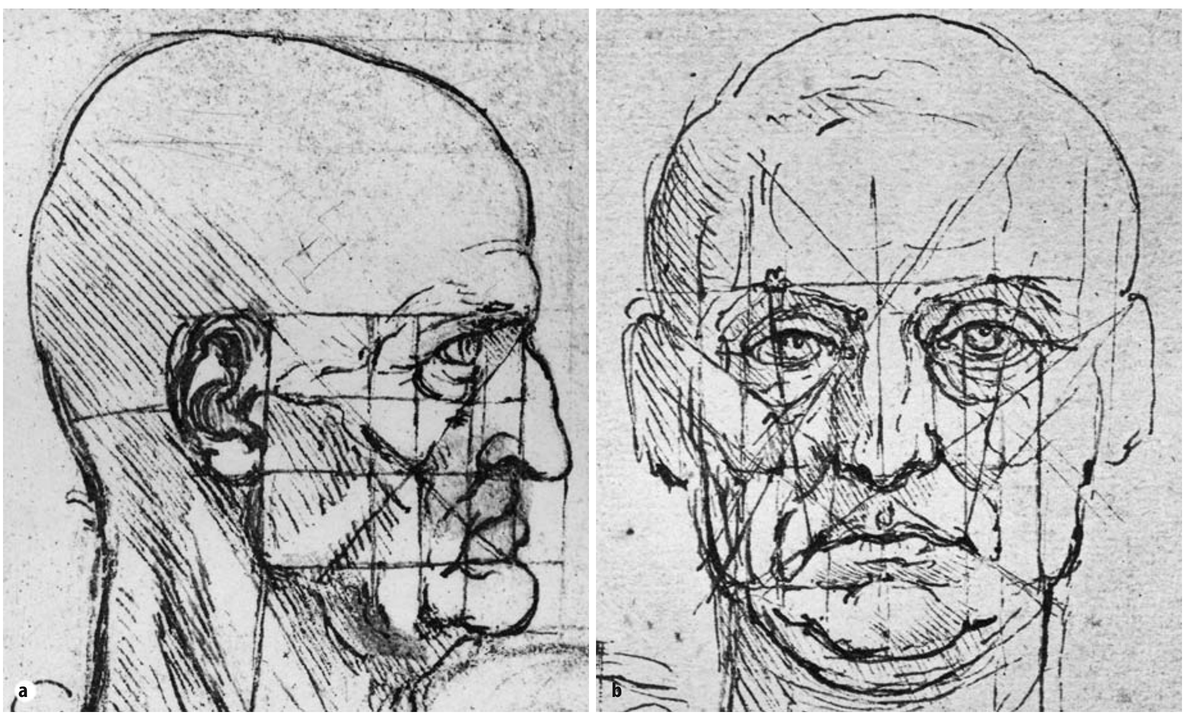


Fig. 1.9. Facial analysis according to Da Vinci (about 1495) [19]. **a** The division of the face into thirds; **b** the proportions of the face

1.7 Using the Past to Influence the Future

Surprisingly, in some instances the past may also serve to ameliorate the future. The canons of facial beauty, laid down by Leonardo Da Vinci (1452–1519), one of the most emblematic masters of the Renaissance, were used to create the ideal face in painting [21], and still represent an appropriate model for predicting results in procedures like rhinoplasty or orthognathic surgery (Fig. 1.9).

What is the purpose of facial analysis today? Its value is to analyse the proportions of the face thoroughly, to make an accurate diagnosis of the deformities and asymmetries, and to establish the surgical procedure best suited to achieve facial harmony. Da Vinci, in his Atlantic code (about 1495), stated that a well balanced face should be divided into thirds: "From the chin to the nostrils is a third part of the face. The same holds for the distance from the nostrils to the eyebrows and from the eyebrows to the hairline" [19]. The concept of the division of the face into thirds appears also in the chapter devoted to facial analysis of the recent book "Nasal Surgery by the Masters" [9] "The face is divided into thirds by horizontal lines tangential to the menton, nasal base, brows and hairline". In considering the alar base width, Da Vinci pointed out its relationship to the distance between the eyes: "Horizontally the width of the nose at its base should be approximately equal to the distance between the eyes" (Notebooks, 1495) [19]. Amazingly, a similar correlation appears in the above mentioned book: "The width of the alar base should be approximately the same as the intercanthal distance". Finally, regarding tip projection Da Vinci said: "In profile the distance from the very edge of the nostril, where it joins the cheek, to the tip of the nose will be equal to the width of the nose from one nostril to the other as seen from in front" [19], which almost corresponds to the phrase in the same book: "Another method to evaluate tip projection is to determine if tip projection equals alar base width".

1.8 Conclusions

What can we learn from old books? We can discover what our forefathers did and recognise their achievements with humility. Comparisons between old and new procedures often show that "Nothing is new under the sun".

Amazingly, knowledge of the work of past masters may influence the future positively by contributing to solutions of current problems. Facial analysis, devised in the Renaissance by Da Vinci to guide painters to a rational approach and to a better understanding of the proportions of the face, still represents an appropriate model for improving procedures such as rhinoplasty or orthognathic surgery.

In this sense the masters of modern rhinoplasty share a common bond with Da Vinci. Facial analysis, based on Da Vinci theories, assists the surgeon in the diagnosis of the asymmetries, and in designing the surgical procedure best suited to achieving facial harmony.

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Factors that Influence the Plastic Surgeon to Innovate or Accept or Reject Innovations of Others

2

R.M. Goldwyn

Unless a surgeon is implacably opposed to change, he or she will have to consider adopting a new technique in order to improve results. It is impossible to prevent changes from occurring in one's personal or professional life. Everyday, even hour by hour, events, minor or major, which demand our response are happening at home, with our family, to friends, and at work, in the office, at the hospital, in the operating room. This is true not just for doctors and those who happen to be plastic surgeons but also our patients. Everything in the universe is dynamic or, as the Greek philosopher Heraclitus (c.540–c.480 B.C.) stated: "All is flux, nothing stays still." But, as Heraclitus insisted, change or flux does not necessarily mean irreparable disarray but could be the unifying force in nature.

For every plastic surgeon change occurs and, if progressive, constitutes a kind of unity: grammar school, middle school, high school, college, medical school, postgraduate training, and finally entry into practice or another area of our specialty. The point of this prologue is to emphasize that by the time a person has become a plastic surgeon, he or she has made innumerable changes, adjustments, and adaptations. In retrospect, no period in our lives pressured us to change and to learn new skills more than did our residency. To remain in a program every trainee must labor hard to create a new professional self and to become board eligible. If not by the time the plastic surgeon has been credentialed then certainly a decade or two later, one can usually identify into which of the following categories he or she fits:

- Those who innovate
- Those who adopt an innovation
- Those who do not innovate and refuse to adopt an innovation

2.1 Those Who Innovate

The innovators among us are comparatively few. Factors of personality not just intelligence and manual skill determine whether a plastic surgeon will be an innovator. These people are willing, even enthusiastic to assume risk and to venture into the unknown. Their nature is to live on the edge in the operating room and perhaps outside it. Their personality compels them to change, to discard the security of the old for the challenge and exhilaration of the new. They have the ability to create, the stamina to persevere, and the ego strength to accept failure.

Most physicians are conservative in their personal demeanor and their professional behavior. The reality is that admission committees at medical schools would likely exclude someone who seems a flagrant non-conformist, disrespectful of authority and tradition.

Discoveries in most fields are made by the young, physics being the prototype. This is true, however, also in non-scientific areas, such as art, literature, architecture, and music.

We must remember that by the time a physician has completed training, he or she is older than many of his peers who have finished their professional schooling. The plastic surgeon is in his or her early or mid-thirties. We should not forget, however, that many monumental advances in medicine have been due to the efforts of young doctors, even students. Oliver Wendell Holmes at 34 and Ignaz Semmelweis at 29 described the cause and the prevention of puerperal sepsis. Ephraim McDowell, at 38, was the first to enter the peritoneum to perform an ovariotomy in a patient who survived. Ambroise Paré, called the Father of Surgery, who had no formal training and therefore was not blinded by false dogma, was 26 at the Battle of Turin, when his supply of boiling oil, made from elderberries, ran out. He treated wounds by applying nothing or oil of roses. To his astonishment and to the gratification of the wounded troops, their pain was less and their healing better. Remarkably Pare lived to be 80 (1510–1590), his biology being another defiance against his era.

Gaspare Tagliacozzi, considered the Father of Plastic Surgery, at age 31 published the first text in our specialty, describing in detail the reconstruction of the nose with a flap from the arm. Although he did not innovate this flap, which was used in the fifteenth century by the Brancas of Catania and perhaps earlier, he codified this technique so that his contemporaries and followers were able to recognize its importance and use it to benefit patients.

One need not, however, go back centuries to find a young innovator. Dr. Joseph E. Murray, a plastic surgeon in Boston, when he was 35, did the first successful organ transplant, a kidney taken from one identical twin to the other. This feat as well as his subsequent research, when he was still young, on the immunology of homotransplantation, led to his receiving the Nobel Prize.

2.2 Those Who Adopt an Innovation

Most plastic surgeons are not leaders but followers willing to change if convinced it is in the best interest of their patients and themselves. They will properly ask why they should discard a technique that has given good or better results with minimal risk. Age, training, skill, flexibility and willingness to take a risk in one's profession, especially in the operating room, are important characteristics that affect a surgeon's decision to learn and use a new technique. Some surgeons are so competitive that if they are not among the avant garde, they feel inadequate, anxious and even depressed. This type of personality is not necessarily disadvantageous since it accounts for progress.

If, when, and to what degree to change are matters that ultimately only the individual plastic surgeon can decide. There are those who always are looking for an opportunity to do something new. They read articles, attend meetings and symposia, consult colleagues in person or by correspondence, seeking advice because of the impetus to do better for their patients and themselves. While they may not be discoverers, they are the leaders of the followers. They are crucial to progress because they disseminate the new.

2.3 Those Who do not Innovate and Refuse to Adopt an Innovation

It is difficult never to change in one's profession, especially in medicine. An internist or surgeon, for example, who has not deviated for decades in the diagnosis and treatment of a condition is remindful of what Talleyrand said of the Bourbons: "They have learned nothing and forgotten nothing." Unfortunately there are plastic surgeons who devote themselves to the status quo. They may like the idea of change but dread the experience. They are unwilling to undergo what they perceive as the considerable discomfort, uncertainty and risk to themselves and possibly the patient. In my experience they exhibit the same inflexibility in their personal lives as well. Some patients feel comfortable and protected by that kind of surgeon who, they may say, is "careful" or "dependable." I heard one of my friends, a surgeon, describe another surgeon as "someone you can trust because he doesn't get any fancy ideas." Residents and colleagues may consider them out of date but they will always have loyal patients who appreciate their caution and are reassured by not worrying that they are being "experimented upon." In truth, as one studies the history of medicine and surgery, that kind of attitude would have spared many patients from the folly of becoming victims of an imprudent, statistically untested operation or treatment extolled by some physicians and surgeons and by the media without proper clinical trials. In the adopting of an innovation, two major factors must be considered: the nature of the innovation and the reputation of the innovator(s).

2.4 Nature of the Innovation

Anyone contemplating adopting an innovation will ask whether it is important to one's practice or professional life. Will the new method significantly improve results? Is it worth learning and doing or is it of minor importance even if it is an innovation?

Any sensible plastic surgeon would want to know the benefit-risk ratio.

Another extremely important consideration, seldom mentioned but always present, is the economic consequence of the innovation. Will doing it confer a fiscal advantage, or not doing it, a penalty, such as loss of patients and income?

Is the innovation relatively easy to learn by simply reading an article or obtaining a video or will it be necessary to witness it and/or dissect a cadaver? Is the learning curve so steep that the surgeon along with his or her patients may fall into disaster?

In this regard, a crucial aspect in the decision of whether or not to embrace the innovation is the opinion of others, namely trusted, reliable colleagues. On too many occasions I have heard a new technique presented by "the professor," but his or her residents later described the results with much less enthusiasm than did their chief. This leads us to the other significant factor in addition to those mentioned: the innovator(s).

2.5 The Innovator

Who the innovator is and how he or she presents the technique also affects whether or not it will be adopted or rejected. There are some who are considered leaders yet who minimize the difficulty and the complications of what they are extolling and trying to popularize.

Is the presenter known to be truthful and reliable, or self-aggrandizing to the point of deception? Has that innovator misled us in the past? Has anyone credible seen his or her results? Some people are convincing speakers and writers but the results are less impressive.

There is a difference to me between reputation and reality. Is this person overrated by those who know his or her work? Occasionally a discrepancy exists between local reputation and national or international repute. One should remember, however, that reputation depends on whom one asks. An associate of the innovator may give a glowing evaluation, considerably different from what one might receive from a past associate or a competitor in the same town. The truth might lie between.

In our own field of plastic surgery, one should recall that the great Dieffenbach (1792–1847), the modern founder of our specialty, recommended partial glossectomy for stuttering. Because of his renown, many surgeons performed the procedure on children who, indeed, stuttered less because of their decreased ability to speak! In my time, Owen Wangensteen, a leader in American surgery and an international figure, who contributed tremendously to medicine and surgery, recommended freezing stomachs for bleeding ulcers and a "second look" with respect to intra-abdominal cancer, i.e. reoperating to find and remove residual cancer. Both these ideas were soon discarded because they were not useful and were hazardous. The point to remember is that the authority of the innovator was responsible for their initial rapid acceptance.

2.6 The Patient

The primary concern of any physician in any area of medicine or surgery is the wellbeing of the patient. My father, a neuropsychiatrist, used to say: "The practice of medicine becomes much easier if the physician never forgets to judge what is being proposed according to what is in the best interest of the patient." That determination, however, is not always easy to make. One is more willing to take a chance if the patient is facing the prospect of death. Most patients in plastic surgery, certainly those who seek aesthetic surgery, are not in that group.

Adopting a new technique in one's clinical practice is a serious undertaking. Failure may be irrevocable. Human beings are liable to suffer by undergoing the "wrong innovation." This is true of both patients and surgeons. Years may pass before the flaws of a once heralded technique become known.

One can undertake an experiment on animals in the laboratory with much less compunction than with human beings clinically. Even in the laboratory, however, respect for the animal should be a consideration.

2.7 Informing the Patient

Axiomatic is not just informing the patient but properly informing the patient who might undergo an innovation. An Internal Review Board exists in every hospital to determine whether patients should have a new treatment, medical or surgical. More often in one's practice subtle situations arise. Do we inform the patient, for example, that we have learned about a new method of performing a facelift and that he or she will be the first to have it? If the patient asks how many we have done, we must respond truthfully. The reality is that plastic surgeons, like all surgeons, may try a variation on his or her basic technique without considering it a sufficient innovation to require additional disclosure to the patient. The other possibility is that the surgeon may think that ideally the patient should be informed but does not do so because the patient may refuse and thereby deny the surgeon the opportunity of performing it.

The dilemma in the practice of plastic surgery is that we have worked hard to evolve a routine that we consider effective and reliable and one with which we are satisfied and comfortable. Soon supposed advances impinge upon us and we must face again disruption in our routine if we choose to make an effort to improve the results for our patients and, in the process, to avoid our own fossilization. This is not a trivial situation. For that reason no surgeon and consequently his or her patients should be ill informed purposely by a colleague whether it is in a presentation at a meeting or an article. It is ethically and scientifically incumbent on anyone communicating to colleagues to be scrupulous in his or her observations, results and conclusions. It is not enough to present only complications along with excellent out-comes but also to divulge average results. This is particularly important and too often ignored in aesthetic surgery. Neither we plastic surgeons nor our patients can escape the reality of the bell-shape curve.

If we do not properly inform the patient or expose the patient to an innovation that we have insufficiently studied or mastered, then in the event of a poor result, the patient and his or her family may use the recourse of a malpractice suit. This possibility, certainly in the United States, is a deterrent either to devise a significant innovation or adopt it precipitously. Progress in medicine and surgery, however, will occur inevitably because of discoveries clinically and in the basic sciences and in technology. A pertinent question to ask oneself when considering an innovation is: "Would I want this tried on me or a member of my family?" One would hope that the surgeon asking such a question would not be self-destructive but always mindful of his or her wellbeing and that of his or her family.

Augustin Belloste (1654 – 1730) in his treatise, *The Hospital Surgeon*, saw the issue then more clearly than do many now:

> *"That which is New at the time, will one day be Ancient; as what is Ancient was once New. It is not Length of Time which can give Value in Things, it is only their Excellency."*

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Tissue Engineering and Plastic Surgery 3

N. Pallua, A. Gröger

Tissue engineering found its application in plastic surgery long before technological advancements allowed the field to expand to what it is today. Both disciplines, tissue engineering and plastic and reconstructive surgery, share a common objective: to provide living tissue for the repair of congenital or acquired defects. Each new achievement in these fields is a consequence of centuries of previous investigation, observation, and insight. Viewed from a historical perspective, it is of great interest to see the development of the distinct field of tissue engineering on the basis of the tradition of plastic surgery, the beginnings of an inextricable relationship. Today, the advances of tissue engineering continue to open up new possibilities in the field of plastic surgery.

The technological innovations of the 20th century revolutionized the field of plastic surgery. Operating microscopes were developed and continuously refined, and the production of microsurgical instruments quickly moved from possibility to reality. With these advances came the advent of microsurgery, the most ambitious technique for tissue transfer yet undertaken. Amongst the breakthroughs that this form of surgery brought with it were improvements to long established surgical procedures. The replantation of severed limbs, for example, became more successful than ever before. Further, the ability to describe in minute detail the angiosomes, or the anatomical vascular supply of any given region, gave way to a variety of new procedures.

The same innovations that dramatically altered the face of plastic surgery made way for the birth of whole new fields of research. The forward movement of scientific technology brought new insights into the structural and functional relationships that prevail on a microscopic level in both physiological and pathological tissues. This foundational understanding, coupled with advances in cell culturing techniques and biomedical research, opened new doors for the old ambition of providing living material for the replacement of defective tissues. The scientific progress of the latter part of the 20th century had made the next step in tissue substitution possible: tissue engineering.

3.1 Basic Principles of Tissue Engineering

Tissue engineering, in comparison to plastic surgery, is a more modern discipline defined as being involved in the experimentation with living tissues outside of a living organism. It is a true product of interdisciplinary cooperation between a vast number of life sciences, including biotechnology, material science, cell biology, cell expansion technology and a variety of medical specialties (Fig. 3.1).

The roots of tissue engineering, however, go deeper than the contemporary definition implies. Up until recent times, the possibilities for treatment requiring tissue substitution included non-biological implants and grafts originating from the patient themselves, a live donor, or a cadaver. The development of the field of tissue engineering research might be viewed as a product of the realization that the traditional materials used for

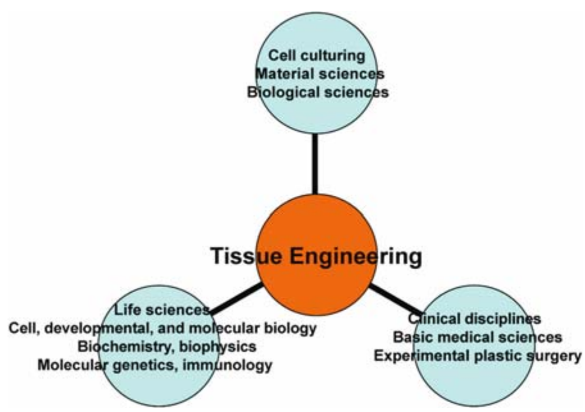

Fig. 3.1. Interdisciplinary cooperation in tissue engineering

the substitution of defective tissues were not sufficient to meet the demands placed on medicine. Solutions were sought outside of these classical therapeutic parameters.

Plastic surgery, in addressing the problem of replacing defective tissues in order to restore structure and function, achieved successes through the practices described above. Alone, however, these practices remain inadequate to meet the demand for tissue replacements needed to mend a vast range of defects. Tissue loss and organ failure are among the most frequent, devastating, and costly problems faced by the health system. Nevertheless, there are grave limitations placed on transplantation medicine, factors including a shortage of tissue and organ donations from either living or cadaver donors, as well as the high costs of transplantation, the side effects of immunosuppression, and recipient morbidity.

Another treatment option, namely the use of nonbiological implants, comes with its own set of drawbacks. While such prostheses very effectively restore structure to damaged tissues, they cannot replace all of the functions of a specialized tissue or organ. Neither can they prevent the progressive decline in the state of health of some patients, as a result of the illness that led to the need for the prosthetic implant in the first place.

The field of tissue engineering offers hope for a resolution of these difficulties. The development of biological substitutes that are intended to replace or improve the structure and function of human tissues has become a possibility. Tissue engineering is based on the knowledge gained through a wide range of scientific branches that allow an understanding of the processes and structure-function relationships within tissues at the microscopic level and beyond. It applies this information to the in vitro production of human tissues and substitutes that are biologically compatible with human tissues. Currently, the production of nearly all types of human tissue is being intensively investigated, with the intention of implementing these to restore, preserve or improve tissue structure and function in human subjects [1].

There are three aspects of tissue engineering that especially deserve attention in respect to the stated objective, the provision of living tissues for the replacement of congenital or acquired defects. First, consideration will be given to the branches of cell and tissue culture. Following this, the importance of the three-dimensional matrix for tissue engineering will be discussed. Last will be a brief account of the biological materials in the field of tissue engineering.

3.2 Cell and Tissue Culture

The first steps towards the attainment of a cell culture were taken by Rudolf Virchow, who was active in the same time period during which Reverdin, Ollier, and Billroth were making their contributions to plastic surgery. Virchow was one of the first advocates of the theory of cellular totipotency, or the ability of a single cell to divide and produce all of the differentiated cells of an organism. He postulated the independent growth of every cell under specific external circumstances, when removed from its collective cell structure, or tissue. Experiments were continuously conducted on the basis of this hypothesis, and it was a man by the name of Arnold who succeeded in verifying the postulate in 1887, when he observed the mitotic division of leukocytes in culture. This was, of course, a first step towards the maintenance and, further, the production of living human tissues outside of the living human organism. It was only 10 years later, in 1898, that Ljunggren managed to keep alive bits of skin in a fluid environment [3]. This was probably the first achievement in the creation of a milieu in which an actual tissue could be maintained external to the organism from which it came.

At about the same time that Erich Lexer was conducting the first mammoplasty, 1912, Carrel achieved the propagation of cells on a glass substrate [2]. The term “in vitro” stems from this time period as a synonym for experiments conducted outside of a living organism. From the onset of in vitro experimentation, it was clear, even without the technology known to modern-day scientists and the knowledge that this technology affords, that the composition of the medium in which cells find themselves outside of the organism is decisive for their ability to maintain life, divide, and differentiate. The goal of all cell expansion technology is to provide a suitable milieu for obtaining cell activity, function, and growth, but one that is defined and reproducible [3]. It was in the 1950s that the term “culture medium” first came to be used. It was used to define a combination of salts, nutrients, amino acids, and vitamins that allowed for the in vitro culture of living cells, which often required the addition of serum for efficacy. The first to succeed in producing a serum-free medium for mammalian cells was Ham, who accomplished this with the Ham F12 combination in 1965 [4].

Today, there is a variety of commercially available culture mediums for use with different cell types. Methods for cell and tissue culture also abound. The best known and most widely used technique for propagating human and animal cells is the monolayer culture using polystyrene dishes as the substrate. Most cell types adhere to the hydrophobic base of these dishes within 1 day, and subsequently begin to grow. The cell