



Contents

<i>Preface to the Fifth Edition</i>	xxvii
<i>List of Editors</i>	xxviii
<i>List of Contributors</i>	xxix
<i>Acknowledgments</i>	l
<i>Dedication</i>	li

Volume One: Principles

edited by Geoffrey C. Gurtner and Andrea L. Pusic

1 Plastic surgery and innovation in medicine	1
<i>Peter C. Neligan</i>	
2 History of reconstructive and aesthetic surgery	9
<i>Riccardo F. Mazzola and Isabella C. Mazzola</i>	
3 Applying psychology to routine plastic surgery practice	24
<i>Nichola Rumsey and Alex Clarke</i>	
4 The role of ethics in plastic surgery and medico-legal issues in plastic surgery	32
<i>Michele A. Manahan and B. Aviva Preminger</i>	
5 Business principles for plastic surgeons	37
<i>C. Scott Hultman</i>	
6 Value-based healthcare	60
<i>Justin M. Broyles, Clifford C. Sheckter, and Anaeze C. Offodile 2nd</i>	
7 Digital photography in plastic surgery	66
<i>Daniel Z. Liu</i>	
8 Pre- and intra-operative imaging for plastic surgery	83
<i>Arash Momeni and Lawrence Cai</i>	
9 Patient safety in plastic surgery	94
<i>Jessica Erdmann-Sager and Christopher J. Pannucci</i>	
10 Anesthesia and pain management in plastic surgery	101
<i>Paul N. Afrooz and Franklyn P. Cladis</i>	
11 Evidence-based medicine and health services research in plastic surgery	115
<i>Sophocles H. Voineskos, Lucas Gallo, Andrea L. Pusic, and Achilleas Thoma</i>	
12 Patient-reported outcomes in plastic surgery	135
<i>Sophocles H. Voineskos, Danny Young-Afat, Madelijn Gregorowitsch, Jonas A. Nelson, Anne F. Klassen, and Andrea L. Pusic</i>	
13 Health services research in plastic surgery	146
<i>Jacqueline N. Byrd and Kevin C. Chung</i>	
14 Principles of cancer management	153
<i>Stav Brown and Babak J. Mehrara</i>	
15 Wound healing	163
<i>Kristo Nuutila, David E. Varon, and Indranil Sinha</i>	
16 Scar prevention, treatment, and revision	186
<i>Michelle F. Griffin, Evan Fahy, Michael S. Hu, Elizabeth R. Zielins, Michael T. Longaker, and H. Peter Lorenz</i>	

17 Skin grafting	206
<i>Shawn Loder, Benjamin Levi, and Audra Clark</i>	
18 Tissue engineering	220
<i>Ramin Shayan and Karl-Anton Harms</i>	
19 Repair, grafting, and engineering of cartilage	235
<i>Wei Liu, Guangdong Zhou, and Yilin Cao</i>	
20 Repair and grafting of bone	265
<i>Iris A. Seitz, Chad M. Teven, Bryce Hendren-Santiago, and Russell R. Reid</i>	
21 Repair and grafting of peripheral nerve	295
<i>Hollie A. Power, Kirsty Usher Boyd, Stahs Pripotnev, and Susan E. Mackinnon</i>	
22 Repair and grafting fat and adipose tissue	309
<i>J. Peter Rubin</i>	
23 Vascular territories	321
<i>Steven F. Morris and G. Ian Taylor</i>	
24 Flap physiology, classification, and applications	346
<i>Joon Pio Hong and Peter C. Neligan</i>	
25 Principles and techniques of microvascular surgery	414
<i>Fu-Chan Wei, Sherilyn Keng Lin Tay, and Nidal F. Al Deek</i>	
26 Tissue expansion and implants	442
<i>Britta A. Kuehlmann, Eva Brix, and Lukas M. Prantl</i>	
27 Principles of radiation therapy	452
<i>Stephanie K. Schaub, Joseph Tsai, and Gabrielle M. Kane</i>	
28 Lymphedema: pathophysiology and basic science	472
<i>Stav Brown, Michelle Coriddi, and Babak J. Mehrara</i>	
29 Benign and malignant nonmelanocytic tumors of the skin and soft tissue	490
<i>Rei Ohtsuka</i>	
30 Melanoma	521
<i>Sydney Chung and Alexander H.R. Valey</i>	
31 Implants and biomaterials	544
<i>Dharshan Sivaraj, Dominic Henn, Timothy W. King, and Kellen Chen</i>	
32 Transplantation in plastic surgery	555
<i>Yannick F. Diehm, Valentin Haug, Martin Kauke-Navarro, and Bohdan Pomahac</i>	
33 Technology innovation in plastic surgery: a practical guide for the surgeon innovator	568
<i>David Perrault, Leila Jazayeri, and Geoffrey C. Gurtner</i>	
34 Robotics in plastic surgery	582
<i>Karim A. Sarhane and Jesse C. Selber</i>	
35 Digital technology in plastic surgery	594
<i>Lynn Jeffers, Hatem Abou-Sayed, and Haley M. Jeffers</i>	
36 Aesthetic improvement through noninvasive technologies	613
<i>Stelios C. Wilson and Charles H. Thorne</i>	
37 Education and teaching in plastic surgery	619
<i>Lydia Helliwell and Johanna N. Riesel</i>	

38	Global plastic surgery	625	9.5	Facelift: Platysma-SMAS plication	203
	<i>Johanna N. Riesel, Peter Nthumba, George Ho, and Amanda Gosman</i>			<i>Miles G. Berry, James D. Frame III, and Dai M. Davies</i>	
39	Gender-affirming surgery	634	9.6	Facelift: Lateral SMASectomy facelift	212
	<i>Shane D. Morrison, William M. Kuzon Jr., and Jens U. Berli</i>			<i>Daniel C. Baker and Steven M. Levine</i>	
<i>Index</i>		<i>652</i>	9.7	Facelift: The extended SMAS technique in facial rejuvenation	219
				<i>James M. Stuzin</i>	
Volume Two: Aesthetic					
<i>edited by J. Peter Rubin and Alan Matarasso</i>					
1	Managing the aesthetic surgery patient	1	9.8	High SMAS facelift: combined single flap lifting of the jawline, cheek, and midface	236
	<i>Michelle B. Locke and Foad Nahai</i>			<i>Timothy Marten and Dino Elyassnia</i>	
2	Principles of practice management and social media for cosmetic surgery	13	9.9	The lift-and-fill facelift	282
	<i>Ashley N. Amalfi, Josef G. Hadeed, and Smita R. Ramanadham</i>			<i>Stav Brown, Justin L. Bellamy, and Rod J. Rohrich</i>	
Section I: Aesthetic Anesthesia Techniques					
3	Essential elements of patient safety in aesthetic plastic surgery	18	9.10	Neck rejuvenation	301
	<i>Jeremy T. Joseph, Gabriele C. Miotto, Felmont F. Eaves III, and Galen Perdikiis</i>			<i>James E. Zins and Jacob Grow</i>	
4	Pain management in plastic surgery	25	9.11	Male facelift	319
	<i>Anna R. Schoenbrunner and Jeffrey E. Janis</i>			<i>Timothy Marten and Dino Elyassnia</i>	
5	Anatomic blocks of the face and neck	33	9.12	Secondary facelift irregularities and the secondary facelift	345
	<i>Stelios C. Wilson and Barry Zide</i>			<i>Timothy Marten and Dino Elyassnia</i>	
6	Local anesthesia	42	9.13	Perioral rejuvenation, including chin and genioplasty	390
	<i>Malcolm D. Paul</i>			<i>Ali Totonchi and Bahman Guyuron</i>	
Section II: Aesthetic Surgery of the Face					
7	Non-surgical skin care and rejuvenation	47	9.14	Facial feminization	404
	<i>Zoe Diana Draelos</i>			<i>Patrick R. Keller, Matthew Louis, and Devin Coon</i>	
8.1	Editors' perspective: injectables and non-surgical resurfacing techniques	53	10	Editors' perspective: brow and eye	424
	<i>J. Peter Rubin</i>			<i>Alan Matarasso</i>	
8.2	Injectables and resurfacing techniques: Soft-tissue fillers	54	11	Forehead rejuvenation	425
	<i>Kavita Mariwalla</i>			<i>Richard Warren</i>	
8.3	Injectables and resurfacing techniques: Botulinum toxin/neurotoxins	73	12	Endoscopic brow lift	441
	<i>Rawaa Almukhtar and Sabrina G. Fabi</i>			<i>Renato Saltz and Eric W. Anderson</i>	
8.4	Injectables and resurfacing techniques: Lasers in aesthetic surgery	84	13	Blepharoplasty	453
	<i>Jonathan Cook, David M. Turer, Barry E. DiBernardo, and Jason N. Pozner</i>			<i>Julius Few Jr., and Marco Ellis</i>	
8.5	Injectables and resurfacing techniques: Chemical peels	96	14	Secondary blepharoplasty	484
	<i>Richard H. Bensimon and Peter P. Rullan</i>			<i>Carl Z. Aschen and Henry M. Spinelli</i>	
8.6	Minimally invasive multimodal facial rejuvenation	118	15	Asian facial cosmetic surgery	513
	<i>Luiz S. Toledo</i>			<i>Jong Woo Choi, Tae Suk Oh, Hong Lim Choi, and Clyde Ishii</i>	
9.1	Editors' perspective: surgical facial rejuvenation	130	16	Facial fat grafting	559
	<i>Alan Matarasso</i>			<i>Francesco M. Egro, Sydney R. Coleman, and J. Peter Rubin</i>	
9.2	Facial anatomy and aging	131	17	Editors' perspective: nose	567
	<i>Bryan Mendelson and Chin-Ho Wong</i>			<i>Alan Matarasso</i>	
9.3	Principles and surgical approaches of facelift	149	18	Nasal analysis and anatomy	568
	<i>Richard J. Warren</i>			<i>Rod J. Rohrich and Paul N. Afrooz</i>	
9.4	Facelift: Facial rejuvenation with loop sutures: the MACS lift and its derivatives	180	19	Open technique rhinoplasty	581
	<i>Patrick Tonnard, Alexis Verpaele, and Rotem Tzur</i>			<i>Rod J. Rohrich and Paul N. Afrooz</i>	
			20	Closed technique rhinoplasty	607
				<i>Mark B. Constantian</i>	
			21	Airway issues and the deviated nose	647
				<i>Ali Totonchi, Bryan Armijo, and Bahman Guyuron</i>	
			22	Secondary rhinoplasty	662
				<i>David M. Kahn, Danielle H. Rochlin, and Ronald P. Gruber</i>	
			23	Otoplasty and ear reduction	681
				<i>Charles H. Thorne</i>	
			24	Hair restoration	690
				<i>Alfonso Barrera and Victor Zhu</i>	

Section III: General Aesthetic Surgery	
25.1	Editors' perspective: liposuction 700 <i>J. Peter Rubin</i>
25.2	Liposuction: a comprehensive review of techniques and safety 701 <i>Gianfranco Frojo, Jayne Coleman, and Jeffrey Kenkel</i>
25.3	Correction of liposuction deformities with the SAFE liposuction technique 723 <i>Simeon H. Wall Jr. and Paul N. Afrooz</i>
26	Editors' perspective: abdominal contouring 731 <i>Alan Matarasso</i>
27	Abdominoplasty 732 <i>Alan Matarasso</i>
28	Lipoabdominoplasty with anatomical definition: a new concept in abdominal aesthetic surgery 775 <i>Oswaldo Ribeiro Saldanha, Andrés F. Canchica Cano, Taisa Szolomicki, Oswaldo Saldanha Filho, and Cristianna Bonetto Saldanha</i>
29	Editors' perspective: truncal contouring 785 <i>J. Peter Rubin</i>
30	Bra-line back lift 786 <i>Joseph Hunstad and Saad A. Alsubaie</i>
31	Belt lipectomy 792 <i>Amitabh Singh and Al S. Aly</i>
32	Circumferential approaches to truncal contouring in massive weight loss patients: the lower lipo-bodylift 819 <i>Dirk F. Richter and Nina Schwaiger</i>
33	Circumferential approaches to truncal contouring: autologous buttocks augmentation with purse-string gluteoplasty 834 <i>Joseph P. Hunstad and Nicholas A. Flugstad</i>
34	Circumferential approaches to truncal contouring: lower bodylift with autologous gluteal flaps for augmentation and preservation of gluteal contour 841 <i>Robert F. Centeno and Jazmina M. Gonzalez</i>
35.1	Editors' perspective: buttock augmentations 854 <i>J. Peter Rubin</i>
35.2	Buttock augmentation with implants 855 <i>Jose Abel De la Peña Salcedo, Jocelyn Celeste Ledezma Rodriguez, and David Gonzalez Sosa</i>
35.3	Buttock shaping with fat grafting and liposuction 869 <i>Constantino G. Mendieta, Thomas L. Roberts III, and Terrence W. Bruner</i>
36	Upper limb contouring 878 <i>Margaret Luthringer, Nikita O. Shulzhenko, and Joseph F. Capella</i>
37	Medial thigh 891 <i>Samantha G. Maliha and Jeffrey Gusenoff</i>
38	Post-bariatric reconstruction 898 <i>Jonathan W. Toy and J. Peter Rubin</i>
39	Energy devices in aesthetic surgery 919 <i>David Turer, Jonathan Cook, Jason Pozner, and Barry DiBernardo</i>
40	Aesthetic genital surgery 926 <i>Gary J. Alter</i>

Volume Three: Craniofacial, Head and Neck Surgery and Pediatric Surgery

Part 1: Craniofacial, Head and Neck Surgery: edited by Richard A. Hopper

1	Management of craniomaxillofacial fractures 2 <i>Srinivas M. Susarla, Russell E. Ettinger, and Paul N. Manson</i>
2	Scalp and forehead reconstruction 39 <i>Alexander F. Mericli and Jesse C. Selber</i>
3	Aesthetic nasal reconstruction 52 <i>Frederick J. Menick</i>
4	Auricular construction 110 <i>Dale J. Podolsky, Leila Kasrai, and David M. Fisher</i>
5	Secondary treatment of acquired cranio-orbital deformities 138 <i>Allan B. Billig and Oleh M. Antonyshyn</i>
6.1	Computerized surgical planning: introduction 155 <i>Richard A. Hopper</i>
6.2	Three-dimensional virtual planning in orthognathic surgery 157 <i>Pradip R. Shetye and Srinivas M. Susarla</i>
6.3	Computerized surgical planning in head and neck reconstruction 173 <i>Maureen Beederman, Adam S. Jacobson, David L. Hirsch, and Jamie P. Levine</i>
7	Introduction to post-oncologic reconstruction 188 <i>Zoe P. Berman and Eduardo D. Rodriguez</i>
8	Overview of head and neck soft-tissue and bony tumors 190 <i>Sydney Ch'ng, Edwin Morrison, Pratik Rastogi, and Yu-Ray Chen</i>
9	Post-oncologic midface reconstruction: the Memorial Sloan-Kettering Cancer Center and MD Anderson Cancer Center approaches 217 <i>Maureen M. Hanasono and Peter G. Cordeiro</i>
10	Local flaps for facial coverage 229 <i>Nicholas Do and John Brian Boyd</i>
11	Lip reconstruction 256 <i>Julian J. Ponsaz and Mitchell Buller</i>
12	Oral cavity, tongue, and mandibular reconstructions 275 <i>Ming-Huei Cheng</i>
13	Hypopharyngeal, esophageal, and neck reconstruction 302 <i>Min-Jeong Cho and Peirong Yu</i>
14	Secondary facial reconstruction 336 <i>Afaaf Shakir and Lawrence J. Gottlieb</i>
15	Facial paralysis 359 <i>Simeon C. Daeschler, Ronald M. Zuker, and Gregory H. Borschel</i>
16	Surgical management of facial pain, including migraines 390 <i>Anna Schoenbrunner and Jeffrey E. Janis</i>
17	Facial feminization 400 <i>Luis Capitán, Daniel Simon, and Fermín Capitán-Cañadas</i>

Part 2: Pediatric Surgery: edited by Joseph E. Losee

18 Embryology of the craniofacial complex	442	25.2 Nonsyndromic craniosynostosis	808
<i>Jingtao Li and Jill A. Helms</i>		<i>Sameer Shakir and Jesse A. Taylor</i>	
Section I: Clefts		25.3 Multisutural syndromic synostosis	827
19.1 Unilateral cleft lip: introduction	451	<i>Richard A. Hopper and Benjamin B. Massenburg</i>	
<i>Joseph E. Losee and Michael R. Bykowski</i>		25.4 Neurosurgical and developmental issues in craniosynostosis	849
19.2 Rotation advancement cheiloplasty	456	<i>Alexandra Junn, John T. Smetona, Michael Alperovich, and John A. Persing</i>	
<i>Philip Kuo-Ting Chen and Lucia Pannuto</i>		26 Craniofacial microsomia	859
19.3 Extended Mohler repair	488	<i>Craig B. Birgfeld and Scott P. Bartlett</i>	
<i>Roberto L. Flores</i>		27 Idiopathic progressive hemifacial atrophy	887
19.4 Anatomic subunit approximation approach to unilateral cleft lip repair	499	<i>Peter J. Taub, Kathryn S. Torok, Daniel H. Glaser, and Lindsay A. Schuster</i>	
<i>Raymond W. Tse and David M. Fisher</i>		28 Robin sequence	902
20 Repair of bilateral cleft lip	519	<i>Sofia Aronson, Chad A. Purnell, and Arun K. Gosain</i>	
<i>John B. Mulliken and Daniel M. Balkin</i>		29 Treacher Collins syndrome	923
21.1 Cleft palate: introduction	538	<i>Irene Mathijssen</i>	
<i>Michael R. Bykowski and Joseph E. Losee</i>		Section III: Pediatrics	
21.2 Straight line repair with intravelar veloplasty (IVVP)	542	30 Congenital melanocytic nevi	935
<i>Brian Sommerlad</i>		<i>Sara R. Dickie, Neta Adler, and Bruce S. Bauer</i>	
21.3 Double opposing Z-palatoplasty	549	31 Vascular anomalies	952
<i>Jordan N. Halsey and Richard E. Kirschner</i>		<i>Arin K. Greene and John B. Mulliken</i>	
21.4 Buccal myomucosal flap palate repair	557	32 Pediatric chest and trunk deformities	974
<i>Robert Joseph Mann</i>		<i>Han Zhuang Beh, Andrew M. Ferry, Rami P. Dibbs, Edward P. Buchanan, and Laura A. Monson</i>	
21.5 The buccal fat pad flap	567	33 Pediatric tumors	988
<i>James D. Vargo and Steven R. Buchman</i>		<i>Matthew R. Greives, George Washington, Sahil Kapur, and Michael Bentz</i>	
21.6 Oral fistula closure	575	34 Conjoined twins	1001
<i>Mirko S. Gillardino, Sabrina Cugno, and Abdulaziz Alabdulkarim</i>		<i>Anna R. Carlson, Gregory G. Heuer, and Jesse A. Taylor</i>	
21.7 Alveolar clefts	583	<i>Index</i>	1011
<i>Katelyn Kondra, Eloise Stanton, Christian Jimenez, Erik M. Wolfswinkel, Stephen Yen, Mark Urata, and Jeffrey Hammoudeh</i>			
21.8 Orthodontics in cleft lip and palate management	592		
<i>Alvaro A. Figueroa, Alexander L. Figueroa, Gerson R. Chinchilla, and Marta Alvarado</i>			
21.9 Velopharyngeal dysfunction	618		
<i>Richard E. Kirschner, Hannah J. Bergman, and Adriane L. Baylis</i>			
21.10 Secondary deformities of the cleft lip, nose, and palate	636		
<i>Han Zhuang Beh, Rami P. Dibbs, Andrew M. Ferry, Robert F. Dempsey, Edward P. Buchanan, and Larry H. Hollier Jr.</i>			
21.11 Cleft and craniofacial orthognathic surgery	661		
<i>Stephen B. Baker, Brian L. Chang, and Anusha Singh</i>			
Section II: Craniofacial			
22 Pediatric facial fractures	708		
<i>John T. Smetona, Jesse A. Goldstein, Michael R. Bykowski, and Joseph E. Losee</i>			
23 Orbital hypertelorism	726		
<i>Eric Arnaud, Giovanna Paternoster, Roman Khonsari, Samer E. Haber, and Syril James</i>			
24 Craniofacial clefts	747		
<i>James P. Bradley and Henry K. Kawamoto Jr.</i>			
25.1 Craniosynostosis: introduction	775		
<i>Christopher R. Forrest and Johanna N. Riesel</i>			

Volume Four: Lower Extremity, Trunk and Burnsedited by **David H. Song and Joon Pio Hong**

1 Comprehensive lower extremity anatomy	1
<i>Rajiv P. Rankin and Grant M. Kleiber</i>	
2 Management of lower extremity trauma	52
<i>Hyunsuk Peter Suh</i>	
Section I: Lower Extremity Surgery	
3.1 Lymphedema: introduction and editors' perspective	76
<i>Joon Pio Hong and David H. Song</i>	
3.2 Imaging modalities for diagnosis and treatment of lymphedema	78
<i>Balazs Mohos and Chieh-Han John Tzou</i>	
3.3 Lymphaticovenular bypass	92
<i>Wei F. Chen, Lynn M. Orfahli, and Vahe Fahradyan</i>	
3.4 Vascularized lymph node transplant	102
<i>Rebecca M. Garza and David W. Chang</i>	
3.5 Debulking strategies and procedures: liposuction of leg lymphedema	111
<i>Håkan Brorson</i>	
3.6 Debulking strategies and procedures: excision	120
<i>Hung-Chi Chen and Yueh-Bih Tang</i>	

4	Lower extremity sarcoma reconstruction	128	15	Reconstruction of acquired vaginal defects	452
	<i>Andrés A. Maldonado, Günter K. Germann, and Michael Sauerbier</i>			<i>Leila Jazayeri, Andrea L. Pusic, and Peter G. Cordeiro</i>	
5	Reconstructive surgery: lower extremity coverage	154	16	Pressure sores	462
	<i>Joon Pio Hong</i>			<i>Ibrahim Khansa and Jeffrey E. Janis</i>	
6.1	Diagnosis, treatment, and prevention of lower extremity pain	180	17	Perineal reconstruction	489
	<i>Brian L. Chang and Grant M. Kleiber</i>			<i>Ping Song, Hakim Said, and Otway Louie</i>	
6.2	Targeted muscle reinnervation in the lower extremity	190	Section III: Burn Surgery		
	<i>Brian L. Chang and Grant M. Kleiber</i>		18	Burn, chemical, and electrical injuries	501
6.3	Lower extremity pain: regenerative peripheral nerve interfaces	203		<i>Raphael C. Lee and Chad M. Teven</i>	
	<i>Nishant Ganesh Kumar, Theodore A. King, and Paul S. Cederna</i>		19	Extremity burn reconstruction	538
7	Skeletal reconstruction	210		<i>S. Raja Sabapathy, R. Raja Shanmugakrishnan, and Vamseedharan Muthukumar</i>	
	<i>Marco Innocenti, Stephen Kovach III, Elena Lucattelli, and L. Scott Levin</i>		20	Management of the burned face and neck	561
8	Foot reconstruction	228		<i>Vinita Puri and Venkateshwaran Narasiman</i>	
	<i>Romina Deldar, Zoe K. Haffner, Adaah A. Sayad, John S. Steinberg, Karen K. Evans, and Christopher E. Attinger</i>		21	Pediatric burns	589
9.1	Diabetic foot: introduction	265		<i>Sebastian Q. Vrouwe and Lawrence J. Gottlieb</i>	
	<i>Kevin G. Kim, Paige K. Dekker, John D. Miller, Jayson N. Atves, John S. Steinberg, and Karen K. Evans</i>		Index 610		
9.2	Diabetic foot: management of wounds and considerations in biomechanics and amputations	270	Volume Five: Breast		
	<i>Jayson N. Atves, John D. Miller, and John S. Steinberg</i>		<i>edited by Maurice Y. Nahabedian</i>		
9.3	Diabetic foot: management of vascularity and considerations in soft-tissue reconstruction	296	Section I: Aesthetic Breast Surgery		
	<i>Paige K. Dekker, Kevin G. Kim, and Karen K. Evans</i>		1	Preoperative assessment and planning of the aesthetic breast patient	1
Section II: Trunk, Perineum, and Transgender				<i>Kiya Movassaghi and Christopher N. Stewart</i>	
10	Trunk anatomy	311	2	Current status of breast implants	13
	<i>J. Andres Hernandez, Andrew Nagy Atia, and Scott Thomas Hollenbeck</i>			<i>Patrick Mallucci and Giovanni Bistoni</i>	
11	Reconstruction of the chest	327	3	Primary breast augmentation with implants	28
	<i>Brian L. Chang, Banafsheh Sharif-Askary, and David H. Song</i>			<i>Charles Randquist</i>	
12	Reconstruction of the posterior trunk	354	4	Autologous fat transfer: fundamental principles and application for breast augmentation	52
	<i>Reuben A. Falola, Nicholas F. Lombana, Andrew M. Altman, and Michel H. Saint-Cyr</i>			<i>Foger Khalil Khouri, Raul A. Cortes, and Daniel Calva-Cerquiera</i>	
13	Abdominal wall reconstruction	388	5	Augmentation mastopexy	69
	<i>Gregory A. Dumanian</i>			<i>Justin L. Perez, Daniel J. Gould, Michelle Spring, and Grant Stevens</i>	
14.1	Gender confirmation surgery: diagnosis and management	407	6	Mastopexy after massive weight loss	83
	<i>Loren Schechter and Rayisa Hontscharuk</i>			<i>Francesco M. Egro and J. Peter Rubin</i>	
14.2	Gender confirmation surgery, male to female: vaginoplasty	414	7	Prevention and management of complications following breast augmentation and mastopexy	92
	<i>Loren Schechter and Rayisa Hontscharuk</i>			<i>M. Bradley Calobrace and Chester J. Mays</i>	
14.3	Gender affirmation surgery, female to male: phalloplasty; and correction of male genital defects	421	8	Short scar breast reduction	102
	<i>Alexander Y. Li, Walter C. Lin, and Bauback Safa</i>			<i>Elizabeth Hall-Findlay, Elisa Bolletta, and Gustavo Jiménez Muñoz Ledo</i>	
14.4	Breast, chest wall, and facial considerations in gender affirmation	439	9	Reduction mammoplasty with inverted-T techniques	131
	<i>Kaylee B. Scott, Dana N. Johns, and Cori A. Agarwal</i>			<i>Maurice Y. Nahabedian</i>	
			10	Breast implant illness: diagnosis and management	154
				<i>Caroline A. Glicksman and Patricia McGuire</i>	
			11	Breast implant-associated anaplastic large cell lymphoma (BIA-ALCL): diagnosis and management	160
				<i>Mark W. Clemens, Eliora A. Tesfaye, and Anand Deva</i>	

12	A critical analysis of irrigation solutions in breast surgery	174	29	Breast reconstruction with the latissimus dorsi flap	355
	<i>Grace Keane, Marissa M. Tenenbaum, and Terence M. Myckatyn</i>			<i>Dennis C. Hammond</i>	
13	Imaging and surveillance in patients with breast implants	182	30	Autologous breast reconstruction with the DIEP flap	371
	<i>Bradley Bengtson, Patricia McGuire, Caroline Glicksman, and Pat Pazmiño</i>			<i>Adrian McArdle and Joan E. Lipa</i>	
14	Breast implant explantation: indications and strategies to optimize aesthetic outcomes	191	31	Autologous breast reconstruction with the free TRAM flap	396
	<i>Connor Crowley, M. Bradley Calobrace, Mark W. Clemens, and Neil Tanna</i>			<i>Jin Sup Eom and Hyunho Han</i>	
15	Management strategies for gynecomastia	200	32	Autologous breast reconstruction with the superficial inferior epigastric artery (SIEA) flap	413
	<i>Michele Ann Manahan</i>			<i>Pierre Chevray</i>	
16	Management options for gender affirmation surgery of the breast	207	33	Introduction to autologous reconstruction with alternative free flaps	420
	<i>Ara A. Salibian, Gaines Blasdel, and Rachel Bluebond-Langner</i>			<i>Maurice Y. Nahabedian</i>	
Section II: Reconstructive Breast Surgery			34	Gluteal free flaps for breast reconstruction	424
17	Preoperative evaluation and planning for breast reconstruction following mastectomy	222		<i>Salih Colakoglu and Gedge D. Rosson</i>	
	<i>Said C. Azoury and Liza C. Wu</i>		35	Autologous breast reconstruction with medial thigh flaps	433
18	Perfusion assessment techniques following mastectomy and reconstruction	234		<i>Venkat V. Ramakrishnan and Nakul Gamanlal Patel</i>	
	<i>Alex Mesbahi, Matthew Cissell, Mark Venturi, and Louisa Yemc</i>		36	Autologous breast reconstruction with the profunda artery perforator (PAP) flap	450
19	Introduction to prosthetic breast reconstruction	239		<i>Adam T. Hauch, Hugo St. Hilaire, and Robert J. Allen, Sr.</i>	
	<i>Maurice Y. Nahabedian</i>		37	Autologous reconstruction with the lumbar artery perforator (LAP) free flap	461
20	One- and two-stage prepectoral reconstruction with prosthetic devices	247		<i>Phillip Blondeel and Dries Opsomer</i>	
	<i>Alberto Rancati, Claudio Angrigiani, Maurizio Nava, Dinesh Thekkinkattil, Raghavan Vidya, Marcelo Irigo, Agustin Rancati, Allen Gabriel, and Patrick Maxwell</i>		38	Hybrid breast reconstruction: combining flaps and implants	468
21	One-stage dual-plane reconstruction with prosthetic devices	265		<i>Arash Momeni, Hani Sbitany, and Suhail K. Kanchwala</i>	
	<i>Brittany L. Vieira and Amy S. Colwell</i>		39	Innervation of autologous flaps	475
22	Two-stage dual-plane reconstruction with prosthetic devices	280		<i>Aldona J. Spiegel and Janak A. Parikh</i>	
	<i>Ara A. Salibian and Nolan S. Karp</i>		40	Stacked and conjoined flaps	481
23	Two-stage prosthetic reconstruction with total muscle coverage	293		<i>Nicholas T. Haddock and Sumeet S. Teotia</i>	
	<i>Colleen M. McCarthy and Peter G. Cordeiro</i>		41	Management of complications following autologous breast reconstruction	488
24	Skin reduction using “smile mastopexy” technique in breast reconstruction	298		<i>Anne C. O’Neill, Vincent J. Choi, and Stefan O.P. Hofer</i>	
	<i>Kiya Movassaghi and Christopher N. Stewart</i>		42	Enhanced recovery after surgery (ERAS) protocols in breast surgery: techniques and outcomes	498
25	Management of complications of prosthetic breast reconstruction	304		<i>Nicholas F. Lombana, Reuben A. Falola, John C. Cargile, and Michel H. Saint-Cyr</i>	
	<i>Nima Khavanin and John Y.S. Kim</i>		43	Secondary procedures following autologous reconstruction	516
26	Secondary refinement procedures following prosthetic breast reconstruction	317		<i>Jian Farhadi and Vendela Grufman</i>	
	<i>Roy de Vita and Veronica Vietti Michelina</i>		44	Introduction to oncoplastic breast surgery	526
27	Introduction to autologous breast reconstruction with abdominal free flaps	336		<i>Maurice Y. Nahabedian</i>	
	<i>Maurice Y. Nahabedian</i>		45	Partial breast reconstruction using reduction and mastopexy techniques	533
28	Breast reconstruction with the pedicle TRAM flap	340		<i>Albert Losken, Nusaiba F. Baker, and Alexandre Munhoz</i>	
	<i>Jake C. Laun and Julian J. Pribaz</i>		46	Oncoplastic breast reconstruction: local flap techniques	547
				<i>Moustapha Hamdi and Claudio Angrigiani</i>	
			47	Surgical and non-surgical management of breast cancer-related lymphedema	556
				<i>Ketan M. Patel, Emma C. Koesters, Rachel Lentz, and Orr Shaully</i>	

48	Breast reconstruction and radiotherapy: indications, techniques, and outcomes	567			
	<i>Jaume Maslà, Crishtian D. Pomata, and Javier Sanz</i>				
49	Robotic-assisted autologous breast reconstruction	581			
	<i>Karim A. Sarhane and Jesse C. Selber</i>				
50	Total breast reconstruction by external vacuum expansion (EVE) and autologous fat transfer (AFT)	590			
	<i>Andrzej Piatkowski and Roger K. Khouri</i>				
51	Current options for nipple reconstruction	603			
	<i>David Chi and Justin M. Sacks</i>				
	<i>Index</i>	610			
Volume Six: Hand and Upper Extremity					
	Introduction: Plastic surgery contributions to hand surgery		liii		
	<i>James Chang</i>				
	Section I: Principles of Hand Surgery				
1	Anatomy and biomechanics of the hand	1			
	<i>James Chang, Anais Legrand, Francisco J. Valero-Cuevas, Vincent R. Hentz, and Robert A. Chase</i>				
2	Examination of the upper extremity	49			
	<i>Ryosuke Kakinoki</i>				
3	Diagnostic imaging of the hand and wrist	70			
	<i>Alphonsus K.S. Chong, Janice Liao, and David M.K. Tan</i>				
4	Anesthesia for upper extremity surgery	95			
	<i>Eugene Park, Jonay Hill, Vanila M. Singh, and Subhro K. Sen</i>				
5	Principles of internal fixation	109			
	<i>Margaret Fok, Jason R. Kang, Christopher Cox, and Jeffrey Yao</i>				
	Section II: Trauma Reconstruction				
6	Nail and fingertip reconstruction	123			
	<i>Amanda Brown, Brian A. Mailey, and Michael W. Neumeister</i>				
7	Hand fractures and joint injuries	147			
	<i>Warren C. Hammert and Randy R. Bindra</i>				
8	Fractures and dislocations of the wrist and distal radius	173			
	<i>Steven C. Haase and Kevin C. Chung</i>				
9	Flexor tendon injuries and reconstruction	193			
	<i>Jin Bo Tang</i>				
10	Extensor tendon injuries	230			
	<i>Kai Megerle and Karl-Josef Prommersberger</i>				
11	Replantation	250			
	<i>Dong Chul Lee and Eugene Park</i>				
12	Reconstructive surgery of the mutilated hand	272			
	<i>S. Raja Sabapathy and Hari Venkatraman</i>				
13	Thumb reconstruction: Non-microsurgical techniques	305			
	<i>Jeffrey B. Friedrich, Nicholas B. Vedder, and Elisabeth Haas-Lützenberger</i>				
14	Thumb reconstruction: Microsurgical techniques	320			
	<i>Nidal F. Al Deek and Fu-Chan Wei</i>				
	Section III: Specific Disorders				
15	Infections of the hand	337			
	<i>Andrew O'Brien, Ryan P. Calfee, Jana Dengler, and Amy M. Moore</i>				
16	Tumors of the hand	356			
	<i>Kashyap K. Tadisina, Justin M. Sacks, and Mitchell A. Pet</i>				
17	Dupuytren's disease	384			
	<i>James K-K. Chan, Paul M.N. Werker, and Jagdeep Nanchahal</i>				
18	Osteoarthritis in the hand and wrist	411			
	<i>Paige M. Fox, J. Henk Coert, and Steven L. Moran</i>				
19	Rheumatologic conditions of the hand and wrist	449			
	<i>Douglas M. Sammer and Kevin C. Chung</i>				
20	Occupational disorders of the hand	491			
	<i>Celine Yeung and Steven J. McCabe</i>				
	Section IV: Nerve Disorders				
21	Nerve entrapment syndromes	499			
	<i>Elisabet Hagert and Donald Lalonde</i>				
22	Peripheral nerve repair and reconstruction	526			
	<i>Simon Farnebo, Johan Thorfinn, and Lars B. Dahlin</i>				
23	Brachial plexus injuries: adult and pediatric	552			
	<i>Johnny Chuieng-Yi Lu and David Chwei-Chin Chuang</i>				
24	Tetraplegia	585			
	<i>Carina Reinholdt and Catherine Curtin</i>				
25	Tendon transfers	605			
	<i>Neil F. Jones</i>				
26	Nerve transfers	638			
	<i>Kirsty Usher Boyd, Ida K. Fox, and Susan E. Mackinnon</i>				
27	Free-functioning muscle transfer	665			
	<i>Siméon C. Daeschler, Kristen M. Davidge, Julia Harhaus, and Gregory H. Borschel</i>				
	Section V: Challenging Disorders				
28	The ischemic hand	680			
	<i>Hee-Shang Ahn, Jung Soo Yoon, and Neil F. Jones</i>				
29	The spastic hand	704			
	<i>Caroline Leclercq, Nathalie Bini, and Charlotte Jaloux</i>				
30	The stiff hand	716			
	<i>David T. Netscher, Rita E. Baumgartner, Kimberly Goldie Staines, and Logan W. Carr</i>				
31	The painful hand	735			
	<i>Hazel Brown, Anna Berridge, Dennis Hazell, Parashar Ramanuj, and Tom J. Quick</i>				
	Section VI: Congenital Disorders				
32	Congenital hand I: Embryology, classification, and principles	746			
	<i>Michael Tonkin and Kerby C. Oberg</i>				
33	Congenital hand II: Malformations – whole limb	770			
	<i>Aaron Berger, Soumen Das De, Bhaskaranand Kumar, and Pundrique Sharma</i>				
34	Congenital hand III: Malformations – abnormal axis differentiation – hand plate: proximodistal and radioulnar	790			
	<i>Brinkley K. Sandvall and Charles A. Goldfarb</i>				

35	Congenital hand IV: Malformations – abnormal axis differentiation – hand plate: unspecified axis	824		
	<i>Christianne A. van Nieuwenhoven</i>			
36	Congenital hand V: Deformations and dysplasias – variant growth	842		
	<i>Wee Leon Lam, Xiaofei Tian, Gillian D. Smith, and Shanlin Chen</i>			
37	Congenital hand VI: Dysplasias – tumorous conditions	868		
	<i>Amir H. Taghinia and Joseph Upton</i>			
38	Congenital hand VII: Dysplasias – congenital contractures	898		
	<i>Ellen Satteson, Paul C. Dell, Xiao Fang Shen, and Harvey Chim</i>			
39	Growth considerations in the pediatric upper extremity	909		
	<i>Marco Innocenti and Sara Calabrese</i>			
			Section VII: New Directions	
			40 Treatment of the upper extremity amputee	930
			<i>Gregory Ara Dumanian, Sumanas W. Jordan, and Jason Hyunsuk Ko</i>	
			41 Upper extremity composite allotransplantation	949
			<i>Christopher D. Lopez, Joseph Lopez, Jaimie T. Shores, W.P. Andrew Lee, and Gerald Brandacher</i>	
			42 Aesthetic hand surgery	963
			<i>David Alan Kulber and Meghan C. McCullough</i>	
			43 Hand therapy	983
			<i>Wendy Moore, Minnie Mau, and Brittany N. Garcia</i>	
			<i>Index</i>	999

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Comprehensive lower extremity anatomy

Rajiv P. Parikh and Grant M. Kleiber

SYNOPSIS

- Success in lower extremity reconstruction is dependent on a comprehensive understanding of structural and functional anatomy. An anatomic- and defect-specific approach to lower extremity reconstruction enables the surgeon to provide tailored solutions for both the preservation and restoration of a functional limb.
- A comprehensive appreciation for normal lower extremity anatomy and anatomical variants is critical to functional limb salvage when treating lower extremity pathology.
- The reconstructive surgeon may also be called upon to harvest tissue for transfer from the many potential donor sites in the lower extremity.
- This chapter aims to provide a comprehensive review of the three-dimensional anatomy of the lower extremity to facilitate operative and clinical decision-making.
- A detailed description is given of each region of the lower extremity with respect to skeletal support, musculofascial anatomy, vascularity, lymphatic drainage, peripheral nerves, and skin and soft-tissue elements.
- A broad overview of available soft-tissue donor sites from each region, donor sites for bone grafts, anatomic basis of common lower extremity flaps, surgical approaches to lower extremity recipient vessels, and common points of nerve injury and entrapment are included to provide a clinically relevant discussion for anatomy of the lower extremity as a framework for common challenges in reconstructive surgery.

The gluteal region

Gluteal skeletal structure

The pelvis consists of the two paired hip bones and the midline sacrum, articulating together at the two sacroiliac joints. The hip bones are formed by the fusion of the ilium, pubis, and ischium. These three bony regions of the pelvis coalesce to form the acetabulum. The large thick bony prominences of

the pelvis serve as attachments for the muscles of the hip and thigh (Fig. 1.1). These prominences also become clinically relevant in contributing to the formation of pressure ulcers, most commonly over the ischial tuberosity, sacrum, and greater trochanter. Dense ligaments stabilize and distribute the numerous opposing forces acting on the pelvis. The sacrospinous ligament runs from the sacrum to the ischial spine, bounding the greater sciatic foramen. The sacrotuberous ligament attaches the sacrum to the ischial tuberosity and encloses the lesser sciatic foramen. Running from the anterior superior iliac spine (ASIS) to the pubic tubercle is the inguinal ligament. The action of the multiple flexors, extensors, and internal and external rotators on the hip joint serves to stabilize and position the torso during the complex process of ambulation.

Clinical correlation – iliac crest bone graft

The iliac crest serves as a versatile source of autogenous bone graft to reconstruct a variety of defects. Bone grafts can be cortical, cancellous, or corticocancellous in composition. Cortical bone is structurally stable with osteoconductive properties and ideally suited for structural defects requiring immediate mechanical stability. Cancellous bone is osteoinductive, osteogenic, and osteoconductive, undergoes rapid remodeling and vascularization, and is ideally suited for non-unions and bony fusion. Cancellous bone can be obtained between the inner and outer table of the ilium. The anterior and posterior iliac crest are common donor sites for cancellous and corticocancellous bone grafts, with 13 cm³ and 30 cm³ average graft volumes available from the anterior and posterior crest, respectively (Fig. 1.2).¹ Anteriorly, bone graft is most commonly harvested from the iliac tubercle, 3–4 cm posterior and parallel to the ASIS to maximize available bone and minimize risk to the lateral femoral cutaneous nerve. The iliac crest lies deep to a musculofascial layer from the external oblique and the iliacus muscle. The ilioinguinal nerve runs along the medial surface of the iliacus muscle and is at risk during harvest from the anterior crest. The anterior iliac crest provides

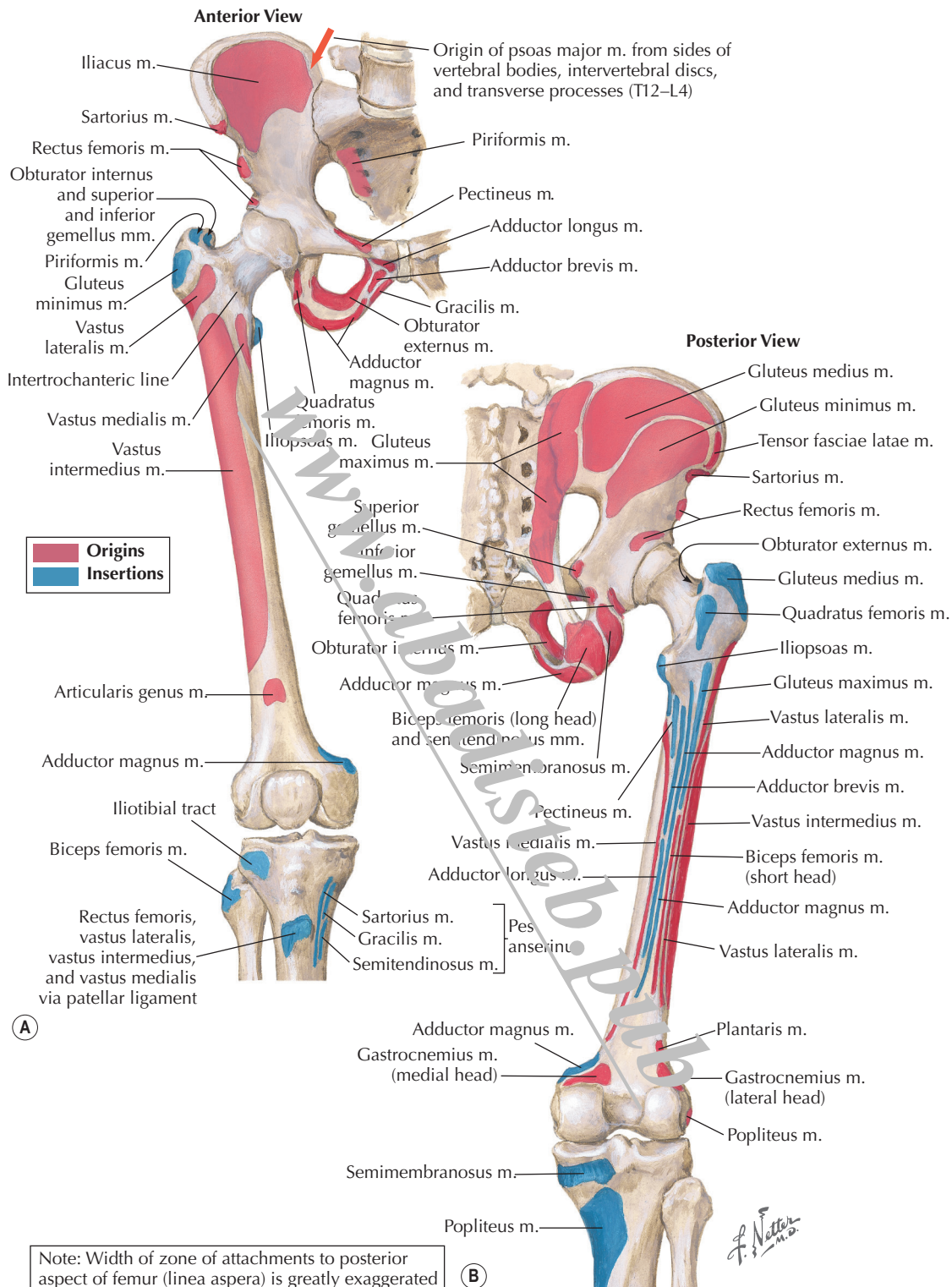


Figure 1.1 Bony attachments of buttock and thigh muscles. (Netter illustration from www.netterimages.com. Copyright Elsevier Inc. All rights reserved.)

twice the volume of packed cancellous bone compared to the distal radius or olecranon. Alternatively, tricortical bone grafts can be harvested from the inner and outer table of the anterior ilium and corticocancellous bone grafts can be harvested to include either the inner or outer table. Posteriorly, the bone is thickest and best harvested in the area superior to a line connecting the posterior superior iliac spine (PSIS)

and the apex of the sacroiliac joint. Harvesting from an area approximately 4 cm distal to the PSIS prevents violation of the sacroiliac joint.² Unicortical and corticocancellous bone grafts can be obtained from the outer table of the posterior ilium and additional cancellous bone harvested from the inner table of the ilium. The iliac crest can also provide vascularized bone for a variety of composite soft-tissue and bone

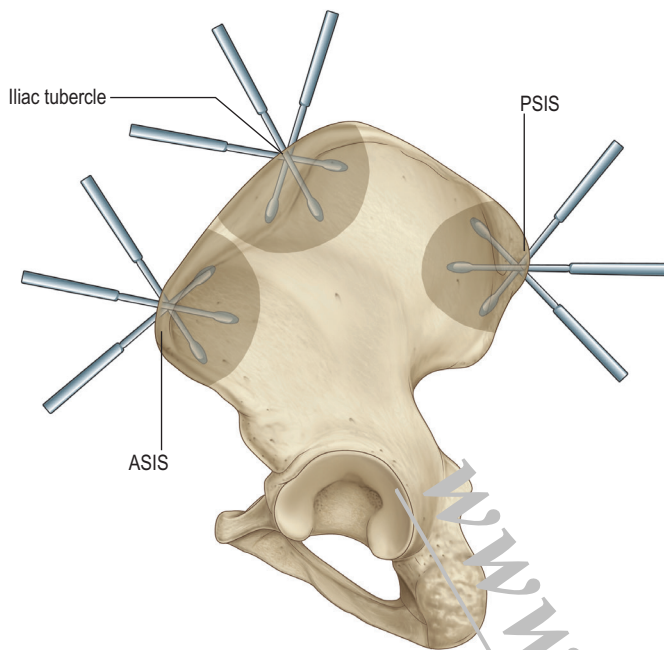


Figure 1.2 Harvest sites for iliac crest bone graft. (Redrawn from Ebraheim NA, Elgafly H, Xu R. Bone-graft harvesting from iliac and fibular donor sites: techniques and complications. *J Am Acad Orthop Surg.* 2001;9(3):210–218.)

defects. Corticocancellous, vascularized bone can be obtained from the outer cortex of the ilium on the lateral half of the iliac crest, supplied by the ascending branch of the lateral femoral circumflex system.³ The inner cortex of the ilium, supplied through nutrient branches off the deep circumflex iliac artery, is another common source of vascularized iliac bone.

Gluteal fascial anatomy

The fascial system of the gluteal region and the lower extremity contains various permutations of a nearly continuous superficial fascial and a deep fascial layer. The superficial system is located in the subcutaneous fat. The deep fascial layer is thicker and frequently can be seen as a dual-layered fibrous band. It usually lies directly over the underlying limb musculature and its proper fascia. The superficial fascia of the gluteal region is contiguous with that over the lower back and continues inferiorly into the proximal thigh. The deep fascia covering the gluteal muscles varies in thickness. Over the maximus it is thin, but over the anterior two-thirds of the medius it thickens and forms the gluteal aponeurosis. This is attached to the lateral border of the iliac crest superiorly, and splits anteriorly to enclose the tensor fasciae latae and posteriorly to enclose the gluteus maximus.

Muscles of the buttocks

The gluteus maximus is the largest muscle in the body and lies most superficially in the gluteal region, originating from the posterior gluteal line of the ilium and the dorsal portion of the sacrum (Fig. 1.3). The superficial fibers coalesce into a thick tendinous expansion which contributes to the iliotibial band of the fascia lata, while the deep fibers insert on the gluteal tuberosity of the femur. The gluteus maximus acts as a

Table 1.1 Mathes–Nahai classification system for muscle vascular supply

Muscle vascular supply type	Description
I	Single vascular pedicle
II	Dominant vascular pedicle and one or more minor pedicles
III	Two dominant pedicles
IV	Segmental vascular pedicles
V	Single dominant vascular pedicle and secondary segmental pedicles

hip extensor when the hip is in a flexed position. In a standing position, the gluteus maximus dorsally rotates the pelvis and torso, maintaining stability. The vascular supply is primarily derived from the inferior gluteal vessels, which supply the inferior two-thirds of the muscle. The superior gluteal vessels supply the superior portion and the first perforator branch of the profunda femoris contributes to the vascular supply of the muscle laterally. For ease of description, the Mathes–Nahai classification system is used when discussing muscle vascularity (Table 1.1).⁴ The gluteus maximus has a type III vascular supply, with two dominant pedicles from the superior and inferior gluteal arteries. Innervation to the gluteus maximus is provided by the inferior gluteal nerve. Underneath the gluteus maximus lie three bursae: the trochanteric, gluteofemoral, and ischiofemoral bursae, which allow frictionless movement over its underlying structures.

The gluteus medius, situated immediately deep to the gluteus maximus, arises from the outer surface of the iliac wing and inserts on the greater trochanter of the femur. It is innervated by the superior gluteal nerve and functions to abduct the hip and medially rotate the femur. Blood supply to this muscle is from the deep branch of the superior gluteal artery and from the trochanteric connection.

The gluteus minimus lies deep to the gluteus medius and arises from the outer surface of the ilium. Its fibers join the aponeurosis of the gluteus medius to insert on the greater trochanter, and the two muscles function together to abduct the hip. The gluteus minimus is innervated by the superior gluteal nerve and receives blood supply from the superior gluteal artery and trochanteric connection. Several small muscles arise from the medial pelvis and insert on the greater trochanter of the femur, functioning collectively to rotate the hip externally. These muscles include piriformis, superior and inferior gemellus, quadratus femoris, obturator internus, and obturator externus.

Gluteal vasculature

The superior gluteal artery (SGA) is the last branch of the posterior trunk of the internal iliac artery. It exits the pelvis through the greater sciatic foramen superior to the piriformis, dividing into two branches (Fig. 1.4). The deep branch runs deep to the gluteus medius, dividing into superior and inferior branches. The superior branch travels laterally to the anterior superior

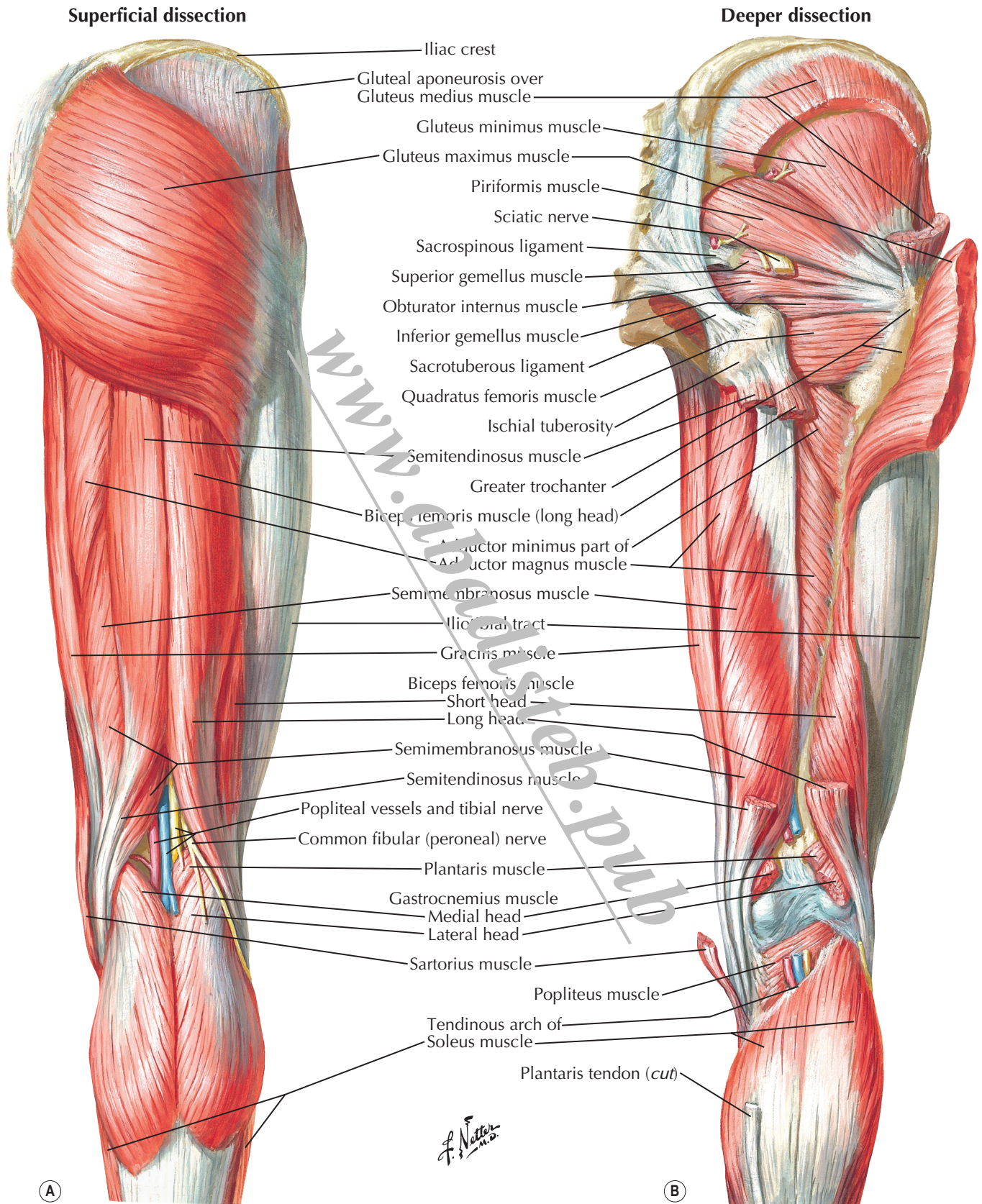


Figure 1.3 Muscles of hip and thigh: posterior views. (Netter illustration from www.netterimages.com. Copyright Elsevier Inc. All rights reserved.)