WCHM

WOUND CARE AND HYPERBARIC MEDICINE

VOLUME 8, ISSUE 3 — FALL 2017

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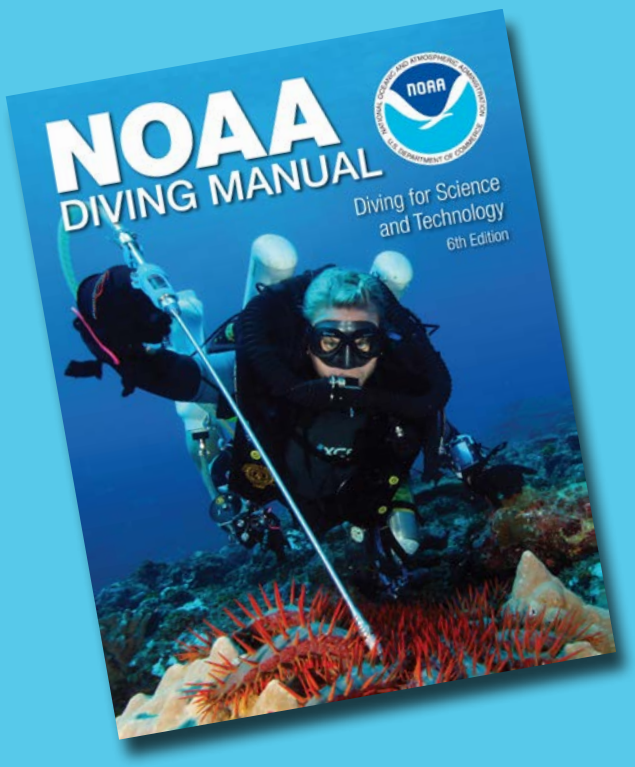
NOAA DIVING MANUAL



Diving for Science and Technology

6th Edition

This 800-page sixth edition of the *NOAA Diving Manual* builds on earlier editions, combining new developments in equipment and cutting-edge methods and procedures to provide a reference text that is useful for not only scientists but also all divers.

Greg McFall, *Content Editor*
John N. Heine, *Technical Editor*
Jeffrey E. Bozanic, PhD, *Technical Editor*

New chapters include:

- Advanced Platform Support — diving with ROVs/AUVs, submersibles, and atmospheric diving systems
- Underwater Photography and Videography

Significantly revised and updated chapters include:

- Diving Equipment
- Procedures for Scientific Dives
- Rebreathers
- Polluted-Water Diving

PRESALE SPECIAL $105

This edition also includes the new NOAA nitrox tables. Dozens of the foremost diving scientists, educators, and other professionals in the field have contributed to and reviewed this important volume. All serious divers should have this comprehensive manual in their library.

ISBN: 978-1-930536-88-3
Price: $116

PRESALES END **OCTOBER 15.**

NOTE FROM THE EDITOR

The fall issue of *WCHM* brings sad news to the diving, hyperbaric medicine, and wound-care industries. Jim T. Joiner, founder and former president of Best Publishing Company, passed away August 27, 2017. A special section begins this issue, remembering his contributions, achievements, and passion. He will be missed by his colleagues and our sympathies are extended to his family.

Jim had proudly published and edited previous editions of the *NOAA Diving Manual*, so it is fitting that the long-awaited 6th edition is now available for presale. It includes new developments in equipment and cutting-edge methods and procedures, providing a reference text that is useful for not only scientists but also all divers.

An excerpt from the Baromedical Nurses Association (BNA) website explains the evolution of the BNA and the awards the organization issued to recognize outstanding leaders who promote the mission and vision of hyperbaric nursing in research, education, and safety.

Two outstanding clinics are recognized this month in *WCHM*'s Clinic in Focus section: the Center for Reconstruction and Wound Healing and Riverview Health Wound Care.

In the field of wound care, Dr. Michael Strauss, Lientra Lu, and Anna Tan provide the last article in their Prevention of New and Recurrent Diabetic Foot Wound series. The article begins with a commentary discussing all five articles published in *WCHM*. We look forward to continued contributions by these experts in the future.

Also in the field of wound care, a case study for trigeminal trophic syndrome (TTS) is discussed by Drs. Ellen H. de Moll, Sandra Wainwright, and Charles Halasz, MD.

Please take advantage of authoring an article for *WCHM*, where you will reach an audience of thousands of wound-care and hyperbaric-medicine practitioners. Submit your articles to info@bestpub.com, or call 561-776-6066, ext 4. We also invite you to join our elite group of *WCHM* advertisers to reach your target audience.

Lorraine Fico-White
Managing Editor, *WCHM*

*The long-awaited, **COMPLETELY REVISED AND UPDATED** edition of Dr. Harry Whelan and Dr. Eric Kindwall's keystone textbook in hyperbaric medicine is now available.*

HYPERBARIC MEDICINE PRACTICE

4TH EDITION

by Dr. Harry Whelan and Dr. Eric Kindwall

Harry T. Whelan, MD, lead editor, collected some of the most renowned practitioners in hyperbaric medicine to create this revised and updated 4th edition, which adds new information of interest to all in the field of diving and clinical hyperbaric medicine.

New contributors have written or revised most chapters, but many authors have returned to update their chapters. New chapters cover areas recently approved for hyperbaric oxygen treatment, such as idiopathic sudden sensorineural hearing loss and central retinal vein occlusion. There are also chapters about submarine rescue and problems that pertain to technical and rebreather diving.

This book will be an essential addition to the library of physicians, nurses, CHTs, CHRNs, and allied health professionals who practice clinical hyperbaric medicine and those involved with the treatment of injured divers.

Print book, ebook, and book on PDF thumb drive are available through Best Publishing Company. Order your copy today!

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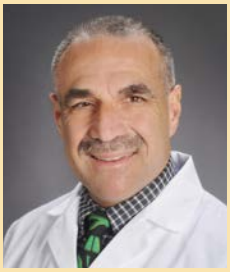

Dr. Whelan, a Milwaukee native, is professor of neurology, pediatrics and hyperbaric medicine at the Medical College of Wisconsin. He is also a captain and a diving medical officer (DMO) in the U.S. Navy and a consultant to the Navy Experimental Diving Unit (NEDU. He recently served as commanding officer of Marine Air Control Group 48 Medical and undersea medical officer for Deep Submergence Unit, which is the Navy's submarine rescue team and its deep-sea research component.

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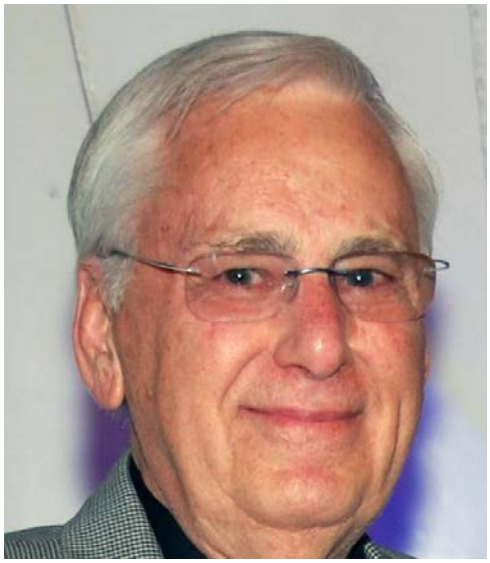

In Memoriam:
JAMES "JIM" T. JOINER

James "Jim" T. Joiner, founder and former president and CEO of Best Publishing Company, passed away on August 27, 2017, with his family by his side.

His passion for diving and medicine were combined into his life's careers. During his tenure as president and CEO of the College of Oceaneering, Jim developed diver training programs and curricula for law-enforcement officers, researchers, diver medics, and scientific, military and commercial divers. To support these programs, he and his wife, Susan, founded Best Publishing Company, which eventually grew to become the world's largest publisher of books, textbooks, and manuals related to all aspects of diving, hyperbaric medicine, and wound-care management. He proudly edited and published the *NOAA Diving Manual,* the *U.S. Navy Diving Manual* and the premier editions of *Hyperbaric Medicine Practice* and *Wound Care Practice*.

He had more than 40 years of diversified experience in the various aspects of the commercial diving, recreational diving, publishing and hyperbaric/wound-care industries. He was also recognized worldwide as a leader in the development and implementation of diving schools, safety requirements for commercial diver education, programs and curricula for law-enforcement, commercial, military, scientific and research divers.

Born in Long Beach, California, in 1935, Jim received his degree in zoology and chemistry from the University of California Los Angeles. Afterward, he attended the UCLA School of Medicine, where he specialized in microbiology and immunology.

He served as a consultant to the State of California and developed the Marine Technology Training Center at the California Institute for Men. He also served as an international consultant, devising feasibility studies and proposals for diving facilities and diver training programs in a host of international countries.

Among the many organizations that were recipients of his 40-plus years of volunteer leadership were the Undersea and Hyperbaric Medical Society (board of directors); Association of Diving Contractors International (chairman, education committee); Association of Commercial Diving Educators (founding president); National Association of Diving Medical Technicians (founder); International Diving Schools Association (cofounder); coauthor for Occupational Safety and Health Administration (OSHA) and U.S. Coast Guard diving standards; and the U.S. government's study for the National Plan for Safety and Health of Divers.

Widely recognized for his contributions to the health and safety of all divers and diving medicine worldwide as well as hyperbaric medicine and wound-care advancement, Jim received numerous awards, was inducted into the Commercial Diving Hall of Fame and was formally recognized with a U.S. Congressional Award for Outstanding Service and Contributions to Safety of Diving (99th Congress).

"Jim always made whoever he spoke with feel special," said Renée Duncan, managing editor of *UHM Journal* and *Pressure*. "He was the special one."

Nothing was more important to Jim than his family, and he will always be remembered for his generosity, humility, patience and wonderfully funny sense of humor. He is survived by his wife of 46 years, Susan; his children, James (Rachel), Nicholas (Brooke), Jules Biggerstaff (Thomas), and Stacy L; eight grandchildren, Isaiah, Jaden, Elijah, Simona, Josie, Isla, Nolan and Charlie, all of Flagstaff, Arizona; sisters, Joan Amaral (Jim Thomas), Joette Waldon (Bob), and Janice Munday (Jeff); his brother, John Joiner; plus a large extended family, which included many special nieces and nephews.

The family requests stories, photos or memories of Jim to be sent to *s2joiner@yahoo.com* for keepsakes. His memorial is planned for a later date. ■

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Hyperbaric Medical Technologist

September 25 – October 7, 2017

This 70-hour course is designed to meet the CSAZ275.4 standard. Successful graduates can be issued a certification from the Divers Certification Board of Canada.

For more information:

https://www.sfu.ca/science/empu/courses/hyperbaric-medical-technologist.html

Hyperbaric Safety Director

December 1-3, 2017

This three-day program provides necessary tools and resources to fulfill the responsibilities of the Hyperbaric Safety Director (as defined by CSA Z275.1). The curriculum includes classroom instruction and practical exercises.

For more information:

https://www.sfu.ca/science/empu/courses/hyperbaric_safety_director.html

Hyperbaric Technician

December 4-8, 2017

This course covers compressor maintenance (by Jordair Compressors) with certification piping (by Columbia Valves) with certification by Swagelok, oxygen servicing with certification by Technical Diving International (TDI), and general maintenance of multiplace and monoplace chambers.

For more information:

https://www.sfu.ca/science/empu/courses/hyperbaric-technician.html

Meet the Faculty

https://www.sfu.ca/science/empu/courses/meet-our-faculty.html

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The Simon Hotel (on campus)
http://www.sfu.ca/stayhere/accommodations/hotel/overview.html

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Get Connected

Email the words “hyperbaric medicine” to *empu@sfu.ca* to be added to the SFU mailing list for updates on hyperbaric research, safety, and training.

Baromedical Nurses Association Awards

By Laura Josefsen, RN, ACHRN
(Source: *hyperbaricnurses.org*)

The Baromedical Nurses Association (BNA) was established in June 1985 to provide registered nurses practicing in hyperbaric medicine a formal organization within which nurses can develop a network and provide professional support. This organization has grown and expanded outside the boundaries of the United States. Today, the BNA has members in Europe, Asia, South and Central America and the South Pacific.

The BNA remains dedicated to offering educational opportunities, supporting nursing research efforts, providing a presence on committees and boards of national organizations, having a public voice in those issues that affect nursing, and providing opportunities for networking and information exchange.

The Diane Norkool Award was created in honor of Diane Norkool and the advancements she made in the profession of nursing through her leadership, research contributions and educational efforts. She was instrumental in developing hyperbaric nursing standards of care, hyperbaric nursing certification and the Baromedical Nurses Association. Individuals eligible for the Diane Norkool Award must be currently serving in the hyperbaric field or making a significant contribution to the field of hyperbaric medicine. The recipient must be a current member of the BNA for the past two years.

The 2017 recipient of the Diane Norkool Award is **Richard "Gus" Gustavson**, MPH, RN, CHRNC, CWCN, CHT, CRT. Gustavson has been involved in HBO nursing for many years and has been involved in the Undersea and Hyperbaric Medical Society (UHMS) as well as the BNA, serving on boards and committees in both organizations almost nonstop.

Recipients of the Diane Norkool Award are the following:

2017: Richard "Gus" Gustavson
2016: Robin Ortega
2015: Connie Hutson
2014: Mary Hirsch
2013: Ann L. "Tina" Ziemba
2008: Monica Skarban
2006: Kathy Furnas
2005: Susan Churchill
2004: Laura Josefsen
2002: Helen Norvell
2001: Claude Wreford-Brown
1999: Christy Pirone
1997: Valerie Larson-Lohr
1996: Diane Norkool

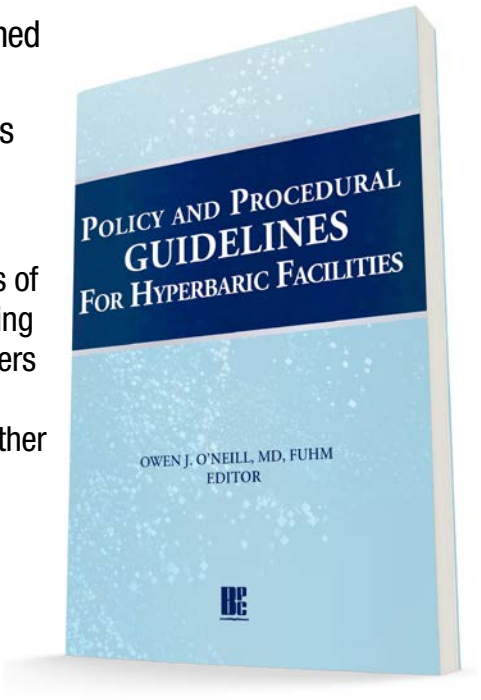
The BNA developed a new award in 2017 in honor of the UHMS 50th anniversary. The Circle of Excellence Award honors a nominee who is not a member of the BNA. While the Diane Norkool Award honors a nurse who makes significant contributions to the field of hyperbaric nursing, it doesn't include the help we have from so many individuals who are not nurses. The Circle of Excellence Award recognizes an individual who exemplifies extraordinary mentoring and/or professional support to promote the mission and vision of hyperbaric nursing, including but not limited to research, education or safety.

Our choice this year for the first Circle of Excellence Award is **Dr. Eugene Worth**. Worth is a physician who has spent countless years assisting nurses on an individual level as well as the BNA in general. He has spoken for in-services, assisted us in formulating our research projects and has been available for advice to the BNA any time he need him. A true educator, he can take a very difficult concept and explain it so easily. Thank you, Dr. Worth, for all your time and caring.

We invite you to become involved in this very dynamic organization. Please contact Robin Ortega, treasurer and webmaster, through *hyperbaricnurses.org* for new and exciting features, including newsletters by BNA President Annette Gwilliam, online education, live webinars, certification, the BNA Awards, and additional exciting and relevant topics. ■

POLICY AND PROCEDURAL GUIDELINES FOR HYPERBARIC FACILITIES

provides needed resource and reference guidelines for new and established hyperbaric facilities, serving as a reference for the development of new hyperbaric policies as well as customizing and enhancing current policies and procedures already in place.



Policy and Procedural Guidelines for Hyperbaric Facilities addresses issues of safety and practice for both the multiplace and monoplace environments. Utilizing regulatory guidelines and standards of practice as its foundation, this book covers governance, administration, emergency procedures, patient care, hyperbaric chamber maintenance, treatment protocols and quality improvement, among other topics. The appendices include sample forms for both Class A multiplace and Class B monoplace chambers.

The guidelines provided in this document will benefit the diverse group of physicians, nurses, tecnicians, and allied health-care personnel in the hyperbaric field as they customize their unit-specific policies and procedures.

Endorsement from Baromedical Nurses Association (BNA)

The Baromedical Nurses Association endorses ***Policy and Procedural Guidelines for Hyperbaric Facilities*** as guidelines to enable hyperbaric facilities to develop and/or endorse their unit-specific policies.

The Baromedical Nurses Association (established in 1985) provides a forum for hyperbaric nursing that encompasses quality, safety, teamwork, mentoring, research, education, and nursing guidelines of standards of care for the patient receiving hyperbaric oxygen therapy.

A customized version of
Policy and Procedural Guidelines for Hyperbaric Facilities
is now available.

The customized version includes the following:

- Your corporate/clinic logo and information
- Five printed copies of your customized version
- PLUS, an electronic version that includes your customization (including a limited usage license, as this is copyrighted material)

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Hyperbaric Medicine Practice, 4th Edition, Is Now Available

The long-awaited, updated edition of Dr. Harry Whelan and Dr. Eric Kindwall's keystone textbook in hyperbaric medicine, *Hyperbaric Medicine Practice*, is now available as a printed book, ebook and a PDF on a thumb drive. Order your copy at *BestPub.com*.

Dr. Whelan, lead editor, explains the importance and relevance of the new 4th edition textbook in the video below.

Watch the video

Dr. Richard Sadler discusses Chapter 44 on closed-circuit rebreathers (CCRs) from *Hyperbaric Medicine Practice*, 4th edition, and explains how and why it applies to practitioners.

Watch the video

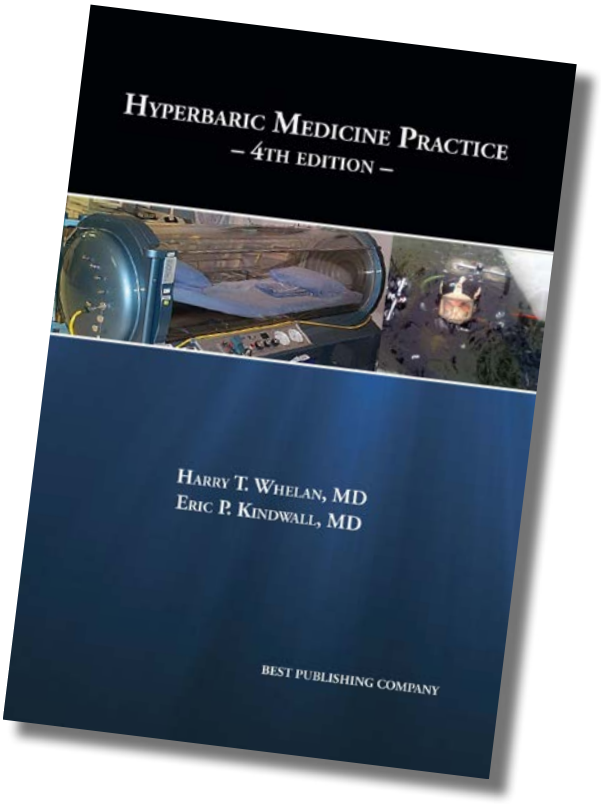
Dr. Whelan speaks with Henry Schwartz, MD, FACP, about the current revision of the textbook and a short history of the legacy of the first editor, Dr. Kindwall.

Watch the video

About the Book

Dr. Whelan collected some of the most renowned practitioners in hyperbaric medicine to create this completely revised and updated 4th edition.

The 4th edition adds new information of interest to all in the field of diving and clinical hyperbaric medicine. Most chapters have been written or revised by new authors, but many authors have returned to update their chapters.



New chapters include indications for hyperbaric oxygen treatment subjects recently approved for treatment such as idiopathic sudden sensorineural hearing loss and central retinal vein occlusion.

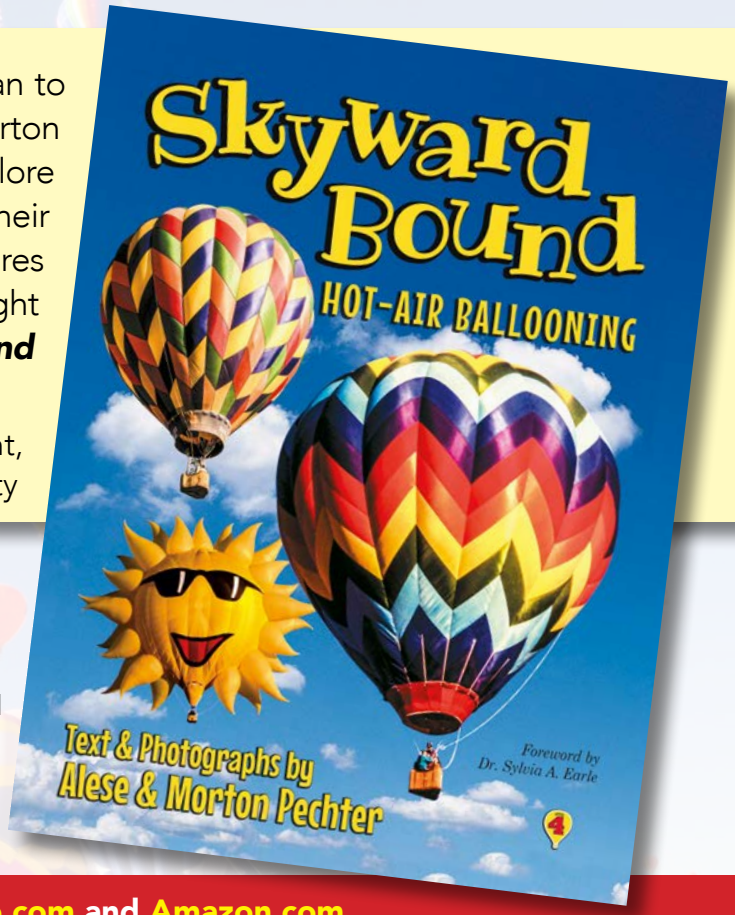
There are also chapters on submarine rescue and problems that pertain to technical and rebreather diving.

This book will be an essential addition to the library of physicians, nurses, CHTs, CHRNs, and allied health professionals who practice clinical hyperbaric medicine and those involved with the treatment of injured divers. ■

REVIEW: "From the deep depths of the ocean to the soaring heights of the skies, Alese and Morton Pechter never fail to excite. Their passion to explore has led them to a lifetime of adventure, and their dedication in documenting these adventures gives others the gift of discovery. Through bright imagery and pleasant narration, ***Skyward Bound*** opens the skies to children and adults alike."

— Jean-Michel Cousteau, President, Ocean Futures Society

ABOUT THE AUTHORS:
Alese and Morton Pechter are world-renowned photo-journalists and authors. They have flown and photographed hot-air ballooning for more than a decade and their work has appeared in periodicals and texts internationally.



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Best Publishing Company is proud to present its first fiction book!

CHERRY RED

by Neil B. Hampson, MD

In this mystery thriller, a series of unusual carbon monoxide poisonings hits Seattle, and former college roommates Dr. Bradley Franklin and police detective Robert Heimbigner team up in an effort to solve the mystery. As the investigation develops, they suspect foul play. Can the old friends uncover the connection between the seemingly unrelated events before more lives are lost?

"In Cherry Red, Dr. Neil Hampson crafts a fascinating murder mystery set in the city famous for coffee, grunge, and innovation. Hampson's recognized expertise in carbon monoxide poisoning is apparent as he takes the reader through scenarios only he could imagine."

— Michael Bennett, MB BS, MD, Conjoint Professor, University of New South Wales, Sydney, Australia, Department of Diving and Hyperbaric Medicine

About the Author:
Dr. Neil Hampson, a Seattle native, is a retired pulmonary, critical care, and hyperbaric medicine physician. He has an international reputation in hyperbaric medicine, specifically in the area of carbon monoxide poisoning. During his clinical career, he treated more than 1,000 patients with carbon monoxide poisoning and published numerous papers in medical journals about the condition.

CLINIC IN FOCUS

The Center for Reconstruction and Wound Healing

What are the most common indications treated at the clinic?

Late effects of radiation, diabetic lower-extremity ulcers, venous ulcers, arterial ulcers, pressure ulcers, skin cancers, surgical wounds (breast, colon, stomach), hand and wrist injuries, traumatic wounds, vasculitic wounds, foot and ankle conditions, complex reconstruction, decompression illness, compromised skin flaps and grafts, refractory osteomyelitis

Interesting success stories from clinic?

We treated a very pleasant gentleman who presented to us in 2016 due to multiple small nonhealing scalp ulcers in the range of 1.5 x 1.3 x 0.2 cms with bone at the base. His history was positive for a squamous cell excision by Mohs surgery in 2012, followed by a split-thickness skin graft from his shoulder, and then 3500 rads of radiation therapy.

Two years later, he was diagnosed with lymph-node cancer of the head and neck and was treated with another 3500 rads. He presented to us with the nonhealing scalp wounds secondary to his Mohs surgery and radiation therapy. His split-thickness skin graft had also failed, probably related to his radiation therapy. He received 30 treatments of hyperbaric oxygen therapy, and then we performed a CelluTome epithelial graft to the involved scalp area and followed this with a 10-treatment course of hyperbaric oxygen therapy due to his extensive history of radiation. By this time he only had a small area of exposed bone of 0.2 x 0.2 x 0.1, and we applied a dehydrated amniotic tissue graft each week for two weeks. His last exam following these applications demonstrated a healed postop surgical wound and healed small ulcers due to the late effects of radiation. The patient is extremely pleased to no longer have any open wounds after suffering for more than two years.

A second case demonstrating the advantages of having a multidisciplinary approach to a problematic wound was that of a 71-year-old woman who presented to the clinic in 2015 with a nonhealing surgical wound of the right lower leg. Her

dermatologist had excised a squamous cell cancer, followed by a course of more than 6000 rads for definitive treatment. She was treated postradiation with several topical creams, but the surgical site failed to heal. After three months she was referred to the Center for Reconstruction and Wound Healing

After assessing that she had adequate arterial flow to the extremity, and ruling out infection, we gave her 40 hyperbaric oxygen treatments as well as intermittent debridements and collagen/oxidized regenerated cellulose (ORC) wound care. Posthyperbaric treatments, she had improved granulation, and the clinic's plastic surgeon performed a split-thickness skin graft. Negative pressure was applied postoperatively.

Finally, she had several dehydrated amniotic tissue grafts applied to cover the small areas where the split-thickness skin graft had failed. By the teamwork of the wound physician and hyperbaric physician and finally the plastic surgeon, the patient had a completely healed wound and has become an advocate for the Center for Reconstruction and Wound Care.

Awards?

The Center for Reconstruction and Wound Care received the Certificate of Distinction–Wound Care Program from the Joint Commission's Disease-Specific Certification Program in July 2017. ■

CLINIC DETAILS

Clinic Name: The Center for Reconstruction and Wound Healing

Location: 4911 Van Nuys Blvd, Suite 100, Sherman Oaks, CA 91402

Website: *www.shermanoakshospital.org/crwh*

Phone: 818-205-1995

How long in business: 4 years

How many chambers: 2

Chamber types: Sechrist 36 monoplace

How many physicians/nurses/CHTs: 6 physicians (3 podiatrists, 1 plastic surgeon, 1 general surgeon, 1 board-certified hyperbaric physician and wound-care specialist); 3 RNs; 2 Mas; 1 CHT and hyperbaric RN

Medical director: Dr. Som Kohanzadeh

Date of UHMS accreditation: Not done yet

Hyperbaric Oxygen Therapy Indications
Thirteenth Edition

Every hyperbaric practicing physician should have this on his or her bookshelf and every hyperbaric unit should have a copy at the chamber. I consider this publication the "Merck Manual" for hyperbaric medicine. Word for word, it is the most valuable reference on hyperbaric medicine available.

- John J. Feldmeier, D.O., FACRO, FUHM and President of the UHMS

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CLINIC IN FOCUS

Riverview Health Wound Care

If an accredited facility, how has seeking UHMS accreditation affected your clinic?

The accreditation has affected the clinic by raising the bar and meeting the highest standards of care and patient safety set forth for hyperbaric treatment. The clinic is continuously streamlining processes to better help our patients and keep the level of care at its finest.

What are the most common indications treated at your clinic?

- crush injury, compartment syndrome, acute traumatic ischemia
- diabetic foot ulcer Wagner Grade III or greater
- healing of other problem wounds
- necrotizing soft-tissue infection
- delayed radiation injury (soft tissue and bony necrosis)
- crushed injury
- compromised grafts and flaps
- refractory osteomyelitis

What is the most memorable treatment success story to come out of your clinic?

In July 2016, Sarah Polakoff's left leg was crushed just below the knee when a car rolled over her. Sarah was lucky and didn't suffer any broken bones or open wounds, but she was left with painful swelling. A staff member at her physician's office recommended Riverview Health Wound Care after Sarah was turned away from an Indianapolis orthopedics practice because they couldn't treat her.

Jennifer Zyromski, MD, a surgeon with Riverview Health Physicians, performed surgery on Sarah's leg on Aug. 12, 2016, to begin the process of healing her injury.

"The damage to the tissue in a crush injury can be pretty extensive, even if there isn't an open wound," Dr. Zyromski said. "The goal of the surgery was to remove a blood clot under her skin that was disrupting her blood supply and, in turn, killed skin tissue in the area. The surgery relieved the pressure but left a pretty big wound to heal."

To heal her wound, Sarah used the services of Riverview Health Wound Care. First, Sarah made regular visits to change a special kind of vacuum dressing designed to heal large wounds by applying continuous negative pressure to the wound to drain it. She had weekly visits to monitor the wound, then she completed 30 treatments in a hyperbaric oxygen chamber for two hours a day to help her body heal the large wound.

"Hyperbaric oxygen treatment increases oxygen levels throughout the body to promote healing," Dr. Zyromski said.

Patients who receive hyperbaric oxygen treatment are required to comply with several safety precautions, because the high-oxygen environment is extremely flammable. In the hyperbaric oxygen chamber, patients are required to wear a 100 percent cotton gown and aren't allowed to wear makeup or jewelry or bring anything in the chamber that could spark a flame — including books. The hyperbaric oxygen chambers at Riverview Health have televisions for patients to watch shows or movies to pass the time.

"The hardest part was being an avid reader and not being able to take a book in there," Sarah said.

CLINIC DETAILS

Clinic Name: Riverview Health Wound Care

Location: 395 Westfield Road, Noblesville, IN 46060

Website: *riverview.org/services/wound-care*

Phone: 317-776-7407

How long in business: 4 years

How many chambers: 2

Chamber types: Sechrist 4100H, Sechrist 3600H

How many physicians/nurses/CHTs: 5 physicians, 5 nurses, 1 CHT

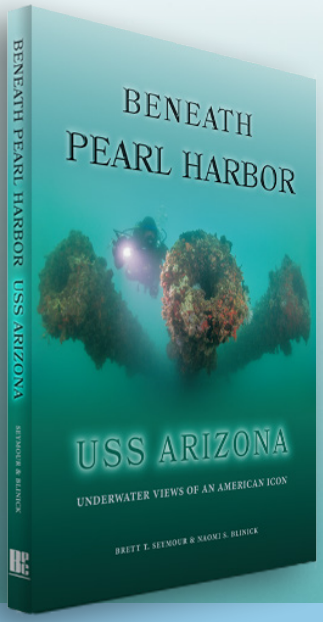
Medical director: Dr. Tracey Ikerd

Date of UHMS accreditation: Feb. 4, 2016

In commemoration of the 75th anniversary of the attack on Pearl Harbor,
Best Publishing Company announces the publication of:

BENEATH PEARL HARBOR: USS *ARIZONA*
UNDERWATER VIEWS OF AN AMERICAN ICON

by Brett Seymour and Naomi Blinick



Experience USS *Arizona* as never before in this collection of images and essays that bring the fallen World War II battleship to life. Explore the submerged ship, its artifacts and history underwater with individuals who have a tangible and passionate connection to the ship—National Park Service divers.

"It is important for future generations to remember what happened on Dec. 7, 1941, and that becomes more difficult with each passing year. I hope that when someone picks up this book, he or she continues to remember the story of USS *Arizona* and its significance to our nation."

—Lauren Bruner, USS *Arizona*

Brett Seymour is the Deputy Chief of the U.S. National Park Service's Submerged Resources Center (SRC).

Naomi Blinick is a freelance photographer and marine biologist.

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Jennifer Idol is the first woman to dive 50 states and author of *An American Immersion*. She's earned more than 27 certifications and has been diving for 20 years. Her photography and articles are published in *DIVER, Sport Diver, Alert Diver, SCUBA Diving, X-Ray Mag, Outdoor Oklahoma, Underwater Speleology, SCUBA & H2O Adventure,* and *Texas Aquatic Science.*

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After 10 weeks, Sarah had much more time on her hands to pursue other hobbies, because her wound care visits dropped down to once a week to check on the healing progress of her wound. On Oct. 15, 2016, she returned to her job as an activities assistant and certified nursing assistant (CNA) at a nursing home. As a CNA, Sarah is accustomed to helping others more often than she helps herself. That defined her experience at Riverview Health Wound Care.

"Caregivers make the worst patients," Sarah joked. "I had to learn to let people help me while I was healing and while I was in and out of the hospital. The staff understood and let me help myself as long as I could do it."

Sarah was initially given a timeline of six months to one year to fully recover, yet after three months she had made significant progress and was healing ahead of schedule. Dr. Zyromski credits Sarah's diligence for her quick healing.

"Sarah came to all of her treatment sessions. She kept her leg elevated and always had her dressings changed appropriately and maintained good nutrition," Dr. Zyromski said.

After many weeks in the care of Dr. Zyromski and the wound care staff, Sarah is back to her normal life of taking care of her 2-year-old daughter with her husband.

Do you work with a management company? If so, which one?

Riverview Health Wound Care is managed by Outpatient Integrated Strategies (OIS).

If you had to pick one thing to attribute your clinic's success to, what would it be?

The clinic provides a multidisciplinary approach to the diagnosis and treatment of chronic wounds. In addition, the clinic offers sophisticated treatment technologies to promote wound healing. Our clinic is run by providers.

What is one marketing recommendation that you can make to help clinics increase their patient load?

The one marketing recommendation that has helped increase our patient load is educating the various physicians about the benefits of HBO_2 and their prospective fields. The wound clinic wants to partner with other physicians to help heal their patients.

Are there are any additional questions you'd like to answer or any other information about your clinic you'd like to showcase?

We have several nurses who have completed and are HBO_2-certified trained operators. In addition, Riverview's program director has also completed the necessary course.

Riverview Health was the first facility in the state of Indiana to become UHMS certified and provide the Luna technology.

Last, the entire staff was nominated for the Daisy Award. (This award for nurses and nurse-led teams recognizes extraordinary practice by nurses who engage in the transitioning process of patients and their families as they access and migrate through the health-care system. The nominees must show extraordinary compassionate care.) ■

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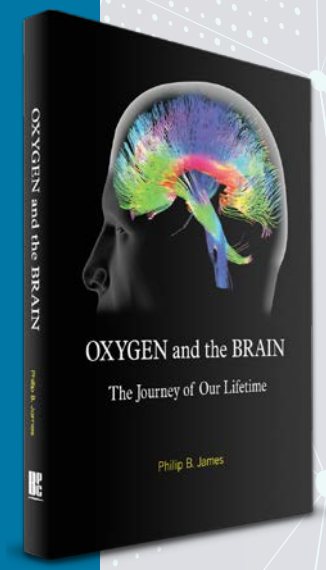

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by Philip B. James, MB, ChB, DIH, PhD, FFOM

Following the human journey from conception to old age, *Oxygen and the Brain* presents evidence amassed over more than a century that can transform the care of patients with birth injury, head trauma, multiple sclerosis, and stroke and can even reverse decline in old age. There is no more necessary and scientific action than to correct a deficiency of oxygen, especially in the brain, and it is simple to give more.

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by Asser Salama

Deep Into Deco is a comprehensive and well-written reference text that covers various topics of decompression theory. It portrays the latest developments and controversial issues in technical diving in a way that is straightforward, easy to read, understandable and free from technical jargon.

From the early history of experimental trial and error to the latest innovations and changes in decompression concepts, *Deep Into Deco* brings the science into sharp focus. Without elaborating on mathematical equations or source code, the book demonstrates how commercial software packages calculate deco schedules. It also explores in detail a grab bag of additional points of interest that contribute to our current understanding of decompression theory.

With a writing style that is a mix of strict no-nonsense reporting along with interesting storytelling, *Deep Into Deco* includes interviews with accomplished divers, industry professionals, researchers and software developers.

This book is a must read for any diver who wants to understand decompression theory, how it evolved, what it accomplished and where the latest research is headed.

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Proactive Diabetic Foot Surgeries

Part 5 in the Prevention of New and Recurrent Diabetic Foot Wounds series

By Lientra Q. Lu, Michael B. Strauss and Anna M. Tan

Commentary on our Prevention of New and Recurrent Diabetic Foot Wounds Series

This article on proactive diabetic foot surgeries for the prevention of new and recurrent diabetic foot wounds completes our five-article series on the prevention of new and recurrent diabetic foot wounds.[1-4,15]

In the current atmosphere of intense scrutiny and unrelenting requirements for authorizations by the payers, outcomes have become a major consideration. Outcomes relate to durability, and durability relates to the prevention of new and recurrent wounds after the healing of a wound, diabetic or otherwise. We believe our series is the most comprehensive literature available on this subject.

The current and previous articles in the series address the crucial topics for wound prevention with 1) patient education, 2) skin and toenail evaluation and management, 3) selection of appropriate protective footwear and 4) early implementation of proactive surgeries. The information from this series will become an essential component for the second edition of our *MasterMinding Wounds* text.

The majority of wounds, when managed appropriately, heal while the patient is hospitalized or in the controlled atmosphere of a skilled nursing facility. Problems arise when patients return to their usual and customary lifestyles. Without adherence to the four topics of our article series, new wound problems are likely to arise. Diabetic patients with healed foot wounds are a special population that need to be followed on a regular basis; their situation is detailed in the second article (i.e., patient education) in our wound-prevention series. This contrasts with the youthful patient with a traumatic wound, where once the wound is healed, follow-up is not usually necessary.

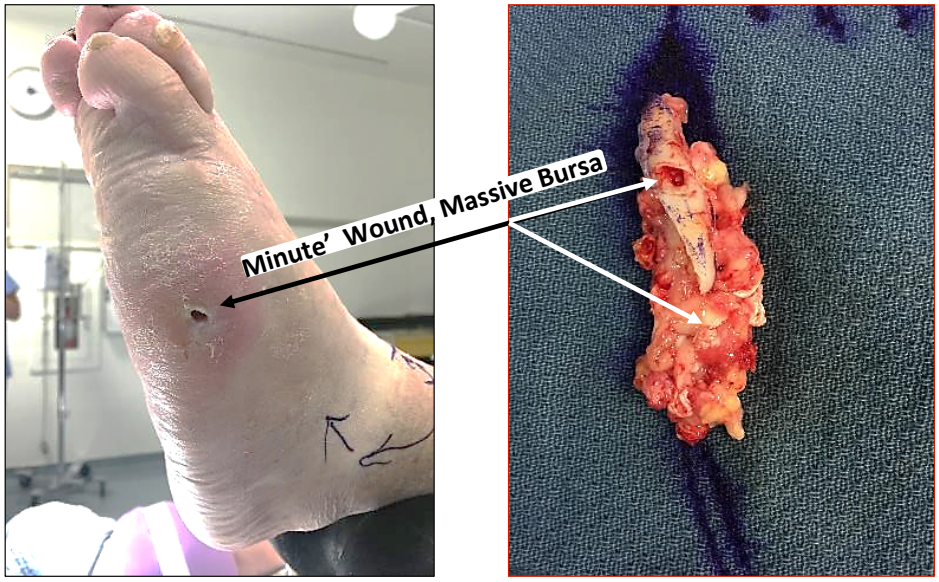
When new, recurrent or impending wounds are first noted in the vulnerable diabetic as well as other at-risk foot populations, immediate proactive interventions need to be initiated. They start with appropriate skin and toenail care, proper selection of protective footwear and debridements of hypertrophic calluses over underlying bony deformities — all of which are detailed in our wound-prevention series of articles. Remember when foot wounds are not healing as expected, three causes account for more than 90 percent of the reasons:[6] 1) underlying bone and soft-tissue deformities, 2) deep infection involving bone, bursa and/or cicatrix and 3) ischemia-hypoxia. Each component of the troublesome triad has appropriate interventions for management; there should be no delays in initiating such. This article will describe what should be done for the deformity component of the triad.

Remember: *"To heal the wound is ideal; to prevent it from returning is sublime."* Our series of wound-prevention articles in *Wound Care and Hyperbaric Medicine* helps achieve the sublimity state.

Proactive diabetic foot surgeries are those done before a new or recurrent wound occurs. As a corollary, if a wound is present, surgical intervention is done before the wound worsens, makes the surgery complicated and/or necessitates a major amputation. In terms of underlying pathology of recurrent or new diabetic foot wounds, the three major indications for proactive surgeries in diabetic feet are 1) deformities (bone, bursa and/or cicatrix), 2) muscle imbalances and 3) contractures or combinations of these (Figure 1). When these problems are addressed proactively, the surgeries can usually be minimally invasive (MIS) and adhere to the goal of keeping them simple and speedy (KISS). MIS and KISS surgeries typically avoid elaborate exposures and extensive dissection of tissues. This is reflected by wound closures that require only simple, removable sutures and staples to close the flaps and skin layers. In addition, the

Perfusion and oxygenation to the "at risk" foot is always a critical consideration. Consequently, revascularization may be needed before doing the proactive surgery. Revascularization options include bypass surgery, angioplasty and stenting. The decision as to what needs to or can be done regarding revascularization is determined by the vascular surgery, interventional cardiologist or interventional radiology consultant.

FIGURE 1. Nonhealing wound due to infected bursa



Legend: Massive bursa formed over end of resected 5th metatarsal (MT) after partial 1st ray amputation. The bursa formed and became infected as a response to the prominence of the remaining end of the fifth MT shaft — obviously a mechanical/deformity problem.

use of internal fixation devices such as screws, plates or intramedullary rods as well as deep nonabsorbable and braided-type sutures is avoided.

Goals of Proactive MIS/KISS Surgeries

The **primary goal** of proactive surgeries is to prevent new or recurrent wounds by doing nonurgent surgeries. This is in contradistinction to reactive surgeries that need to be done on an urgent basis for impending toe or lower-limb-threatening diabetic foot problems. **Secondary goals** include achieving plantigrade and pain-free feet. Pain is often not a consideration in this patient group, however, due to diabetic sensory neuropathies. Ability to wear protective footwear and restore mobility are **tertiary goals**. Rarely, the patient is left with a chronic, stable, small wound that requires minimal wound care but still allows mobility. Elimination of this type of wound with surgery could require altering foot anatomy and biomechanics to such a degree that when ambulation is resumed, worse problems develop. In these situations, the adage "the cure is worse than the disease" is applicable.

Although this article, Part 5, is directed to the surgeon, it integrates well with all the information presented in our preceding four wound-prevention articles.[1-5] All wound care givers should be aware of the proactive MIS/KISS surgical options and readily refer to surgeons familiar with them for operative management. The consensus opinion risk factors for incipient new and recurrent diabetic foot wounds should be used to support the decision for referral for proactive MIS/KISS surgeries. They include 1) peripheral artery disease, 2) deformity, 3) previous wound, 4) prior amputation, and 5) neuropathy.[6] As the number of risk factors increase, the likelihood of a new or recurrent diabetic foot wound increases proportionately.[7]

This article discusses six surgical procedures that meet the criteria for MIS/KISS surgeries for the prevention of new and recurrent diabetic foot wounds. It applies equally well, however, to patients who are not diabetic and who have one or more of the above enumerated risk factors. It is appropriate to do some of the surgical procedures in the clinic or at the bedside in the hospital or skilled nursing facility. Regardless, the knowledge of these available MIS/KISS interventions adds an additional dimension to the comprehensive management of the diabetic foot.

It is unfortunate that the risk factors are described only as present or absent without consideration for severity by this consensus group. We feel that severity needs to be factored into making the decision for referrals for MIS/KISS proactive surgeries. We propose categorizing each risk factor as insignificant, moderate or a severe problem (Table 1). With this grading system, decisions for proactive surgeries become objective. Consider the following:

One risk factor in the severe category, two in the moderate category or combinations of these deserve consideration for surgical interventions.

If the risk factors are not all present or all are minimal, rechecks should be done periodically; annually if the patient is compliant versus monthly if the patient is noncompliant.

Each diabetic patient should be educated in recognizing the risk factors and if any appear or noticeably worsen, an expedited evaluation should be done.[2]

Toe Tendon Tenotomies to Mitigate Deforming Forces

While toe deformities may appear to be unimportant, they can have serious consequences. This is especially the situation in patients with diabetes who have neuropathies. A small ulcer can evolve to osteomyelitis of the phalanges, septic joints of the toes, ascending tenosynovitis and progressive necrotizing soft-tissue infections. Malperforans ulcers are invariably the consequence of underlying bone and joint deformities, and the pathology in the toes is no different than when they occur in the foot and ankle.[8] Consequently, early

attention to correction of gnarled toes is an essential proactive wound-prevention measure for the insensate foot; it has more than cosmetic ramifications. This section describes the anatomy of claw, hammer and mallet toes, explains the pathophysiology that leads to forefoot and toe wounds, and provides a dozen paradigms about tenotomies to manage the axial (that is, the toes are inline with the metatarsals) deformities of the toes.

Classification of axial toe deformities. The classification of axial toe deformities is straightforward (Figure 2). A hammer toe occurs with hyperextension at the metatarsophalangeal joint and flexion at the proximal interphalangeal joint with or without extension of the distal interphalangeal joint. A claw toe is present when the metatarsophalangeal joint is hyperextended and the proximal interphalangeal joint is hyperflexed with or without hyperflexion of the distal interphalangeal. In a "pure" mallet toe deformity, the metatarsophalangeal joint and proximal interphalangeal joints are unaffected, but the distal interphalangeal joint is flexed.

Pathophysiology of axial toe deformities. The pathophysiology of the toe deformities that leads to forefoot and toe wounds results from neuropathy. The essential problem is a motor neuropathy in which fine muscle balance between flexor and extensor muscles is altered or lost. With loss of the intrinsic muscles that flex the toes at the metatarsophalangeal joints and extend the toes at the interphalangeal joints, hyperextension of the metatarsal phalangeal joints occurs due to overpull of the toe extensor muscles, while overpull of the flexor muscles cause toe interphalangeal joint flexion contractures (Table 2). Consequences of the muscle imbalances include:

1. Clawing of the toes with inability to visualize the flexor creases of the toes, i.e. the "hidden crease" sign

TABLE 1. Quantifying risk factors for diabetic foot ulcers

Assessment \ Grade	2 Not Problematic	1 Mild to Moderate	0 Severe
1. Peripheral Artery Disease	Palpable pulses	Doppler pulses	Imperceptible pulses
2. Deformity	None significant	Palpable or visible with or without erythema or attenuation of skin	Ulcer or impending skin breakdown
3. Previous wound	Normal healing	Delayed healing	Requiring surgery to correct or close
4. Prior amputation	Toes	Forefoot	Proximal to forefoot
5. Neuropathy	None	Impaired sensation, minor contractures and/or muscle weakness	Insensate, major contractures, paralysis

Note: Half points may be used if the findings are mixed or intermediate between two grades.

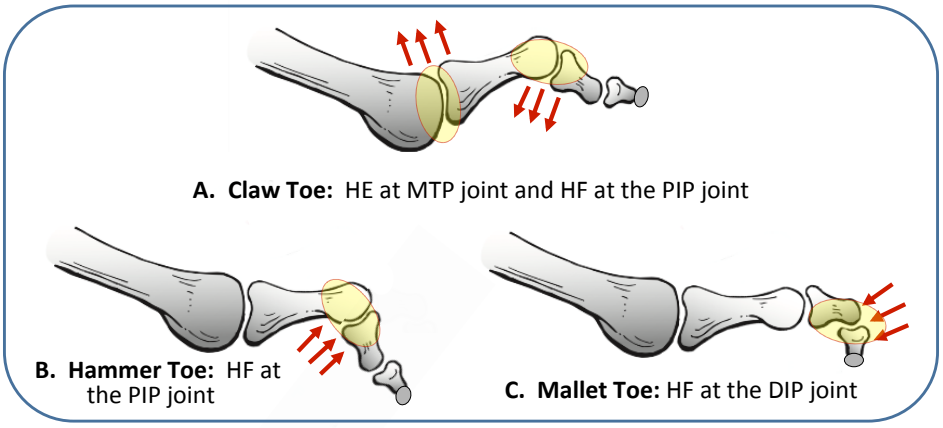
TABLE 2. Toe deformities and their potential wound problems

Deformity	Description	Pathomechanics (Etiology)	Wound Concerns
Mallet toe	Flexion contracture at the distal interphalangeal joint	Overactivity of the flexor digitorum longus muscles	Ulcerations at the toe tip and over apices of the IP joint; toenail injury
Hammer toe	Flexion contracture at the proximal IP joint	Overactivity of the flexor digitorum brevis mucles and loss of toe intrinsic muscles	Same as above
Combination of hammer and mallet toe	Flexion contracture at both the IP joint levels	Combinations of the mallet and hammer toe etiologies	Same as above plus "kissing" lesions between phalanges
Dorsiflexed toe	Hyperextension posturing of toe at the metatarsal-phalangeal joint level	Overactivity of the long extensor tendons to the toe	Nail matrix and dorsal distal phalanx wounds from pressure contact with the toe box of the shoe
Claw toe	Hyperextension contracture at the MTP joint and flexion contractures at the PIP and DIP joints	Loss of toe intrinsic muscle function plus overactivity of toe flexor and extensor muscles. MT heads displaced plantarward	Wound over IP joints and tips of toes; mal perforans ulcers under metatarsal head displacements

Note: *Since the hallux has only a single interphalangeal joint, a flexion deformity at this level may be named either a hammer or a mallet toe.

Abbreviations: DIP = distal interphalangeal, **IP** = interphalangeal, **MT** = metatarsal, **MTP** = metatarsophalangeal, **PIP** = proximal interphalangeal

FIGURE 2. Bone and joint anatomy of clawed, hammer and mallet toes



Legend: Axial deformity classification of toes based on levels of joint involvement. Table 2 explains the pathophysiology causing the deformities. Red arrows indicate levels of joint contractures. Yellow oblongs indicate sites for ulcerations. The clawed toe is the cause of the malperforans ulcer under the metatarsal head — note the dorsal subluxation of the proximal phalanx, which "drives" the MT head downward.

Key: **DIP** = distal interphalangeal, **HE** = hyperextension, **HF** = hyperflexion, **MTP** = metatarsal phalangeal, **PIP** = proximal interphalangeal joint

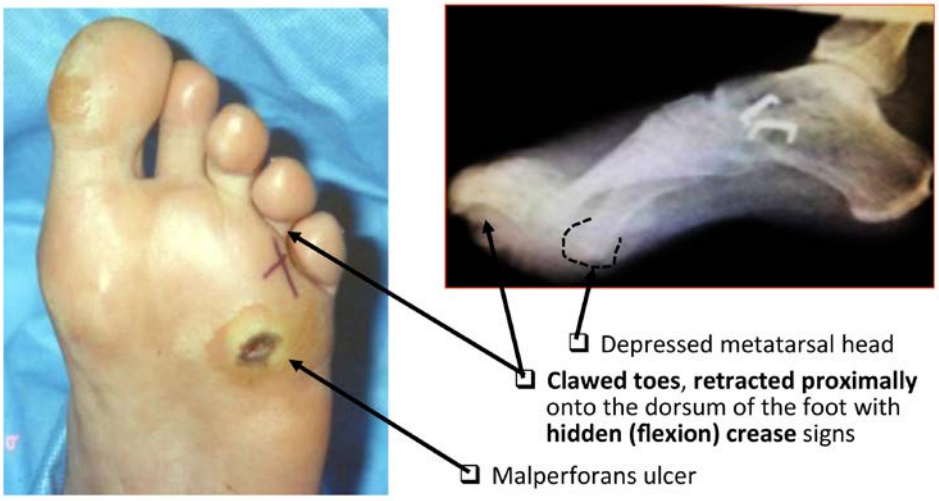
2. Retraction of the toes proximally onto the dorsum of the foot
3. Dorsal subluxation of the proximal phalanges over the metatarsal heads
4. Downward pressure on the metatarsal heads (from the subluxed metatarsophalangeal joints) into the forefoot fat pad with loading as occurs with standing and walking
5. If not corrected, a malperforans ulcer develops as the plantar surface of the metatarsal head erodes from inside-to-outside with weight bearing because of the deformity (Figure 3). This often goes unnoticed because of diabetic sensory neuropathy.

If the intrinsic muscles of the foot continue to function but there is unbalanced overpull of the extensor muscles, the toes may remain straight but be hyperextended at the metatarsal-phalangeal joints.

The hammer and mallet toe deformities occur because of overpull of the flexor tendons and loss of the intrinsic muscle abilities to extend the interphalangeal joints. If the problem lies primarily with the short intrinsic flexors of the toes, the hammer toe deformity occurs and causes the toe tip to "drive" into the sole of the shoe. The consequence is a pressure sore at the tip of the toe. This typically progresses to a penetrating ulcer to the distal tuft and osteomyelitis of this structure (Figure 4). Overpull of the long flexor muscles of the toes results in mallet deformity. When the combination of the above problems occurs, the hyperflexed proximal interphalangeal (PIP) joint in association with the hyperextended metatarsophalangeal joint can cause a pressure sore over the apex of the PIP joint (Figure 5). With progression, the ulceration erodes into the joint, causing a septic joint and osteomyelitis. If unchecked, the infection can track proximally along the tendon sheaths, resulting in ascending tenosynovitis and progressive necrotizing soft-tissue infection.

Usually a sensory neuropathy is associated with the motor neuropathy, especially in the patient with diabetes mellitus. Other motor neuropathies, however, have hereditary causes such as Charcot-Marie-Tooth disease, acquired causes such as a result of trauma, and/or demyelinating causes such as multiple sclerosis that may not have sensory neuropathy components to them. While a sensory neuropathy does not cause a deformity, it may delay the diagnosis of the deformity because of the absence of pain and delay the patient from seeking care until a complication arises, such as obvious infection at the deformity site or systemic sepsis. Consequently, any patient with sensory neuropathy in the feet and associated toe deformities should be informed of the need for

FIGURE 3. Deformities and contractures causing a malperforans ulcer



Legend: Deformities and contractures generate biomechanical problems, which in turn lead to wounds — as in this example of a malperforans ulcer

FIGURE 4. Ulceration at tip of hammer toe deformity

Legend: The reason for the toe tip ulceration is obvious from the examination. The mallet toe deformity increased the contact pressure when standing and walking between the toe tip and the underlining supporting surface enough to generate a pressure sore over toe tip.

Note the flexor creases of the clawed toe are obscured because of the flexion contractures. We label this clinical finding the "hidden crease" sign.

proactive interventions anytime an impending pressure sore is observed in the forefoot and/or toes. Also, all foot-care providers should be aware of this information and counsel their patients accordingly.

Paradigms for evaluation and management of axial toe deformities. With the above considerations and experiences with several hundred tenotomies of toe tendons (MBS) in the past dozen years, we reiterate some of the above information as well as share our "pearls" in the evaluation and management of axial toe deformities. A large review experience of toe tenotomy surgeries is found in the Tamir et al. article in *Foot and Ankle International* (2014).[9] Whereas some of the procedures need to be done in the operating room, we do the majority of tenotomies in our outpatient wound-care programs. The following are 12 paradigms that relate to axial toe deformities and their management with tenotomies.

1. Often toes are retracted proximally onto the dorsum of the foot due to overactivity of the long extensor tendons. This leads to downward pressure on the metatarsal heads and is a precursor to malperforans ulcerations (Figure 5). The retracted toe sign is an indication for toe extensor releases.
2. Manipulation of interphalangeal joint contractures should always be a component of the tendon release procedures. Occasionally, the manipulation results in avulsion of skin at flexor creases of the interphalangeal joints. All of these superficial wounds have healed without incidence.
3. In many instances, extensor tendon releases are difficult to perform in the presence of edema, scar or hidebound skin. In these cases we perform these procedures in the operating room (see text box).

FIGURE 5. Ulceration over proximal interphalangeal joint

Legend: Ulceration over proximal interphalangeal (PIP) joint secondary to hammer toe deformity. The biomechanical problem is that of the apices of hyperflexed PIP joints causing pressure concentrations with the toe box of the shoe.

Note the unhealthy long, dystrophic and fungus-infected toenails and the scaly, callus skin (at the toe tips), indicating that toenail and skin-care instruction are also needed.

Two-centimeter incisions are made and carried through the subcutaneous tissue level in the intermetatarsal spaces just proximal to the metatarsal necks. The extensor tendons are then captured with a curved hemostat brought to the skin surface and incised under direct visualization with a scalpel, scissors or electric cautery. Much variation in the extensor tendon anatomy has been observed, often requiring release of more than one tendon for each toe. The short incisions are usually closed with small nylon sutures or staples (if already on the field from closing a wound at a different site).

4. Releases of extensor hallucis longus tendons for managing clawing of the great toes have generally not been effective in managing malperforans ulcerations of these toes. In such cases, the underlying bony deformities require sesamoid removals.
5. If the patient with a neuropathic foot is in the operating room for a foot surgery unrelated to toe deformities, then tenotomies should be recommended to the patient at the time of the preoperative evaluation. We perform our toe flexor tenotomies at the level of the metatarsal head rather than at the proximal interphalangeal joint crease levels. The additional soft-tissue padding (metatarsal head fat pad) affords more reliable healing rates compared to hidebound flexion joint creases.
6. With ankylosed interphalangeal joints, tenotomies may need to be

An ovoid incision is made about 8 mm wide centered over the apex of the deformity with, the ends of the ovoid at about the midpoint of the medial and lateral sides of the toe. The ovoid skin incision is carried down to the bone level and the skin, extensor tendon and extensor joint hood are excised. Next precise parallel osteotomies perpendicular to the long axes of the phalanges on both sides of the joint are made. The ovoid skin is closed with small nylon sutures. The approximation of the skin edges brings the osteotomized phalangeal ends in contact with each other, straightens the toe and acts as an external splint to maintain the toe alignment.

supplemented with realignment interphalangeal joint resections. We also do this minimally invasively. Our approach negates the need for maintaining alignment of the interphalangeal joint fusion with temporary placement of a Kushner wire through the medullary canal and the potential problems it imposes, such as keeping the patient nonweight bearing, infection of the pin tract and/or breakage or bending of the pin (see text box).

FIGURE 6. Percutaneous transection of bowstringing extensor tendon

Legend: The contracted toe extensor tendons are easily released when they bowstring across the dorsum of the forefoot. This can be done with a #11 scalpel blade using a 2-3 mm incision. No suturing/stapling of the small incision is needed.

The contracted muscle tendon units cause hyperextension of the toes at the metatarsal phalangeal joints, retraction of the toes proximally on the dorsum of the foot and downward pressure of the proximal phalange base on the metatarsal head.

FIGURE 7. "Textbook" versus minimally invasive surgery approaches to claw toes

"Textbook" Approach

Minimal Invasive Approach

Legend: In the left-side photo, the patient had the more traditional (textbook) approach for dealing with her claw toe deformities, including rerouting the flexor tendons to the dorsums of the proximal phalanges, interphalangeal joint fusions and temporary percutaneous joint pinnings. Note the shortened 2nd and 3rd toes and their recurrent deformities. These toes were almost totally immobile. Thirty to 45 minutes surgical times, at best, are required to perform these procedures for each toe.

The right-hand photo shows the photos of previously clawed toes managed with tenotomies, limited open for the extensor tendons and percutaneous for the flexor tendons. With bilateral toe deformities, the patient elected to have the procedures done at one time in the operating room versus serial releases in the office. Although the toes are immobile, they remain straight, at normal length and are not prone to developing ulcers. Note the mild recurrent hammer deformity of the little toe. If the patient so elects, this can be managed with a second-stage in-office percutaneous flexor tenotomy.

7. Infrequently, toes straightened with tenotomies develop recurrent deformities. This should be mentioned in the preoperative orientation for the patient. If necessary, second-stage tenotomies and/or joint resections (see previous text box) are done when needed.
8. Active toe flexion and extension for respective extensor and flexor tenotomies by the awake patient facilitates the releases. This makes the tendons taut like a bowstring (and sweeping the #11 scalpel blade transversely across the tendon in a pendulum-like fashion with the 2- to 3-millimeter skin incision as the pivot point) easy to release (Figure 6). Usually audible and palpable sensations confirm the tenotomy is complete and verified by the patient being unable to actively flex or extend the toe. If the patient is insensate, as is frequently the situation in patients with diabetes mellitus, no anesthesia is needed. If sensation is present, a field block with 1% lidocaine (without epinephrine) proximal to the incision provides adequate anesthesia for the procedure.
9. Anticoagulation is not contraindication to doing these minimally invasive surgeries. In the anticoagulated patients, we typically double the time we apply direct pressure to the operative site(s); i.e., 10 minutes instead of five.
10. Advanced peripheral arterial disease, even in those patients with barely perceptible Doppler pulses, has not been a contraindication for doing these minimally invasive tenotomies. After the tenotomies, we allow our patients to walk out of the office. Bandaging is minimal and done to maintain the toe in the corrected position — usually with weaving between the toes or horseshoe wrap under or over the toe, depending on the correction desired.

11. After having dealt with many toe deformities with "textbook" management (i.e., correction utilizing flexor tendon transfers and arthrodesis of the interphalangeal joints) of clawed, hammer and mallet contractures, the minimally invasive toe tenotomy procedures without question are our preferred recommendations (Figure 7).
12. When patients are presented the options of living with nonfunctional deformed toes that are at risk for developing ulcerations versus straight, cosmetically pleasing, not actively mobile toes that are not prone to ulceration, the answer is invariably the straight toe choice. This option is especially recommended for the patient with comorbidities such as diabetes mellitus, peripheral artery disease and peripheral neuropathy. Percutaneous and limited open (may be required for extensor tendons) tenotomies are the minimally invasive, quick and easy solution to achieve this goal.

Summary. Our approach to managing clawed, hammer and mallet toes has been uniformly successful with almost 100 percent satisfaction in the patients. One nonanticoagulated patient did develop a hematoma at a single open extensor tenotomy site, and a couple others had minor superficial skin dehiscence that subsequently healed with minor care. No complications were associated with the solely percutaneous technique. Several patients required delayed secondary procedures such as flexor tenotomies after their extensor tenotomies. If the procedures are done in the office, clinic or at bedside, no more than two tenotomies are done at any one time. At these venues, the patients are given prophylactic oral antibiotics for a day or two.

What surgical skills are needed to perform the percutaneous tenotomies? Surgeons familiar with foot anatomy and an understanding of the pathophysiology of the axial toe deformities are the logical choices. Although obviously bowstringing tendons are easy to transect, more difficulty may be experienced with tendons "hidden" by fatty subcutaneous tissues, edema, scar tissue or hidebound skin. For such situations, the tenotomies should be performed by a foot and ankle surgeon, especially when these conditions are present on the dorsum of the foot. For easily accessible tendons, any wound care giver with suturing and debriding experience should be able to perform the minimally invasive percutaneous procedures after being suitably mentored and found to be competent in doing the tenotomies. Occasionally, a 2-3 mm incision becomes extended because of patient movement or inexperience. If this occurs and the accidental incision is large enough, it can be easily approximated with a couple of small nylon sutures.

Another advantage of our MIS and KISS approach to axial toe deformities is its cost effectiveness. When done in the clinic or bedside, the charges are a fraction of what they would be if done in the operating room. Use of the operating room may cost $5,000 to $10,000 versus the in-clinic, bedside procedure costing 1/10th to 1/20th of this. The information described above demonstrate the considerations we address when providing this effective, cosmetically pleasing and cost-effective option to our patients with clawed, hammer and/or mallet toes.

Realignment of Metatarsal Heads to Manage Malperforans Ulcers

Malperforans ulcer (MPU) is a term used to describe an ulcer over a bony deformity. The ulcer develops from contact pressures between the overlying skin and the underlying deformity. It most frequently occurs under the metatarsal heads in the forefoot. It is typically associated with other conditions affecting the nerves causing neuropathy and often a complication in diabetes mellitus, in which case it is often referred to as a diabetic neuropathic ulcer. Conditions that predispose patients to malperforans ulcers (see previous toe deformity section) include, but are not limited to, impaired pain perception at the skin pressure point over a bony prominence. clawed toes due to muscle imbalances, metatarsophalangeal joint subluxations/dislocations, and metatarsal heads being directed plantar ward.

In contrast to ulcers from shear forces, trauma, venous stasis disease, arterial insufficiency, vasculitis or combinations of these that have external causes, the malperforans ulcer evolves from inside to out. When the deformity with or without contact pressures exceeds the integrity of the overlying skin, an ulcer develops.

In the insensate foot, the patient may not appreciate the pressure concentrations between the deformity and the underlying skin. In the sensate foot, the pain would be analogous to walking with a pebble in the shoe.

Progression of problems from MPUs. MPUs may initially appear benign, but if left untreated, they can evolve to more serious problems and even limb-threatening conditions. If the surface of the MPU seals with a crust or fibrous tissue, an abscess can form in the subcutaneous tissue layer and lead to sepsis in the foot. As the abscess enlarges, the infection can spread into the surrounding tissues and proximally along tendon sheaths. If the wound is infected with group A *Streptococcus*, commonly known as "flesh-eating bacteria," or other tissue toxic bacteria, it can rapidly destroy skin, fat and the tissue covering the muscles. When this occurs, the problem can lead to a limb-threatening necrotizing fasciitis.

Total contact casting (TCC) is the most-often-utilized treatment for forefoot malperforans ulcers; however, it is not the most effective. During TCC treatment, the leg is casted to offload pressure to the forefoot. The patient may need to have serial casting for as long as six months with biweekly recasting to achieve healing of the MPU. This method does not provide access for wound care during those biweekly intervals. The trapping of moisture and sweat promotes bacterial growth inside the cast and can cause dermatitis and secondary wounds. The recurrence rate is also greater than 50 percent because the underlying bony deformity is not addressed.[10] When the cast is removed, the patient is likely to walk on the same pressure points with recurrence of ulcers even with protective footwear.

Management of the MPU. We recommend management of MPUs according to their stages of progression (Table 3, Figure 8). We utilize percutaneous drilling and closed osteoclasis of the metatarsal heads for management of other than superficial MPUs when neither osteomyelitis of the metatarsal head nor sepsis is present in the foot. If not done, previously toe tendon tenotomies are done in conjunction with the metatarsal head realignment surgery. Drilling and osteoclasis needs to be done in a sterile environment. With local anesthesia, typically a foot block, the metatarsal neck is scored with a 1-millimeter-wide puncture wound using a 0.62 mm Kushner wire. The bone is then broken (osteoclasis) at the drilling site and the metatarsal head redirected upward so that it is no longer deformed downward.

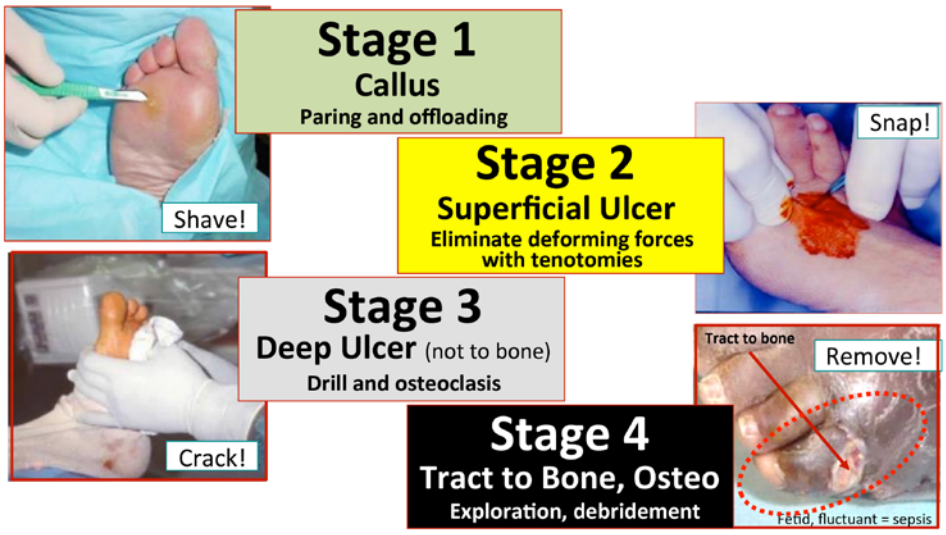
The foot is wrapped with elastic bandage without a splint or a cast. The patient can fully weight-bear and walk out of the surgery site with postop shoe. With the bandage, the newly redirected metatarsal head can load-share with adjacent heads. Prophylactic antibiotics are used perioperatively. With this technique, the malperforans ulcer typically heals within two or three weeks, as opposed to many months' duration with total contact casting. Due to the sensory neuropathy, patients experience no pain during the fracture healing process, which may take six weeks to three months.

Scoring of the bone is analogous to cutting a board into two pieces with only a drill being available. With the drill, a series of drill holes are made in a straight line across the board. With sufficient drill holes, the board can then be easily broken (i.e.. the bone equivalent of osteoclasis of the metatarsal neck) along the line of (i.e., scored) drill holes.

TABLE 3. Management of malperforans ulcers

Stage	Findings	Management
1	Callus formation under bony prominences	Debride calluses, protective footwear
2	Superficial ulcer (skin only) Clawing of toes	Toe tendon tenotomies (possible Achilles tendon lengthening) plus management methods for Stage 1
3	Deep penetrating ulcer (but soft tissue coverage over bone)	Realign metatarsal (MT) head with drilling and osteoclasis of MT neck
4	Metatarsal head osteomyelitis, abscess, ascending sepsis	Exploration and debridement including bone and soft tissue

FIGURE 8. Staging and management of the malperforans ulcer



Legend: Staging and management of the forefoot malperforans ulcer is simplified using the above system. If the stage 4 ulcer seals off, ascending tenosynovitis and necrotizing soft tissue infection may occur.

Clinical observations with the drilling and osteoclasis technique. With more than 200 cases from Long Beach Memorial Medical Center and Harbor-UCLA Medical Center, we have had uniformly good outcomes: one infection, a couple of cases of slow healing, and almost no transfer lesions. The contraindication for drilling and osteoclasis is if the metatarsal head is infected (i.e., osteomyelitis is present) and/or the foot is septic. In such situations, formal exploration, debridement and ray resection are required.

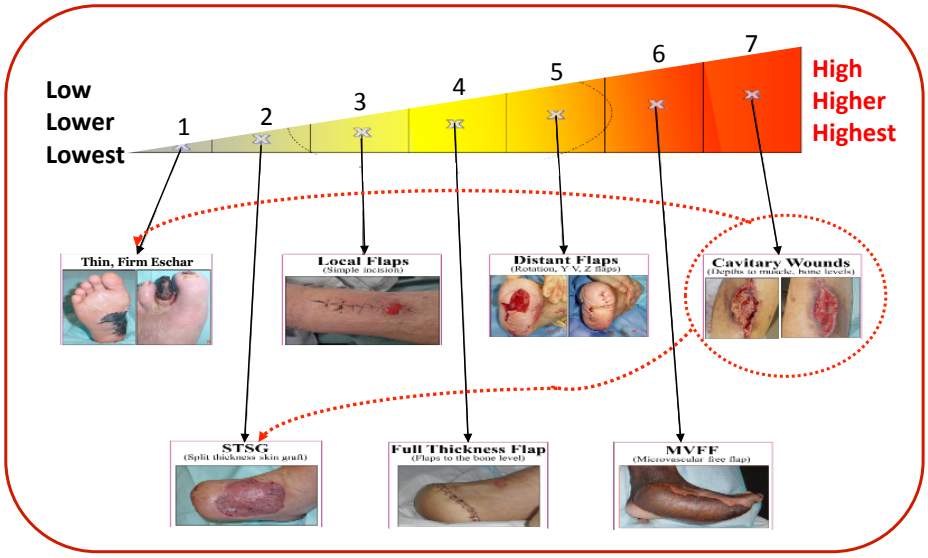
Forefoot Narrowing for Cleft Wounds

This condition refers to diabetic and vasculopathic patients with a nonhealing/slow-healing ischemic wound after middle metatarsal

resection. The cavity usually persists without evidence of filling in. Surgeons are often reluctant to place a skin graft in the cleft. The challenge is how to maintain a "mechanically sound" foot and achieve wound healing.

Multiple options are available to manage cavitary wounds, but there is a hierarchy from low oxygen and perfusion demands to high oxygen perfusion demands (Figure 9). A split-thickness skin graft (STSG) often results in partial take with sloughing in the depths of the cavity. The STSG, however, has relatively low metabolic demands compared to other techniques to manage cavitary wound. A transmetatarsal amputation can be performed to eliminate the wound, but this shortens the lever arm of the forefoot. Ischemia and higher metabolic demands to heal a full-thickness flap, however, may result in the flaps failing, sloughing and/or dehiscing. This, of course, leads to new wound problems. A below-knee amputation will lead to less mobility for the patient and require a prosthesis for walking. If there is muscle weakness or balance problems, the patient may become wheelchair bound. Narrowing of the forefoot can obliterate the wound. Elastic wraps or casting to maintain the narrowed position, however, can lead to pressure necrosis. Narrowing of the forefoot by compression with external fixation mitigates these problems.

FIGURE 9. Perfusion and oxygen needs hierarchy for healing of various wound types



Legend: The cavitary wound has the greatest metabolic demands for healing. By obliterating the cavity with forefoot narrowing (or partial wound approximations), the wound can be converted to a less-demanding one for healing, healing by secondary intentions or split-thickness skin graft (STSG).

FIGURE 10. Forefoot narrowing with temporary external fixation

Legend: Nonhealing cavitary wound obliterated with forefoot narrowing and temporary external fixation followed by a split-thickness skin graft.

Technique for fixator application. A patient with an ischemic foot and nonhealing wound after middle metatarsal resection requires a debridement to achieve a healthy vascular base before placement of the external fixator. When this is achieved, the patient is brought to the operating room. Two pins are each placed in the first and fifth metatarsal shafts. Palpation of bony landmarks eliminates the need for imaging (fluoroscopy) methods. The cleft is obliterated with narrowing of the foot and holding the narrowed position with a cathedral configuration using pin grippers, clamps and rods (Figure 10). Once the cleft is obliterated and a superficial wound remains, it can be skin grafted or healed by secondary intention. The skin graft markedly reduces metabolic requirements to heal as compared to healing of the cavitary wound.

Literature substantiation. In 2002 Strauss et al. reported using forefoot narrowing with external fixation on 15 patients.[11] Twelve patients (80 percent of the study population) completely healed and resumed their previous levels of activity.

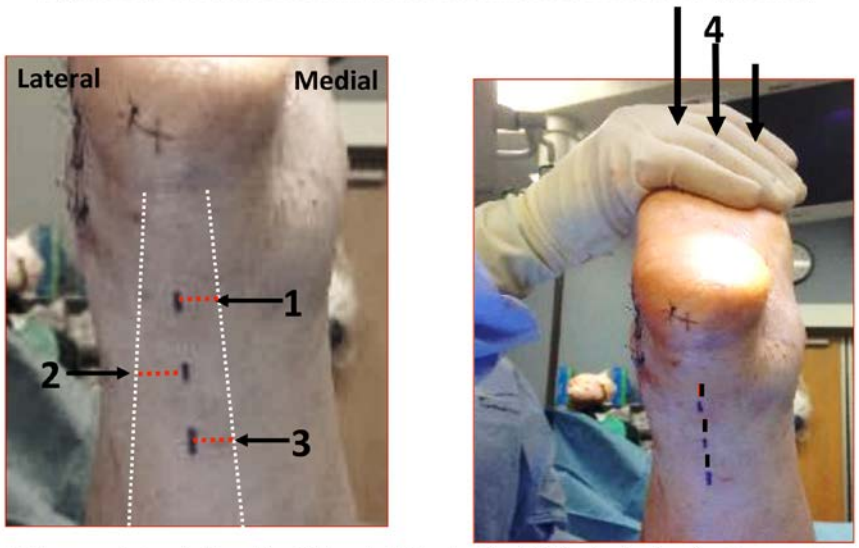
Percutaneous Achilles Tendon Lengthening for Equinus Deformities

The indication for Achilles tendon lengthenings is any forefoot surgery where the forefoot cannot be easily

dorsiflexed beyond the neutral ankle positions (e.g., equinus contracture).[12,13] A "softer" indication for lengthenings is a foot surgery in which hindfoot varus is contributing to a varus deformity of the hindfoot. With reduced pressure on the forefoot when standing and walking, the likelihood of new or recurrent malperforans ulcers at this site is lessened.

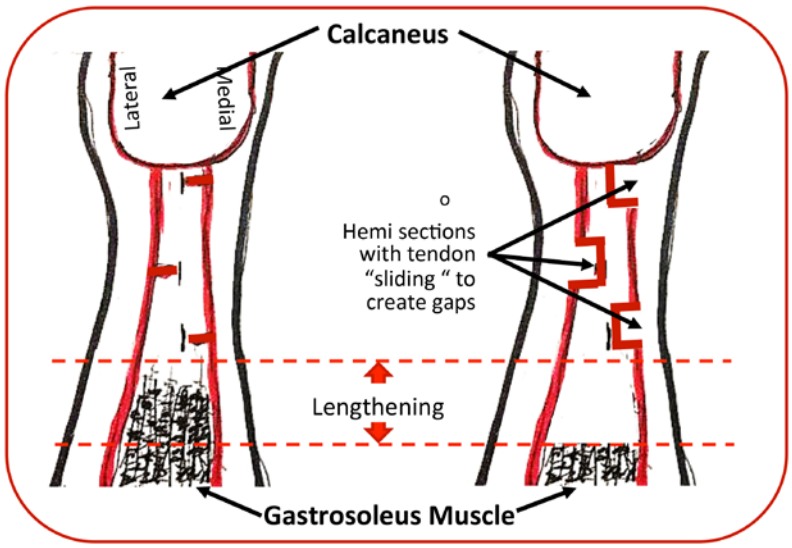
Procedure. The surgery is usually done in the supine position under anesthesia. A #11 scalpel blade is used to make three hemisections (Hoke technique) of the tendon (Figures 11a and 11b). The first hemisection is on the medial half of the Achilles tendon at its insertion on the calcaneus to counteract hindfoot varus. The second incision is at 2 cm proximal to the first incision, and the hemisection is done on the lateral half of the tendon. The third incision is done 2 cm proximal to the second incision. After that, forceful upward (dorsiflexion direction) pressure is applied to the plantar aspect of the forefoot while the leg is stabilized. Signs of a successful lengthening include audible and palpable sensations that confirm the tendon release, easily being able to dorsiflexed the foot beyond neutral position, and palpable gaps in the tendon at the hemisection sites. Typically, the corrected ankle condition is maintained in a cast for a six-week period. For severe contractures, external fixation is used to stabilize the foot and serial adjustments of the fixator are done to stretch out the tight posterior capsule structures and achieve a plantigrade foot (Figure 12).

FIGURE 11a. Percutaneous tri hemisection Achilles tendon lengthening



Legend: There are 4 steps in the minimally invasive tri hemisection Achilles tendon lengthening procedure. Notice the small incisions are made in the axial direction. Then the #11 scalpel blade is rotated 90° to hemi-sect the tendon (dotted red lines). By releasing the medial portion of the tendon at its insertion on the calcaneus, hindfoot varus can be mitigated.

FIGURE 11b. End results of tri hemisection Achilles tendon lengthening



Legend: With the tri hemisections, gaps are created in the tendon when forefoot pressure is applied in a dorsal ward direction. Often the gaps can be palpated through the skin, further signifying that the hemisections were effective.

Other considerations. Additional applications of tendo-Achilles lengthening (TAL) include club foot (Ponsetti technique), cerebral palsy, Charcot-Marie-Tooth disorder, and Charcot neuroarthropathy. Options other than the tri hemisection technique include incising the gastrocnemius tendon, muscle and/or fascia at the proximal (Silfverskiold, Baumann), middle (Strayer), distal third portions (Vulpius), or open step-cutting the tendon. These techniques are usually effective if the ankle can be brought to the neutral position when the knee is flexed to the 90-degree position (i.e., Silfverskiold test). For quickness, minimal complications and regardless of the Silfverskiold test, the distal tri hemisection of the tendon is our procedure of choice for the TAL. In addition, the TAL can be done with a local anesthesia without a tourniquet, especially in the patient with sensory neuropathy.

Ostectomies, Bursectomies, Cicatrixectomies for Underlying Deformities

Abnormal callus, bursa and cicatrix formations represent the body's attempts to generate a protective barrier

WOUND CARE CERTIFICATION STUDY GUIDE
SECOND EDITION

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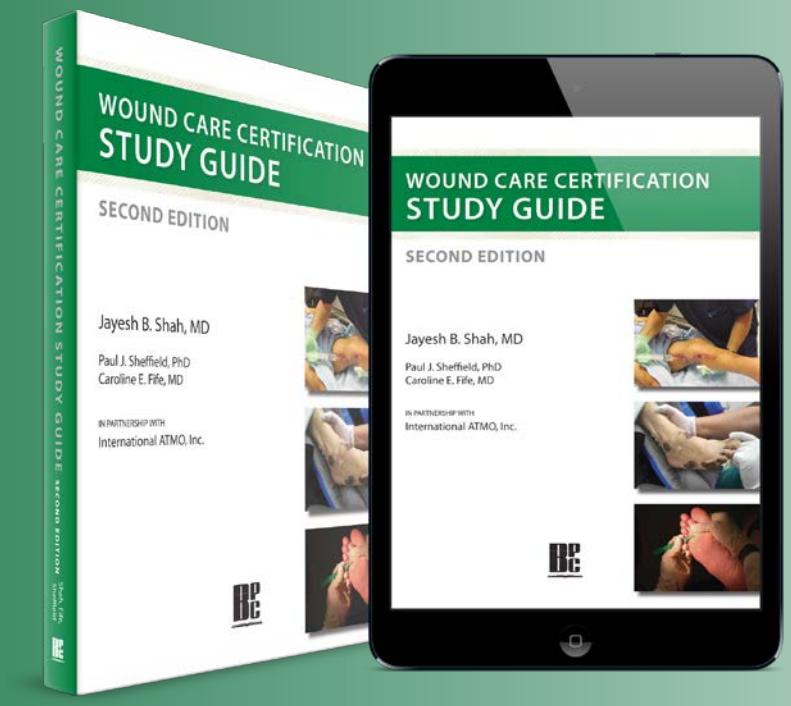

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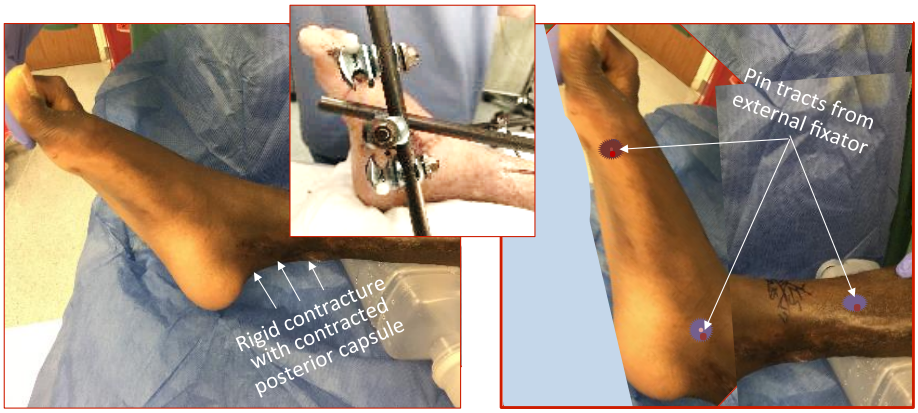
FIGURE 12. External fixation as an adjunct to Achilles tendon lengthening

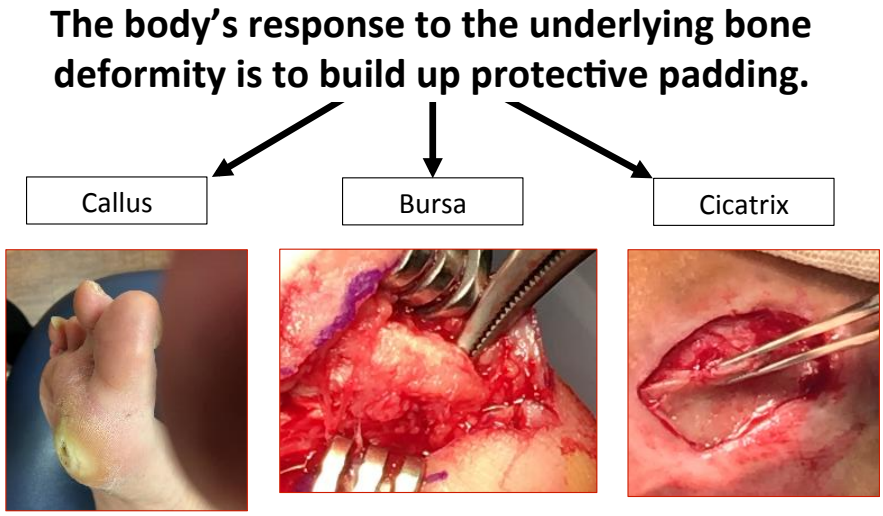


60º rigid equinus contracture after gunshot wound and revascularization of leg

10º remaining equinus after external fixator readjusted; additional dorsiflexion gained to achieve a plantigrade foot with casting

Legend: The external fixator is an adjunct to managing severe, rigid equinus contractures. With readjustments of the fixator, additional correction of the contracture can be achieved. This occurs as a consequence of stretching the posterior capsule with its viscoelastic (stretch-relaxation) properties.

FIGURE 13. Tissue responses to underlying deformities



Legend: The body tries to mitigate pressure buildups over deformities by developing padding-type tissues. While initially they may serve a protective role, with continuing enlargement they add to the deformity and lead to complications themselves such as ulcers, infection (see Figure 1) and interference with wound healing,

between the underlying bony deformity and the overlying skin (Figure 13).[14] This is often self-defeating in as much as these responses increase the magnitude of the deformity and at a certain point overwhelm the elasticity of the skin. The result is skin ulceration and the ensuing complications that can arise from the loss of skin integrity such as cellulitis, sepsis, ascending infection and necrotizing soft-tissue infection. Underlying deformity bone, bursa, or cicatrix is one component of the "troublesome triad" that also includes deep infection and ischemia-hypoxia.[8] Of the three components of the "troublesome triad," the underlying deformity component is the easiest to address with MIS and KISS surgeries.

Ostectomies and calluses. Ostectomies address underlying deformities and the abnormal biomechanics resulting from them. Deformities may be spurs, osteophytes, eburnations, posttraumatic defects/malunions, and Charcot neuroarthropathies. Often, however, the bony prominent is minimal; the "real" pathology is in the callus, bursa, and/or cicatrix overlying the deformity. These are the body's responses, as stated above, to build up protective padding over the underlying bone deformity.

A callus is a variant of normal skin that hypertrophies and becomes excessively keratinized. It is a toughened area of the horny layer of the skin, which can become extremely thick and hard in response to repeated friction, pressure, or irritation. Callus offers protection to the underlying epithelium and related skin structures. With pathological callus, the underlying etiology is invariably a bony deformity. Repetitive stress over the deformity, usually from contact pressure from loading and/or improper footwear, causes the overlying skin to thicken in an attempt to prevent loss of its integrity. When this is overwhelmed, there is skin breakdown and ulceration. Three permutations to callus responses to underlying deformity and ways to manage them include (Figure 14):

- **Benign calluses** are thin, dry crusts with grape-seed-size underlying ulcers at the pressure sites. Appropriate management at the insipient stage is first paring down the callus to soft pliable skin. The skin under the callus after debridement should have the same pliability and texture as the adjacent skin; the second step is the use of protective footwear to offload the mitigate and mitigate the abnormal biomechanics.
- **Worrisome calluses** are dry, firm callus circumscribing malperforans ulcer. They usually improve with the same interventions plus optimal wound management possibly using bioengineered skin substitutes.
- **Alarming calluses** are white and typically surround a biofilm over infected bone. They often signal

underlying bone or bursa and require exploration and debridement of the infected material. Moist callus may also be from edema fluid from the wound oozing onto the adjacent tissue and should be removed with simple paring.

Bursa. A bursa is a tissue sac lined with synovial cells and filled with synovial fluids. It allows soft tissue to glide over bony prominences or tendons in a nearly frictionless manner. Analogous to the callus, the thickened bursa adds to the thickness of the soft-tissue deformity and contributes to ulceration. With continued loading, the bursa hypertrophies and converts via metaplasia to a firm, relatively avascular cicatrix-bursa combination (Figure 1). With ulceration, bacteria inoculate the pathological bursa tissues, proliferate, and become a source of chronic infection. If the ulcer seals off, the infection process can proceed to deeper tissues, leading to abscess, osteomyelitis, ascending suppurative tenosynovitis, and necrotizing fasciitis.

Management. To manage the deformity, the first step is to offload the deformity site by removing or relieving pressure areas in the insole and shoe linings or increasing paddings of the surrounding area. The second step is serial debridements of the callus in the clinic. If skin integrity is threatened and/or a wound is already present, exploration and debridement of the bursa and cicatrix in the operating room is needed. Finally, ostectomy (often the minor part of the surgery versus the bursectomy and cicatrix removal), osteotomy and realignment of the affected bones (often guided by imagine studies) and/or amputation for more severe deformities are needed.

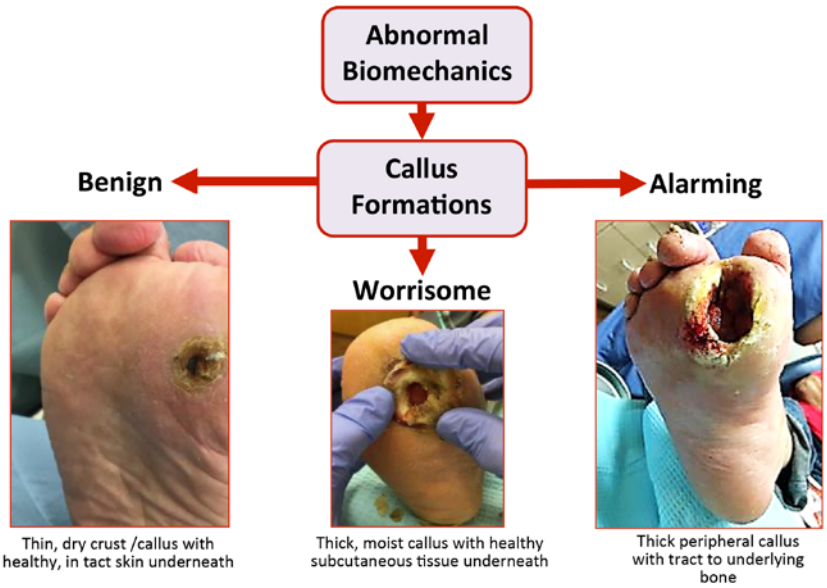
Alignment Correction and External Fixation for Configuration Problems

Malaligned feet lead to pressure concentrations bursa formation, ulcerations, infections, and often major amputations. Foot alignment problems include forefoot abduction/adduction, foot and ankle inversion (varus/eversion (valgus), equinus contractures, and combinations of these.

Management. While proactive surgical correction may, at first inspection, appear to be a major undertaking for these problems, surprisingly minimally invasive, KISS (keep it simple and speedy) surgical procedures can prevent these problems from becoming limb threatening (Figure 15).

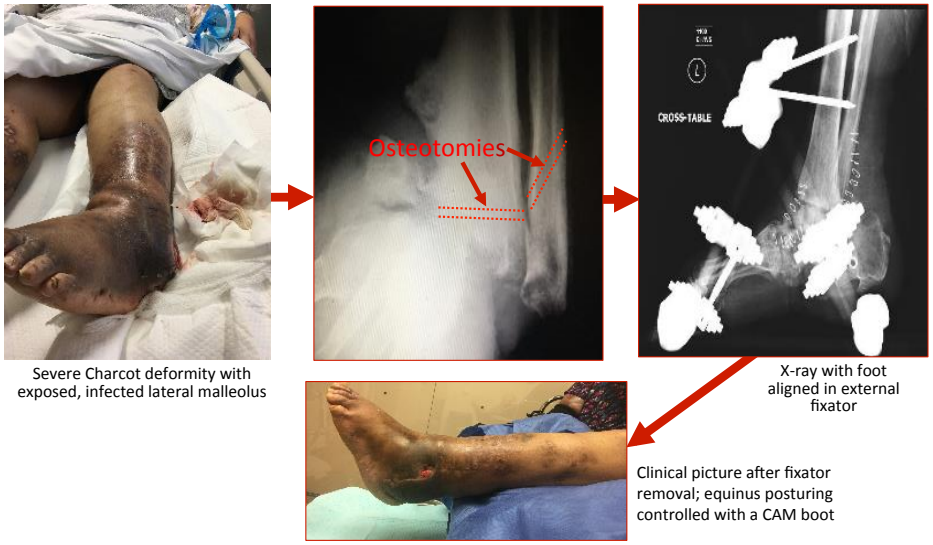
The first step in the surgery is the release of all dynamic deforming forces. It only takes a few minutes to

FIGURE 14. Types of callus responses in the foot



Legend: Benign calluses can be managed with serial debridements and offloading. Worrisome callus often improve with optimal management as use for benign calluses plus biologic dressings. Alarming calluses require ostectomies or ray resections of bone deformities.

FIGURE 15. Minimally invasive, keep it simple and speedy surgery with external fixator to manage severe deformities



Legend: Severe deformities managed with debridement, osteotomies (with debridement of the bones distal to the osteotomy) and maintenance of alignment with temporary external fixation make it possible to salvage the severest of diabetic foot deformities with MIS/KISS interventions.

do percutaneous and/or limited open tenotomies. Next, the bony deformity is removed, again a relatively short procedure since what needs to be done is obvious and often associated with a wound, which directs what dissection is needed. Step three is single- or dual-plan osteotomies to axially align the foot with the leg and put it in a plantigrade position. This is the most demanding of the four-step corrective procedure and requires experience in doing such. The last step is to maintain the alignment with temporary external fixation. The spanning external fixator across the foot and ankle can be applied in 15 to 20 minutes.

Dynamic forces are executed through muscle contractions. With muscle imbalances, as is typically associated with motor neuropathies, muscle contractions often initiate the deformities. With persistence, the bones of the foot and ankle remodel in response to the deforming forces. Once this occurs, the deformity becomes rigid rather than passively correctable. Consequently, not only are tenotomies required to mitigate the dynamic forces, but bone realignment (osteotomy) becomes necessary to achieve satisfactory foot alignment.

Dynamic deforming forces from muscle contractions must be differentiated from static deforming forces from ligaments, and joint capsules. These structures will stretch out with time if maintained in the corrected position due to their viscoelastic properties. Viscoelastic is a property of connective tissues. In simplified terms, it means these tissues elongate with time or change from an elastic deforming state (e.g., stretching a rubber band and then releasing it to return to its original length) to a plastic deforming state (e.g., stretching a stick of licorice), which maintains the new elongated state.

Fascia does not appear to have the same viscoelastic properties as the other connective tissues mentioned above. Hence, fasciotomies may be required for the plantar fascia in associated with foot deformities. Another situation in which fasciotomies are needed is with chronic exertional compartment syndromes.

The spanning external fixator is applied by placing two traversing (center-threaded) pins in the foot. The first is placed from medial to lateral (to lessen the chances of injury to the neurovascular structures passing nearby). The second pin is placed through the forefoot again from medial to lateral, with the goal of centering the pin in the first metatarsal and passing through as many other metatarsals as possible. Two half-pins placed at slightly diverging angles are placed from the anterior medial and anterior lateral directions in the distal third of the leg. With the use of bone landmarks, no imaging techniques (such as fluoroscopy) are needed for pin placements.

Compliance considerations. If the management is to be successful, utmost compliance to postoperative care must be done. This includes cleansing the pin-skin interfaces with hydrogen peroxide or normal saline to remove debris and wrapping the interfaces snuggly with gauze to prevent edema, oozing and secondary infection around the pin tracts. The patient should be nonweight bearing with the external fixator. The goal is to maintain the fixator for a minimum of six weeks to allow the soft tissues and bone (if osteotomies are done) to accommodate to the corrected position. After this, a walking leg cast is applied for a six-week duration. Finally, protective footwear from quality shoes to Charcot restraint orthotic walker (CROW) is prescribed depending on the residual appearance of the foot and ankle.

Conclusions

Even though this information is oriented toward the surgical perspective, it is essential that all wound-care providers be aware of the surgical alternatives that exist for preventing new and recurrent diabetic foot wounds as well as wounds in nondiabetics. When the deformity component of the "troublesome triad" (deformity, deep infection — including bone, bursa and cicatrix — and ischemia-hypoxia) is present and there is risk of a wound developing, we strongly recommend early attention to proactive surgeries.

It behooves nonsurgically trained wound-care providers to have a cadre of surgeons available who are comfortable with the surgeries described in this article and, if not, the information in this article with its associated references be made available to them. In the insipient stages, new or recurrent diabetic foot wounds with underlying deformities can be managed with the minimally invasive, keep it simple and speedy surgeries with the techniques herein described. ■

As an aside, a coauthor (MBS) used the same principles and techniques in managing severely deformed, neglected club feet with wounds and/or massive bursa during a recent orthopaedic humanitarian mission to Vietnam. With soft-tissue releases plus osteotomies and initial corrections maintained with external fixators, remarkable corrections were achieved. The patients are now transitioning from casts with plantigrade, axially aligned feet to protective footwear.

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MICHAEL STRAUSS, M.D., an orthopaedic surgeon, is the retired medical director of the Hyperbaric Medicine Program at Long Beach Memorial Medical Center in Long Beach, California. He continues to be clinically active in the program and focuses his orthopaedic surgical practice on evaluation, management and prevention of challenging wounds. Dr. Strauss is a clinical professor of orthopaedic surgery at the University of California, Irvine, and the orthopaedic consultant for the Prevention-Amputation Veterans Everywhere (PAVE) Problem Wound Clinic at the VA Medical Center in Long Beach. He is well known to readers of *WCHM* from his multiple articles related to wounds and diving medicine published in previous editions of the journal. In addition, he has authored two highly acclaimed texts, *Diving Science* and *MasterMinding Wounds*. Dr. Strauss is actively studying the reliability and validity of the innovative, user-friendly Long Beach Wound Score, for which he already has authored a number of publications.

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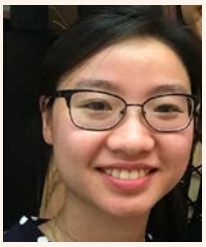

LIENTRA LU is a research coordinator at the VA Medical Center in Long Beach, California, under the guidance of Dr. Ian Gordon, a vascular surgeon, and Dr. Michael Strauss. She is also an administrative assistant in the accounting department of the Southern California Institute for Research and Education (SCIRE). She received a bachelor of science degree in chemical biology at the University of California, Berkeley, in 2015 and subsequently has taken medically related courses at the University of California, Los Angeles. Miss Lu is helping with diabetic foot and venous leg ulcer studies at the VA Medical Center while also serving as an assistant in patient care at the PAVE Clinic there. She also works with the American Red Cross in her other interest, disaster preparedness.

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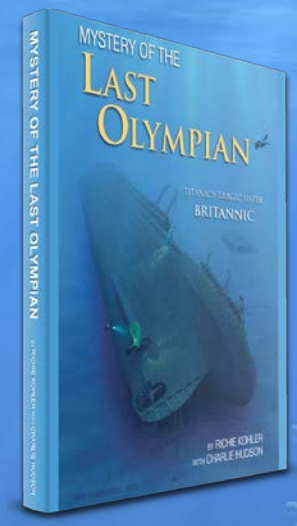

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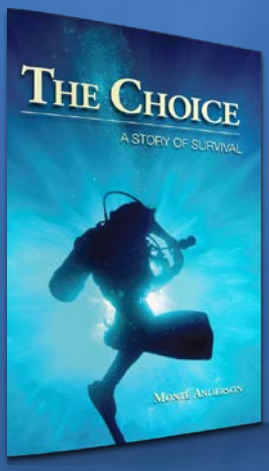


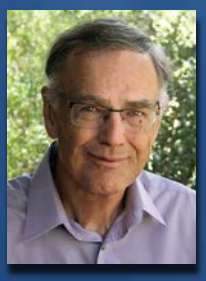
THE CHOICE: *A Story of Survival*

by Monte Anderson

As three friends drove across the Navajo Reservation in northern Arizona after backcountry skiing in Colorado, they talked about their lives. Then one said, "I really shouldn't be alive today."

David Scalia's astounding story occurred in 1982, when a scuba equipment failure caused a devastating accident, but he had a scrapbook documenting everything that happened. He suffered incalculable damage to his body for more than 12 grueling hours. Days later, he was given a profound choice — to live or to die. Almost unbelievable, this is his true story — and it involves some friends and colleagues you may know, including Dr. Gregory Adkisson, Dr. Tom Neuman, and Dr. Paul Phillips.

About the Author: Monte Anderson completed a medical residency at Creighton University and continued his studies with subspecialty training in gastroenterology and hepatology as an army officer at Fort Sam Houston in San Antonio, Texas. After his discharge from the military, most of his career was happily devoted to the Mayo Clinic in Arizona. Feeling that true tales tend to be more compelling than fiction, he has always preferred reading nonfiction, especially since something is always learned in the process. *The Choice: A Story of Survival*, his first effort outside of scientific writing, is nonfiction.



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Trigeminal Trophic Syndrome

A case report of a factitial wound and how addressing etiology can promote healing

By Ellen H. de Moll, MD,[1] Sandra Wainwright,[2] MD, and Charles Halasz, MD[3]

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Trigeminal trophic syndrome (TTS) is defined by characteristic crescentic ulcers, predominantly of the nasal ala, extending to cheek and upper lip, which can also develop on the forehead and scalp with an associated sense of itch, formication or burning on the face. It is typically associated with damage to the trigeminal nerve.

Case Report

A 48-year-old Caucasian man with a past medical history notable for obesity, peripheral neuropathy, right lateral medullary stroke 11 months prior to presentation, hypertension, diabetes, hyperlipidemia, atrial fibrillation, and depression, presented to the dermatology clinic with a right infranasal ulceration and complaints of facial "tingling" (Figure 1).

A wound culture from May 2013 grew *Staphylococcus aureus*, and the patient used a combination gel composed of 2.0 percent hydrocortisone acetate, 1.0 percent iodoquinol and 1.0 percent aloe polysaccharides. Viral culture was negative for herpes simplex virus (HSV) 1 and 2. A curettage biopsy was performed without complication and demonstrated broad areas of erosion covered by fibrin and neutrophils. The dermis demonstrated increased vascularity and neutrophilic and lymphocytic infiltrate. Despite treatment with antibiotic cream, the patient complained of a persistent tingling sensation and was referred to neurology.

He was evaluated by neurology and started on gabapentin with significant improvement of facial tingling.

The patient was referred to wound care by his dermatologist for a second opinion on wound management. The patient was using hyaluronic acid gel, but the wound on examination was desiccated with dried fibrin at the ulcer base. Additionally, the patient admitted that he felt compelled to touch the wound throughout the day, in part by habit and in part due to the underlying tingling sensation.

The decision was made to apply a hydrocolloid dressing to provide warmth, moisture and an occlusive barrier that would protect the wound from the patient. The patient was seen the following week to assess response to therapy. With hydrocolloid dressing, gradual resolution of the ulcer was seen, and patient had total healing within six weeks of being seen in wound care (Figure 1).

Discussion

The true epidemiology of TTS is not known, though its association with stroke, as in this patient, and other less-common causes is well described, but it is often misdiagnosed and underreported. There has been growing evidence in both neurology and dermatology literature that points to the relative frequency of this disease.

The development of TTS has been associated commonly with stroke (30 percent), including Wallenberg syndrome.[1] Other causes of TTS include trigeminal nerve ablation (30 percent), craniofacial surgery (21 percent) and less commonly neuroma, postencephalitic parkinsonism, syringobulbia, meningioma and astrocytoma.[2]

In one review of 60 cases of TTS, the nasal ala were involved in 79 percent of cases, the cheek 28 percent and corneal lesions 18 percent.3 The differential includes malignancy and multiple infectious causes (Table 1). Biopsy is often nonspecific but may be helpful in ruling out malignancy and special stains to rule out less-common infections. In some cases, the pathology has shown a decrease in sensory nerves in affected skin.[3,4]

Although treatment regimens vary widely, most practitioners agree that patient education and behavior modification are crucial to the success of therapy.[5]

Hydrocolloid dressing has reportedly been effective in a seven patient case series, as it was in our patient.[2] Hydrocolloid is beneficial as it serves as an anatomic barrier as well as a physical barrier that prevents further manipulation of the

FIGURE 1. Before hydrocolloid dressing and gabapentin

FIGURE 2. After hydrocolloid dressing and gabapentin

TABLE 1

Infectious	Other
Herpes	Pyoderma gangrenosum
Syphilis	Wegner's granulomatosis
Yaws	Midline granuolma
Leprous trigeminal neuritis	Factitial dermatitis
Deep fungus	
Mycobacteria	
Rhinoscleroma	
Leishmaniasis	

wound by patients inadvertently due to underlying irritant sensation. In general, surgical repair is often unsuccessful.[2]

Systemic therapy is often successful when there is underlying burning or tingling sensation, to help limit patient's desire to irritate the wound further. Gabapentin has been shown to be effective as a first-line treatment, with carbamazepine demonstrating somewhat less efficacy as a second-line therapy.[3] There is less evidence to support the use of pregabalin, amitryptiline, pimozide given the small number of published cases. Essentially, TTS is a disorder in which neuropathy stimulates the patient to touch the wound. Blunting the neuropathic sensation with medication and employing a dressing that acts as a barrier and is cosmetically acceptable like a hydrocolloid were the successful therapies in this case.

TTS can pose a diagnostic and therapeutic dilemma to physicians in multiple specialties, and, as in our case, patients may benefit from multidisciplinary management to address the dermatology/wound and neurologic manifestations of their disease. It is crucial to consider TTS in the differential for patients with unilateral facial ulcers, particularly with history including stroke or trigeminal nerve ablation. Appropriate education and therapy can lead to greatly improved outcomes and full healing of the ulcer. ■

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